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Study on a Freshwater Goby, *Rhinogobius similis* GILL, with a Proposition on the Relationships between Land-Locking and Speciation of Some Freshwater Gobies in Japan[1]

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Introduction

"Yoshinobori" *Rhinogobius similis* GILL is a common freshwater goby in Japan and is well known of its variabilities in form and colour (TOMIYAMA, 1936). In the course of the investigation of its life history since 1956, it was found that there were three ecological types in this species, namely a fluvial type, an amphidromous type and a lacustrine type (in the last one, an adfluvial type was also contained), and the fluvial type was clearly discriminated from the other two types not only in the life-historical features but also in the morphological characters of the adult fish[3]. These examinations have led me to settle up an opinion on the relationships between land-locking and speciation of Yoshinobori as well as the other freshwater gobies in Japan, which will be dealt with in some detail in the present paper.

I. Comparison of the Life Histories among the Three Types

Egg size and egg number. A spawning female of the fluvial type contains 74–127 eggs (examined with 16 specimens of 39.0–47.5 mm in body length), each from 1.4 to 2.1 mm in diameter (with 3 individuals of 42.0–46.2 mm in body length) (Fig. 1, B). While the adult fish of the amphidromous type have about 1,100–2,800 eggs of 0.4–0.8 mm in diameter (with 11 and 3 specimens of 36.5–56.5 mm in body length) (Fig. 1, A).

The ratios of ovary weight to body weight of the above individuals extend from 11 to 15 percent in both the types, therefore, above difference in the egg

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3) These details will be found in other papers (MIZUNO, in press).

size is not considered to be due to the difference in the maturity of fish. In fact, the spawned eggs of both the types in the rivers are clearly distinctive as shown in Fig. 2, A and the intermediate egg size has not been found.

Body form and habitat in each developmental stage. The newly hatched larvae of the amphidromous type, about 4.0 mm in total length, are different from the later stages in their whole structure, being characterized by the presence of a continuous fin fold (Figs. 2, C, a and 3, B). They lie still on the bottom of an aquarium, making return trips to the water surface infrequently like the larvae of a mosquitoes. After the absorption of the yolk, they enter into swimming life and tend to crowd together towards the lightest section in an aquarium. They seem to be carried down into a sea within a few days after hatching. For, the larvae of this type are never seen in a river since then. After two or four months, many immature fish (Fig. 3, C) ascend a river in schools from a sea, settle down gradually to take up the benthic life picking on bottom insects or on algae. After about two years, they grow up the adult size of about 6–7 cm in total length without caudal (Fig. 3, D).

While in the fluvial type, the newly hatched larvae of about 7.5 mm in total length are characterized by the presence of properly constituted fins with ossified rays of regular number (Fig. 4, B); and transform directly into young fish with the essential form of adults (i.e., advanced frys or alvins) like a salmon larva (Fig. 4, C). Furthermore, they enter into benthic life without passing a swimming stage and do not show such a phototactic behaviour as the larvae of the amphidromous type do. The main habitats of these alvins remove from the calm places near stream banks to the middle of currents in the course of growth to adults (Fig. 4, E). They attain the mature size of about 5 cm two years after hatching.

In a word, the fluvial type spends its whole life in a stream. Comparing the newly hatched larvae of the amphidromous type (Fig. 3, B) with the embryos of the fluvial type (Fig. 4, A), it is clear that the fish of the latter type pass their swimming stages in the eggs.

Eggs and development of the lacustrine type. Yoshinobori inhabits also such lakes and ponds to which the fish of amphidromous type can not ascend. Namely, it is land-locked in these lakes and ponds, and on this point, it is distinguished as the lacustrine type from the amphidromous type. But, the former spawns a great number of small eggs as well as the latter, and the morphological features of each developmental stage are the same in both the types.

On the other hand, the lacustrine type invariably spends its swimming larval stage in a lake or a pond, as though the larvae of the amphidromous type live in a sea. Thus, both the types pass their swimming stages in the standing waters which seem not to be indispensable for the demersal larvae of the fluvial type.

Spawning habit. In the Kinki District, the spawning season is some time in June and July in both the types. The breeding rooms were found under

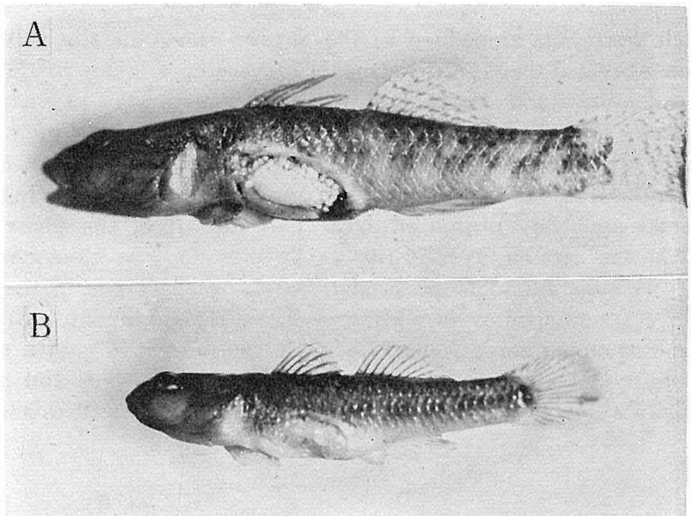

Fig. 1. Female adults with mature eggs of an amphidromous type (A) and a fluvial type (B).

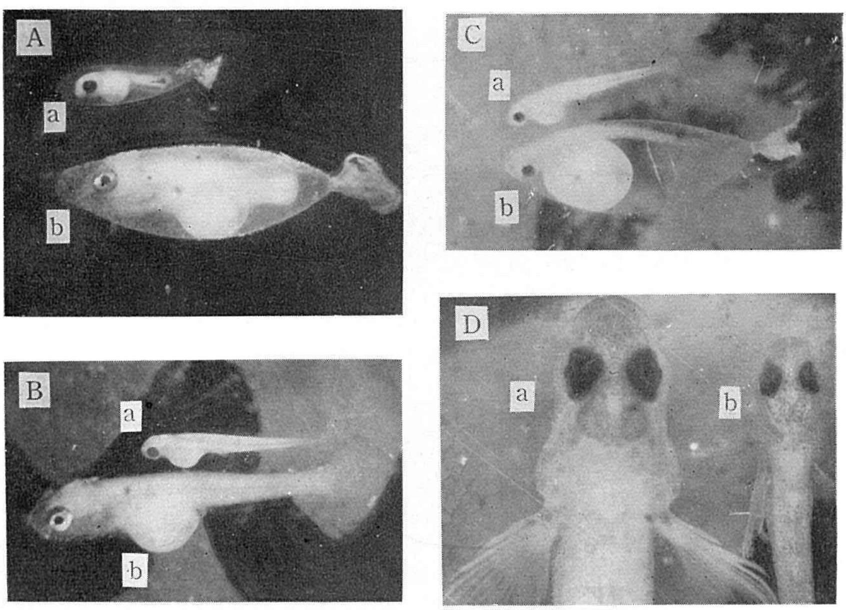

Fig. 2. Comparisons of egg size and forms in some developmental stages between an amphidromous type (a) and a fluvial type (b).

A : comparison of spawned eggs.

B : a newly hatched larvae.

C : the same of an amphidromous type (a) and an embryo of a fluvial type (b), both are nearly in the same developmental stage.

D : an immature fish of an amphidromous type ascending a river from sea (a) and a larva of a fluvial type soon after absorption of a yolk.

stones which were half embedded in the bottom sands in the streams or the ponds. The spawned eggs were attached, in a single layer, to the under surface of these stones and a male fish was observed to stay in each room until the eggs hatch, while a female leaves there soon after spawning.

Stomach contents. During the summer of 1955 and the spring of 1958, the gobies of amphidromous type picked on the bottom insects exclusively, while in the summer and the autumn of both 1957 and 1958, the algae were their main foods in the Ukawa river (KODAMA, in press). The stomach contents of the fluvial type were found to be predominated by the algae in the summer of 1957 in the Katsuragawa river (MIZUNO *et al.*, 1958), but in the Satsukigawa river by the bottom animals (GOSE, 1958). Furthermore, the gobies of lacustrine type fed mainly on the bottom insects near Ibuki sub-ward and on the algae near Sakaguchi sub-ward respectively in the Anegawa river (KODAMA, in press).

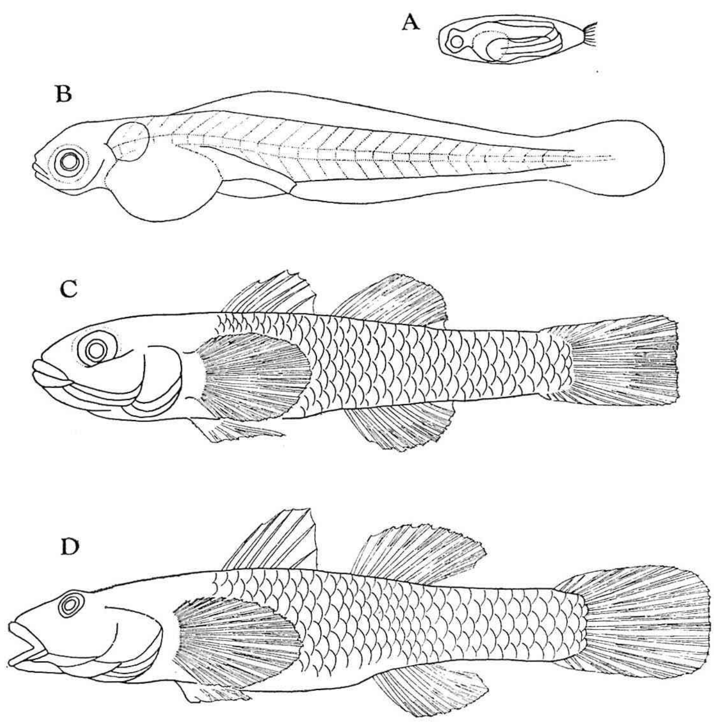

Fig. 3. Morphological changes in some developmental stages of an amphidromous type.
A : an egg and enbryo (×8.5).
B : a newly hatched larva (×20).
C : an immature fish ascending a river from sea (×4.0).
D : an adult (×1.7).

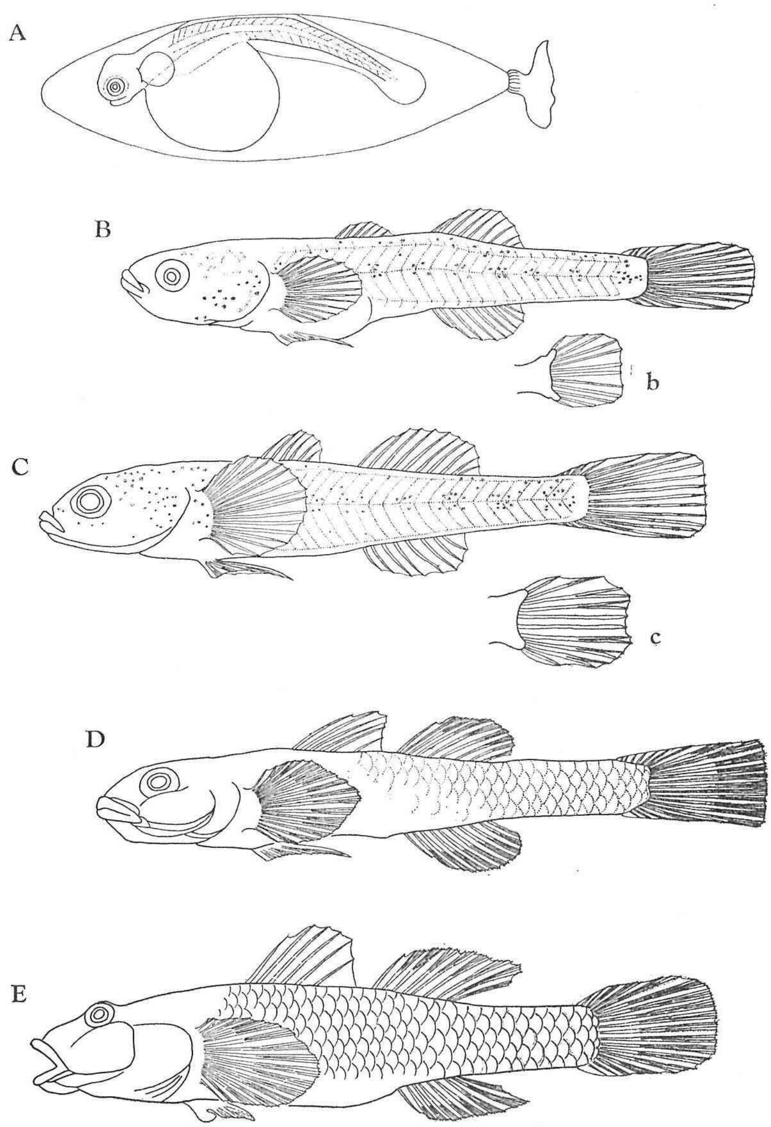

Fig. 4. The same of a fluvial type.
A : an egg and embryo (×8.5).
B : a newly hatched larva and its ventral fin (b) (×8.5).
C : an early post larva and its ventral fin (c) (×8.5).
D : an immature fish (×4.0).
E : an adult (×1.7).

In a word, the adult fish of whichever type are able to feed on bottom insects as well as on algae, and, as reported by KAWANABE (1959) on stream fishes, they also seem to have a partiality for one side of both foods according not only to food condition in their habitats but also to the composition and population of the fish society.

A preliminary consideration and a summary on the life history. Contrary to the similarities of the spawning and the food habits, the three ecological types show the differences from each other at least in the modes of migration during the courses of their developments. Especially, the difference in egg size between the fluvial type and the other two types is seen clearly even in the same place and at the same time, and the intermediate egg size has never been observed. It is well known that a larger fish spawns a greater number of larger eggs than a smaller one of the same species kept under same conditions (BROWN, 1957). In the case of Yoshinobori, however, adult size of fluvial type is never larger than the other types. Though it is also a general principle that a larger fry tends to hatch from a larger egg in a same species, it has usually no morphological distinctions as against a smaller fry.

After all, above differences in eggs as well as in larvae between the fluvial type and the other two types are not considered to be intraspecific variations owing to the dissimilarities of external conditions only. The former type therefore seems to belong to a different species from the latter. On the other hand, though the lacustrine type was distinguished as the land-locked fish from the amphidromous type, both of them show the several agreements both in size and in number of the mature eggs, in the morphological characters of each developmental stage and in the habit of passing their larval stages in the standing waters such as lakes, ponds and seas.

Many investigations have hitherto been carried on with Yoshinobori. The fish dealt with by NIWA (1954) may correspond to the fluvial type, and that examined by OHIRA (1958) and KOBAYASHI (1923) to the amphidromous type, and OKADA and SEIISHI (1938) seem to have reported on the fish of the lacustrine type respectively.

II. Comparison of Morphological Characters of the Adult Fish

External characters. The colour pattern on body sides, the most conspicuous one in this fish, is clearly distinctive between the amphidromous type and the fluvial type (Fig. 5). In the former it is brownish as a whole in formalin, with seven dark cross bands on each side, which join each other at the middle line on the back. While in the latter, darker patches along the middle on each body side, five to ten in number, are very faint and longitudinal. In some cases, these unite with each other to be a longitudinal streak or line. The colour pattern of the lacustrine type (Fig. 5, B), the most variable among the three types, bears a resemblance to that of the amphidromous type.

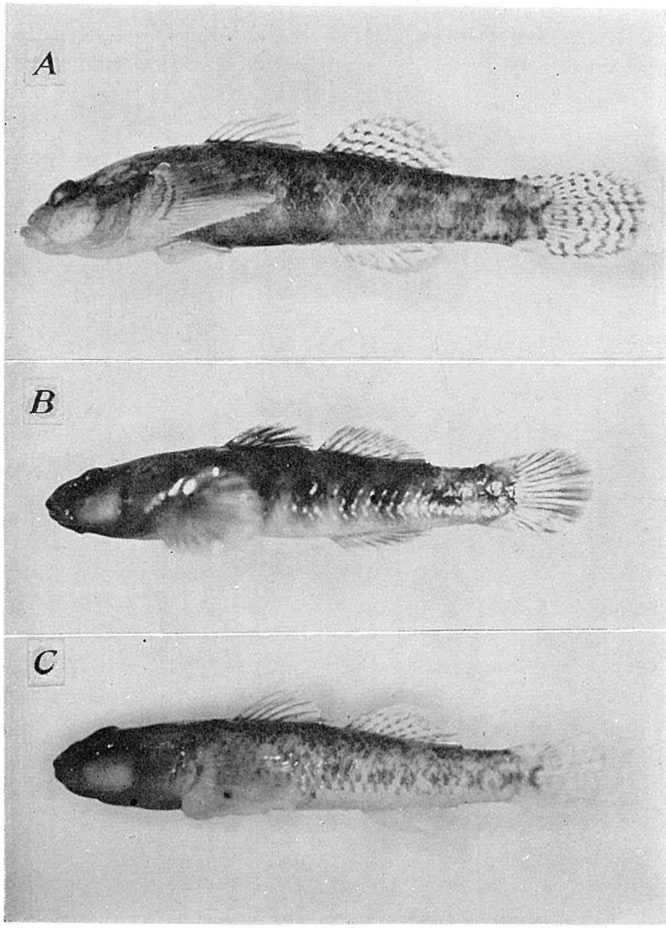

Fig. 5. Female adults in formalin of an amphidromous type (A), a lacustrine type (B) and a fluvial type (C) (×1.2).

The body forms were examined by 14–31 specimens in each type (Table 1). The differences in the average values among stations are so immense within a same type that those cover the differences among the three types.

The numbers of fin rays were counted with about 70–200 individuals (Table 2). In all fins except the 2nd dorsal, notable differences were seen between the fluvial type and other types. Especially in the pectoral fin rays, the fluvial type shows the average value of 16.41±0.09, comparing with that of 19.71±0.14 in the amphidromous type and that of 20.57±0.16 in the lacustrine type. The individuals with VII first dorsal spines were seen in about 10 to 100 in the former, but no such specimen in the latter two types. Between the amphi-

Table 1. Average values and those confidence intervals (reliability: 95 percent)

Type	Station	Body L./ Head L.	Body L./ L. of Caudal Ped.
Fluvial type	R. Yuragawa	3.37±0.09	3.92±0.13
	R. Inukaigawa	3.94±0.12	3.82±0.09
Amphidromous type	R. Ukawa	3.39±0.15	3.96±0.08
	R. Sôshagawa	3.57±0.12	3.74±0.07
Lacustrine type	L. Biwako	3.25±0.08	3.93±0.16

Table 2. The same of the fin-rays counts and the vertebral numbers.

Type	Station	First dorsal spines	2nd dorsal rays
Fluvial type	R. Yuragawa	6.08±0.12 (96)	9.21±0.19 (30)
	R. Inukaigawa	6.23±0.53 (13)	8.69±0.26 (13)
	R. Mino-o-gawa	6.06±0.11 (35)	9.00±0.00 (16)
	R. Yoshinogawa	6.00±0.00 (11)	8.82±0.40 (11)
	R. Sôshagawa		
	R. Shigenobugawa	6.06±0.12 (33)	8.79±0.23 (33)
	R. Hijikawa	6.33±0.27 (15)	9.00±0.20 (15)
	R. Takahashigawa	6.00±0.00 (12)	9.00±0.38 (12)
	Total	6.09±0.04 (215)	9.01±0.11 (120)
Amphidromous type	R. Ukawa	5.98±0.03 (64)	9.10±0.11 (30)
	R. Yanokawa	6.00±0.00 (21)	8.95±0.12 (21)
	R. Sendaigawa	5.99±0.05 (74)	8.93±0.06 (74)
	R. Sôshagawa	5.96±0.08 (25)	8.96±0.08 (25)
	R. Shigenobugawa	6.00±0.00 (16)	8.81±0.29 (16)
	Total	5.98±0.02 (113)	8.99±0.04 (166)
Lacustrine type	L. Tôyako		
	Pond in Hirosaki city	6.00±0.00 (28)	9.25±0.17 (28)
	Pond in Kôriyama city	6.00±0.00 (30)	8.47±0.19 (30)
	L. Suwako		
	L. Biwako	6.00±0.00 (55)	8.79±0.10 (47)
	Total	6.00±0.00 (113)	8.91±0.10 (105)

of the measurements of the three ecological types in *Rhinogobius similis.*

L. of Caudal Ped. / H. of Caudal Ped.	Head L./ L. of Snout	Head. L./ Eye D.	Head L./ L. of Caudal Fin	Head. L./ L. of Pectoral Fin
2.29±0.13	3.14±0.18	4.89±0.13	1.27±0.06	1.27±0.05
2.35±0.11	2.98±0.11	5.38±0.09	1.29±0.08	1.32±0.05
2.97±0.08	2.71±0.17	5.25±0.39	1.25±0.05	1.27±0.06
2.12±0.06	2.66±0.10	5.41±0.26		
2.23±0.13	2.77±0.16	5.37±0.24		

The numbers of examined specimens were put in parentheses.

Anal rays	Pectoral rays	Caudal rays	Vertebrae
8.63±0.33 (15)	16.63±0.13 (85)	15.64±0.25 (15)	28.07±0.10 (30)
8.43±0.43 (13)	17.00±0.41 (13)	15.31±0.24 (13)	27.85±0.17 (20)
8.19±0.40 (16)	16.14±0.17 (35)		
8.36±0.33 (11)	16.46±0.46 (11)		
			27.91±0.19 (12)
8.18±0.19 (33)	16.33±0.19 (33)	14.82±0.27 (33)	27.91±0.19 (12)
7.73±0.49 (15)	16.60±0.33 (15)		
8.33±0.37 (12)	16.33±0.33 (12)	14.67±0.32 (12)	
8.22±0.12 (115)	16.41±0.09 (204)	15.07±0.17 (73)	27.92±0.02 (105)
8.33±0.25 (15)	19.83±0.12 (94)	16.07±0.14 (15)	26.00±0.00 (27)
8.52±0.18 (21)	19.71±0.42 (21)	15.57±0.23 (19)	26.00±0.00 (19)
8.80±0.20 (74)	20.14±0.23 (74)		
8.83±0.16 (24)	19.48±0.26 (25)	15.56±0.26 (18)	26.00±0.00 (23)
8.81±0.29 (16)	19.63±0.42 (16)	15.31±0.33 (16)	26.00±0.00 (16)
8.90±0.06 (141)	19.71±0.14 (136)	15.66±0.12 (80)	26.00±0.00 (85)
			26.00±0.00 (5)
9.35±0.17 (28)	21.07±0.30 (28)		
8.10±0.18 (30)	20.63±0.29 (30)	15.60±0.30 (30)	25.96±0.07 (28)
	19.79±0.68 (14)		
8.71±0.20 (35)	20.33±0.19 (35)	15.40±0.25 (35)	25.98±0.03 (128)
8.62±0.13 (93)	20.57±0.16 (134)	15.42±0.10 (65)	25.98±0.02 (161)

dromous type and the lacustrine type, such remarkable distinctions are not observed.

In all types, a ctenoid scale is the principal one covering almost all body, becoming smaller only towards belly and nape. The number of scales in a lateral series, estimated by 46–70 specimens in each type, are 32–36 in the amphidromous type, 32–37 in the lacustrine type and 33–37 in the fluvial type. The scales before first dorsal, examined by 56–98 individuals, are respectively 3–18, 0–14 and 0–14 in each type. The scales on belly are clearly seen in almost all specimens of the amphidromous type, but in many specimens of the other types, are difficult to recognize by naked eyes.

It is well known that the ventral fin of *Rhinogobius similis* forms a circular powerful adhesive disk against a water flow (HERRE, 1933). This is certainly so in both the amphidromous type and the fluvial type. While in the case of the lacustrine type, especially living in the calm ponds, its longitudinal oval disk is of little use in adhering itself. Except this fin, there are few distinctions in the forms of both paired and unpaired fins of the three types. The disposition of sensory canal pores on a head shows also no marked distinction and coincides with the result of TAKAGI (1957) who examined this species.

Internal characters. Vertebrate numbers were counted in about 80–160 specimens. The fundamental number of vertebrae are 28 (abdominal v. 11+caudal v. 17) in the fluvial type, while 26 (10+16) in the other types. These values show little variations among stations; moreover, above differences are seen in the same stations (Table 2).

The teeth in each jaw, with or without a caninoid, are all about three in bands. The tongues with round tips are supported by their fan-shaped glossohyals in all the types.

A preliminary consideration and a summary on the morphological comparisons. Three ecological types show not only remarkable similarities between each other but also notable variabilities within a same type in many characters, for example, in the body form, the size and the form of fins, the state of scales, the disposition of sensory canal pores, the form of teeth and glossohyals, etc. These were the reasons why Yoshinobori has been considered to be single species with few doubtness, since TOMIYAMA (1936) created the present category of this fish in the course of reviewing the gobioid fishes in Japan.

In spite of these similarities, the fluvial type is clearly distinctive from the other two types not only in both the number of pectoral fin rays and the colour patterns of body sides as the external features but also in the number of vertebrae as the internal one. If many specimens are examined, the counts of first dorsal spines will be included as one of noticeable features.

Considering the more distinctive features of the fluvial type, such as the egg size and the larval form mentioned in the previous section, it is clear that the fluvial type belongs to a different species from the other two types, which have no more distinctions than the intraspecific variations with each other.

So, the fluvial type is named hereafter as "Kawayoshinobori", and to the other two types are given a customery name "Yoshinobori". Namely, Yoshinobori in the hitherto sense are divided into two species, Yoshinobori and Kawayoshinobori.

To decide the scientific name of both the species, it may be necessary to examine the type-specimens of the described species of *Rhinogobius*, *Ctenogobius* and *Tukugobius*. But, *Ctenogobius similis* JORDAN et SNYDER, 1901, *R. fluviatilis* TANAKA, 1925, *Rhinogobius nagoyae* JORDAN et SEALE, 1906, *C. kurodai* TANAKA, 1905 and *C. katonis* TANAKA, 1905, all described from Japan, were estimated to correspond with the fishes of the amphidromous type or the lacustrine type of *R. similis*, from the descriptions as to the former three and from the results of my examination on the specimens identified as the latter two (preserved in the collection of Tokyo University). Taking account of the above conclusion, it seems to be reasonable to apply the name '*Rhinogobius similis* GILL' to Yoshinobori temporarily and to remain the definite nomenclature in future, in view of that the GILL's original discription is too imperfect to decide the matter at the present.

Meanwhile, HERRE (1927) created *Tukugobius* from the Philippines and described such features that spawning female had contained about 135 eggs, each from 1.5 to 2 mm in diameter,······ they inhabited mountain creeks exclusively,······ and this genus was closely allied to *Rhinogobius* of authors, etc. However, he reported also in 1933, "Recently, I have examined a series of *Rhinogobius similis* GILL, from Japan, and the related species from Japan and Formosa, and have compared them with the three species of *Tukugobius*······. They are all very closely related and are all evidently true *Rhinogobius*. *Tukugobius* HERRE is therefore an exact synonym of *Rhinogobius* GILL." (HERRE, 1933).

Above descriptions show that *Tukugobius* is related to Kawayoshinobori more closely than to Yoshinobori *R. similis*. His last conclusion may be erroneous, as it was unknown to him that in the '*R. similis*' two species were included and he should have compared *Tukugobius* with the specimens of Kawayoshinobori. All the species of the genus *Rhinogobius*[4] have VI spines in the first dorsal (KOUMANS, 1941) and their fundamental number of vertebrae are 26 so far as has been examined (DÔTU, in preparation). Considering the first dorsal spines of VI or VII in number, the vertebral count of 28 and the peculiarities in the life-historical features of Kawayoshinobori, it is appropriate to conclude that this fish belongs to a genus different from *Rhinogobius*, and to revive *Tukugobius* as the generic name of this fish. Referring to KOUMANS' above mentioned revision on the gobioid fishes, there seems to be no proper genus that may be applied to Kawayoshinobori other than *Tukugobius*.

Kawayoshinobori seems to be closely related not only to the three species

4) The '*Rhinogobius*' in this report is equal to the '*Ctenogobius*' of KOUMANS (1941).

of *Tukugobius* but also to *Rhinogobius taiwanus* OSHIMA, 1919 and *R. fukushimai* MORI, 1934. But, it differs in the number of sensory canal pores from *R. taiwanus*, in the number of first dorsal spines from *T. bucculenatus* and in the scale number of lateral series from the other three species respectively. Therefore, a new name *Tukugobius flumineus* will be given for Kawayoshinobori, description of which will be found on the later pages. All these species may, however, be lumped together in a single, very variable kind, as though HERRE (1927) mentioned already with the three species of *Tukugobius* in the Philippines.

After all, above conclusions are summarized as next:

Hitherto name	Ecological type (Conventional grouping)	Proper name
Yoshinobori *Rhinogobius similis*	Amphidromous type	Yoshinobori *Rhinogobius similis*
	Lacustrine type	
	Fluvial type	Kawayoshinobori *Tukugobius flumineus*

TAKAGI (1950, 1953 and 1957) proposed that the morphological features of a scale and a glossohyal, the dispositions of sensory canal pores were useful to estimate the affinity among the different species and genera of gobioid fishes. No marked distinctions in these characters are recognized between *R. similis* and *T. flumineus*. Taking account of the more similarities and the variabilities in the other morphological characters without vertebral counts, number of first dorsal spines and pectoral fin rays, the latter is reasonably concluded to be allied to the former.

The pterygiophores of first dorsal spines associate with the neural spines of abdominal vertebrae one by one. The increasing of the latter is therefore considered to bring the increasing of the former. The vertebral number of a fish hatched from a larger egg tends to be more numerous among the allied species (HUBBS, 1926), and the remarkably enormous size of the egg of *T. flumineus*, which passes its swimming stage in the egg, seems to have been acquired in the course of land-locking in the rivers during the geological age. Namely, the increasing in the number of both vertebrae and first dorsal spines of this fish, seems to have been brought on by the enlarging of egg size, and these characters may have been all acquired in the process of land-locking, which will be dealt with in Section IV. In a word, *T. flumineus* has been derived from *R. similis* or its allied species.

III. Comparison of Distributions

Ecological distribution. The specimens collected from 115 stations were examined. As the result, *Tukugobius flumineus* is concluded to inhabit mainly the tributaries or the middle and upper courses of main streams; while in the middle and lower courses, *Rhinogobius similis* is generally abundant (Fig. 6). It may be natural that the latter is distributed near the sea where its larval stage is spent.

T. flumineus was not found at all in the numerous specimens collected from such lakes and ponds as Lake Tôyako, a pond in Hirosaki city, Lake Suwako, Lake Biwako, and six ponds in Osaka city, Matsuyama city and Hukuoka city. Namely, this fish seems not to live in both lakes and ponds. It reminds us of HERRE's description of *Tukugobius* in the Philippines that they inhabit mountain creeks exclusively (HERRE, 1927). *Tukugobius* may be a mountain stream goby as a whole. Further, in the above mentioned stations, the lacustrine type of *R. similis* is found, for the fish of amphidromous type can not ascened there.

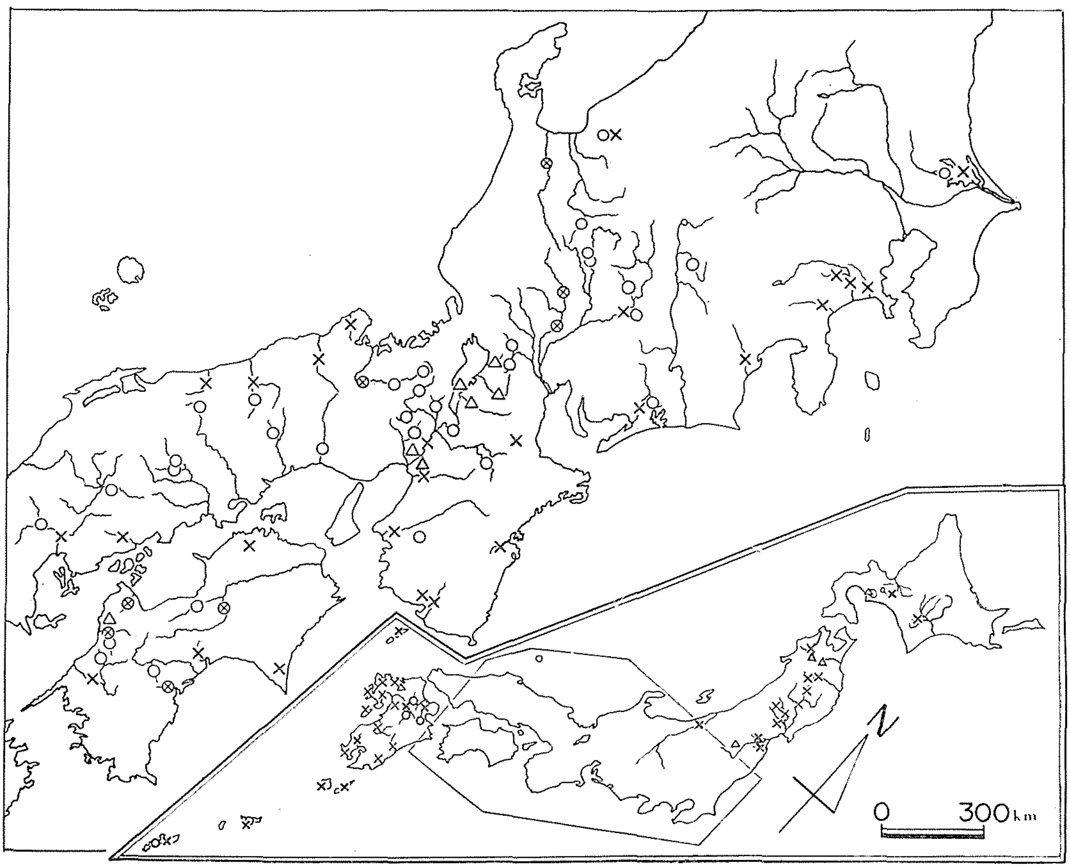

Fig. 6. Distributions of *Rhinogobius similis* (× : amphidromous type, △ : lacustrine type) and *Tukugobius flumineus* (○).

Geographical distribution. Though *R. similis* is found all over Japan north to the Hokkaido District, the distribution of *T. flumineus* seems to be restricted to the southwestern region of Japan (Fig. 6).

TOMIYAMA (1936) reduced 10 foreign species into the synonym of *R. similis.* Certainly, taking account of their descriptions and the other papers, *R. aestivaregia* MORI, 1934 (described from China), *R. similis lindbergi* BERG, 1933 (from the Amur District), *R. formosanus* OSHIMA, 1919 (from Formosa) seem to correspond to *R. similis.* But, *R. fukushimai* (from China) and *R. taiwanus* (from Formosa) may be rather closely related to *Tukugobius* in Japan and the Philippines, as mentioned previously.

Thus, *R. similis* is distributed in Japan, the Amur District, China and Formosa; while *Tukugobius* spp. in Japan, China, Formosa and the Philippines. Namely, though the northern boundary of the former extend farther to north than the latter in Japan as well as in its adjacent region, the geographical distributions of both coincide rather well with each other. The former lives in the lower course of a same river compared with the latter (Fig. 6) and shows the stronger tolerancy to the high water-temperature (MIZUOKA, oral publication at the 30th Congr. Jap. Zool. Soc.). The latter, being land-locked in a river, may have been difficult to extend its distribution as against the former. So, the reason of the difference in the northern boundary will be solved fruitfully not on the basis of the tolerancy to water temperature but on the basis of the geological transition since the origin of the latter.

IV. Discussion and Conclusion

The gobioid fishes have specialized themselves from the typical Percomorphi (MATSUBARA, 1955), and originated evidently in the sea. In the present time, their majority are marine and brackish fishes. Some of them have invaded in the freshwater region, and show various modes of migration in relation to the return trips to the sea. For example, *Leucosparion petersi* ascends an estuary only in order to spawning like a salmon (YABE, 1930). *Eleotris melanosoma* and other three species in the Philippines invade in a river at their immature stages and descend to a sea in their spawning seasons (HERRE, 1927). *E. oxycephala, Tridentiger obscurus, Luciogobius guttatus, Rhinogobius giurinus, Chaenogobius urotaenia, Ch. castanea* and *Sicydium japonicum* in Japan are carried down to sea in their early larval stages and ascend a river at the immature stages like the amphidromous type of *Rhinogobius similis* (DÔTU, 1954, 1955 and in preparation). Also, some invade in a freshwater region temporarily, e.g., *Acanthogobius flavimanus.* Some populations of *Eleotris oxycephala, Luciogobius guttatus* and *Chaenogobius castanea* spend their whole life in a brackish region (AOYAGI, 1957).

In spite of these diversity, they show the agreement on the point that they all pass their swimming larval stages in a sea. Meanwhile, *Tridentiger obscurus, Rhinogobius giurinus, Chaenogobius urotaenia* and *Ch. castanea* are also able to spend their whole life in a freshwater region (DÔTU, in preparation), but in these cases, like the lacustrine type of *Rhinogobius similis*, lakes and ponds are used as the substitute of seas for the habitats of their swimming larvae. Probably, all freshwater gobies passing an amphidromous life in Japan may be possible to spend a lacustrine life also. Amphidromous gobies hatch from eggs in a freshwater region, and soon after then, live at the coastal region in a sea where they suffer the wide fluctuation in salinity. So they seem to have acquired the powerful tolerancies to this condition.

After all, as the habitats of their larval stages, no essential difference seem to have been existent among seas, lakes and ponds. Conversely speaking, in the process of land-locking into these places, they need not have suffer the strict changes in the eggs as well as the morphological characters from larvae to adults.

In fact, as though there are no marked distinctions between the amphidromous type and the lacustrine type of *R. similis*, the above mentioned four lacustrine species show no remarkable differences from their amphidromous ones respectively, and speciations have not occurred in the course of land-locking. *Chaenogobius isaza*, which is distributed only in Lake Biwako, seems to be only an exception, for the reason of that there is no amphidromous type in this fish. But, between *Ch. isaza* and *Ch. castanea*, the latter of which spends an amphidromous life as well as a lacustrine life, merely slight distinctions are observed (TAKAGI, 1952).

Majority of freshwater gobies in Japan spend either an amphidromous life or a lacustrine life, and they spawn a large number of small eggs from which swimming larvae hatch, like nearly all the marine, the brackish and the freshwater gobies examined by many authors (these papers are shown by asterisks in the list of the literature cited).

While, the life histories of the fluvial type in Japan have been found only in the two species of *Odontobutis obscura* (DÔTU, in preparation) and *Tukugobius flumineus*. This fact may be sufficient to suggest how difficult was the process of land-locking into a river, especially into a torrential stream which occupies a large percentage of rivers in the Japanese Archipelago. *Odontobutis obscura* spawns a small number of large eggs in which swimming stages are passed. These features may have been acquired in the course of land-locking and as the result, this species has necessarily speciated from an unknown eleotrid, as though *Tukugobius* (probably including the three species in the Philippines) originated from *Rhinogobius similis* or its allied species.

After all, in the Japanese Archipelago at least, no marked variation has been brought on in both the developmental process and the morphological characters of the adult gobies in the course of the land-locking from an amphidromous life to a lacustrine life. On the other hand, the gobies land-locked to spend a fluvial life have suffered the remarkable changes in some of these features and speciated from their corresponding amphidromous species.

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Summary

A common polymorphic freshwater goby, "Yoshinobori" *Rhinogobius similis* GILL, was divided into the three ecological types of an amphidromous type, a lacustrine type and a fluvial type; and these types were compared on the subjects of life-historical features as well as morphological characters.

1. Both the amphidromous type and the lacustrine type spawn in summer a great number of small eggs, from which swimming larvae hatch. Their larval stages are spent in the standing waters like seas (in the case of the former), lakes and ponds (in the case of the latter). Both the types correspond to "Yoshinobori" *R. similis* GILL in the hitherto sense. They are distributed all over Japan (north to the Hokkaido District), the Amur District, China and Formosa.

2. The fluvial type spawns in summer a small number of large eggs, in which their swimming stages are passed. The newly hatched larvae transform directly into benthic young fish of the essential form of adults. They spend their whole life in the mountain streams exclusively in the southwestern province of Japan. This fish, named "Kawayoshinobori", is clearly different from *R. similis* and corresponds to a genus *Tukugobius* HERRE, 1927, in its morphological characters of adult fish as well as in both egg size and ecological distributions. For this fish was given a scientific name of *T. flumineus*.

3. Increasing in the egg size, in vertebral counts and in the number of first dorsal spines of this fish, in comparison with *R. similis*, may have been

all brought on in the process of land-locking into a stream. *T. flumineus* may have been derived from *R. similis* or its allied species, for the reason of that both show some remarkable similarities in general morphological characters as well as in geographical distribution except the distinctive features mentioned above.

4. After the comparison of the relationships between the types of land-locking and the morphological changes or the speciations of some freshwater gobies in the Japanese Archipelago, it was concluded that, though in the course of land-locking from an amphidromous life to a lacustrine life, no marked variations have occurred usually in both the developmental process and the morphological features of adults; the gobies land-locked to spend a fluvial life as such *Tukugobius flumineus* and *Odontobutis obscura*, have suffered the remarkable changes in some of these characters, and have clearly been derived from their corresponding amphidromous species.

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