

Hybridization Experiments in Cyprinid Fishes. VII. Reciprocal Crosses between *Pseudogobio* *esocinus* and *Biwia zezera*

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In order to elucidate whether or not the success of hybrid development is correlated with the supposed degree of phylogenetic relationship based on morphological studies, hybridization experiments between Japanese cyprinid fishes have been performed by the author since 1961. For the same purpose as above, *Pseudogobio esocinus* and *Biwia zezera* are artificially crossed in the present experiments.

These two species belong to the same subfamily, Gobioninae, and their habitats are confined to the same geographical area of river. However, there are some morphological wide differences between them. If they were closely related phylogenetically we would expect that hybrids could be reared with a survival rate similar to that of controls.

Before going further, the author wishes to express his sincere gratitude to Prof. Hisao KOBAYASHI for his valuable advice and consultation.

Results

1) Early development and viability

Eggs from *Pseudogobio* ♀ × *Biwia* ♂ go through cleavage almost identical with that of straight-fertilized eggs and develop into embryos without any observable deformity. These crossed embryos hatch and resulted fry grow normally. Six hybrids reach the five-month old and then three of them can be reared until one-year old.

In the reverse cross, viz., *B.* ♀ × *P.* ♂, also normal embryonic development takes place and hatched larvae grow normally. They reach the two-month old with a survival rate similar to that of controls. Majority of hybrids, however, die of a technical mistake during about two to three months after hatching. Only one hybrid can be reared until five-month old.

2) External characters

Seven hybrids of five-month old and one-year old provided the writer with an opportunity to study the inheritance of parental characters.

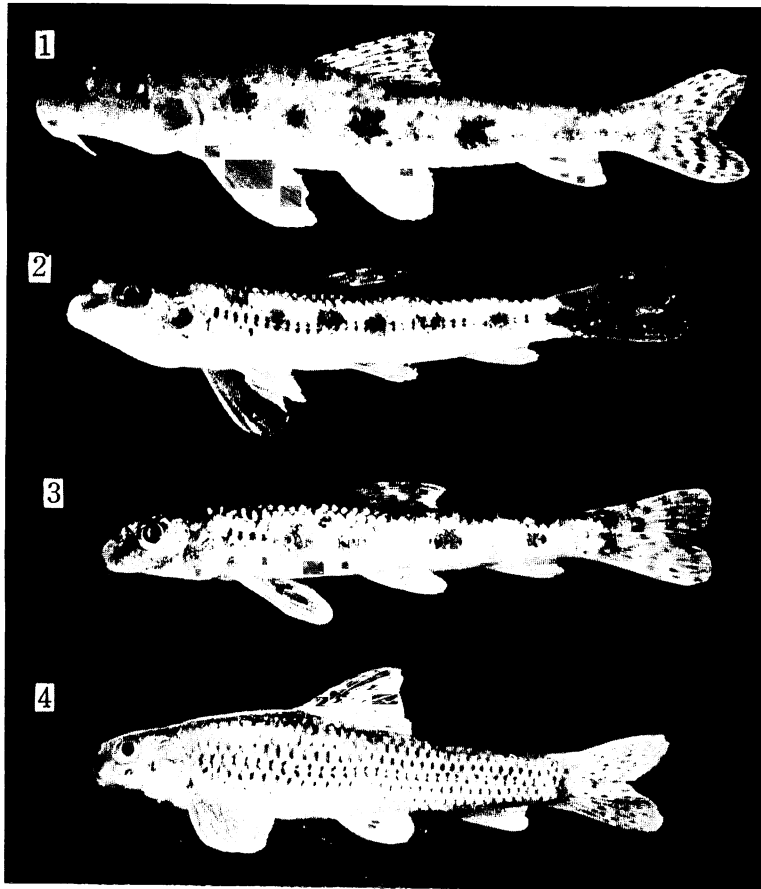


Fig. 1. *Pseudogobio esocinus* male of three-year old, 116 mm in body length.

Fig. 2. A hybrid male, *Pseudogobio esocinus* ♀ × *Biwia zezera* ♂, one-year old, 35 mm in body length.

Fig. 3. The reverse hybrid, *Biwia zezera* ♀ × *Pseudogobio esocinus* ♂, five-month old, 34 mm in body length.

Fig. 4. *Biwia zezera* male of two-year old, 48 mm in body length.

Pseudogobio have a pair of longer barbels than diameter of eye and their very thick lips are equipped with numerous nipplelike protuberances. Large pectoral fins are extended to the ventral fin base (Fig. 1). In *Biwia*, however, neither the barbels nor the protuberances are observable in their jaws. The small pectoral fins reach the midway between the base of the pectoral fin and the insertion of the ventral fin (Fig. 4).

Hybrids are typically intermediate in these characters between those of the parental species. That is, hybrids from *Pseudogobio* ♀ × *Biwia* ♂ have shorter barbels than those of *Pseudogobio*; the length being 1/3 to 1/5 diameter of eye. The nipple-like protuberances covering the lips are less conspicuous than those of *Pseudogobio* control. The pectoral fin is not so long to reach the ventral fin (Fig. 2). These

characters are almost similar to these of the reverse hybrids (Fig. 3).

3) Behavior

Furthermore, some habitual intermediacy are observed in the present hybrids. *Pseudogobio* usually live on the sandy bottom of river. They actively dig out the bottom stirring up sands and sometimes burrow into the bottom exposing only their protruded eye balls outside. Numerous funnel-like hollows, therefore, are observed on the bottom, the diameter being about three times of the length of their head (Fig. 5). On the other hand, no hollow is formed in *Biwia*, because they neither dig out nor burrow into the bottom, though they live on the sandy bottom (Fig. 6).

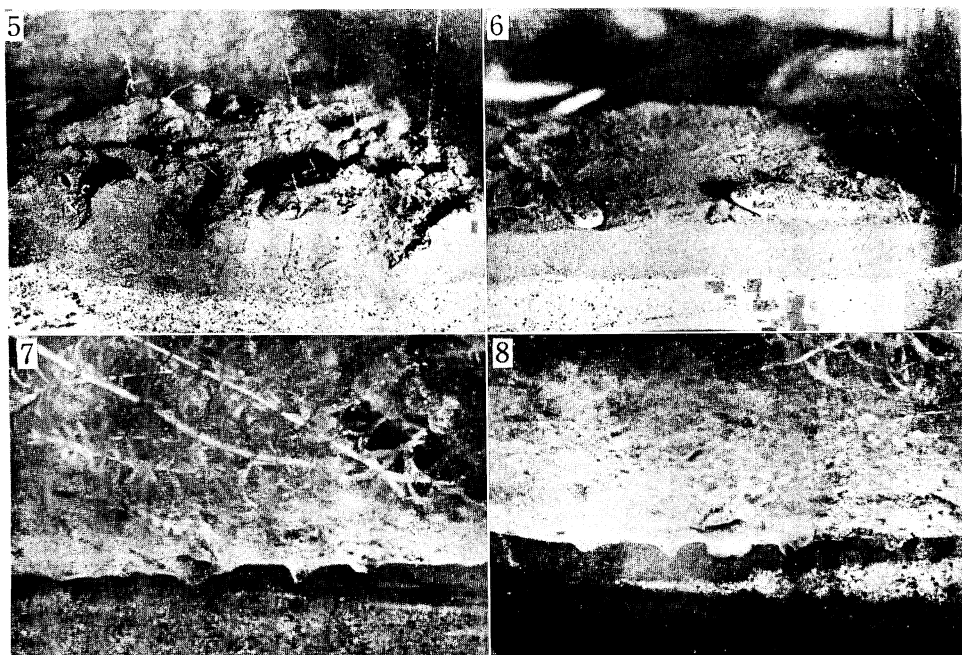


Fig. 5. Funnel-like hollows formed on the bottom where *Pseudogobio esocinus* controls are reared.

Fig. 6. No hollow on the bottom where *Biwia zezera* controls are reared.

Fig. 7. Hollows formed on the bottom where the hybrids, *Pseudogobio* ♀ × *Biwia* ♂ are reared.

Fig. 8. Hollows formed on the bottom where the reverse hybrids, *Biwia* ♀ × *Pseudogobio* ♂ are reared.

Hybrids from *Pseudogobio* ♀ × *Biwia* ♂ always creep on the bottom and sometimes dig out the bottom, while they do not burrow as *Pseudogobio* does. Thereby, a few hollows are formed on the bottom though they are smaller than those of *Pseudogobio* (Fig. 7). Such intermediacy of behavior is also observed in the reciprocal hybrids, *B.♀* × *P.♂* (Fig. 8).

4) Sex and male sterility

Of three hybrids from *Pseudogobio* ♀ × *Biwia* ♂, two were male and the remaining

one was apparently neuter which had not gonad. Anatomical observation during the spawning season revealed that testes of the two hybrid males were nearly normal in external form. No spermatozoa, however, was observed in their testes which was fixed with formalin, while there were numerous spermatocytes. This fact may indicate that spermatogenesis of hybrids is impaired. On the other hand, many spermatozoa were observable in testes of *Biwia* control. In the reverse cross, $B. \text{♀} \times P. \text{♂}$, sexuality of hybrids was indistinguishable, because all of them died within five months after hatching as described above.

Discussion

In the preceding paper of this series (SUZUKI 1963a), it has been suggested that cyprinid hybrids which are able to be brought to attainment of adult food are confined to the intergeneric or interspecific hybrids among members of the same subfamily. The present results that hybrids between *Pseudogobio esocinus* and *Biwia zezera* can be reared until one-year age with a survival rate similar to that of controls may have given a proof for SUZUKI's suggestion.

As described above, the present intergeneric hybrids are morphologically intermediate between those of parental fishes. Such inheritance of parental characters are similar to those in the other intergeneric cyprinid hybrids as reported by many workers (cf. MATSUI, 1931; HUBBS and MILLER, 1943; HUBBS and BAILEY, 1952; WEISEL, 1954, 1955; DUUVENÉ DE WIT, 1960, 1961; SUZUKI, 1961, 1962, 1963a, 1963b, 1963c; KOBAYASHI, Hir. 1962). In addition to this, behavior of the present hybrids is also intermediate.

Fact that the present hybrids are completely male sterile is the same as that in the case of the cross between *Pseudogobio esocinus* and *Gnathopogon elongatus elongatus*, as reported by SUZUKI (1963a). This may show that the gap of genetical relation between *Pseudogobio esocinus* and *Biwia zezera* is similar level to that between *Pseudogobio* and *Gnathopogon*. Moreover, such relation is similar to that between *Biwia* and *Gnathopogon*, that is, hybrids between both species is also male sterile (SUZUKI, 1963c).

Summary

The reciprocal crosses between *Pseudogobio esocinus* and *Biwia zezera* are successful and three hybrids from $P. \text{♀} \times B. \text{♂}$ are reared until they reach one-year age with a survival rate similar to that of controls. The hybrids are not only intermediate morphologically, but also they behave intermediately between their parental forms. Of three hybrids reared until one-year age, two are sterile males and remaining one is a neuter. None of spermatozoa is observed in their testes.

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