

On the Sterile F₁ Hybrids between the Genera *Pseudogobio* and *Gnathopogon* (Cyprinidae)

Ryo Suzuki

(Received October 14, 1972)

Artificial crosses among species of the Cyprinidae, Cobitidae and Cyprinodontidae were performed with 130 combinations by Suzuki (1961; 1963; 1968). The initial objective of the studies was to elucidate whether or not the success of hybrid development is correlated with the closeness of taxonomical position of crossed fishes. Those experiments indicated that many intergeneric and interspecific hybrids became sterile, their sex ratio skewed to one sex and that some hybrids showed greater survival rates in early stage of development than those of controls. The present paper deals with some additional results related to survival rates during the first to the second years in the hybrids between *Pseudogobio esocinus* (Temminck and Schlegel) and *Gnathopogon elongatus elongatus* (Temminck and Schlegel), and the values of several parts of weight against the total body weight in the F₁ hybrids were compared with that of the parent species.

The experiments were primarily carried out at the Department of Biology, Aichi Kyōiku University, Okazaki, from 1959 to 1961. The hybrids were produced from reciprocal crosses between both species.

These hybrids are the same as that reported by the same author (1963; 1968). The origin of both parental species and the details of hybridization techniques are given by Suzuki (1968). Hybrid fry at the two-month old stage were used for the experiment. Fifty fry in each hybrid combination were taken at random and then reared separately in two cement cisterns, 148 × 70 cm width and 40 cm depth. Each cistern was supplied with spring water at a flow rate of 500 ml/min. Water temperatures in the cisterns varied from 5° to 10°C in the winter and 27° to 30°C in the summer. Tiny earthworms, fish meal, rice bran, and wheat flour sufficient to satisfy their appetites were fed to the hybrids. Controls consisted of the fry produced from eggs fertilized with spermatozoa

of the same species, and were kept under same condition as that of the hybrids.

In the cross between female *Gnathopogon elongatus elongatus* and male *Pseudogobio esocinus*, successful fertilization took place and eggs went through cleavage and normally developed into embryos without any observable deformities. Newly hatched fry fed and the survival rate beyond the fry stage was higher than that of the controls as shown in Fig. 1. Ten hybrids survived to third year, although some hybrids died at second year due to a technical mistake. Eight of the three year-old survivals were male, one was female and another hermaphrodite. The survived hybrid female and two hybrid males were kept together in a breeding pond supplied with aquatic plants for egg-attachment. This pond is the same as that used for hybrids. However, no sexual display was observed during the following month. On the other hand, in the controls, the sex ratio was 1:1 and spawning occurred several times in the same breeding pond used for hybrids.

Average body weight of hybrids at third years was generally greater than that of controls and the condition factor was somewhat lower than that of the controls (Table 1). External characteristics and behavior of these hybrids have been reported by Suzuki (1963).

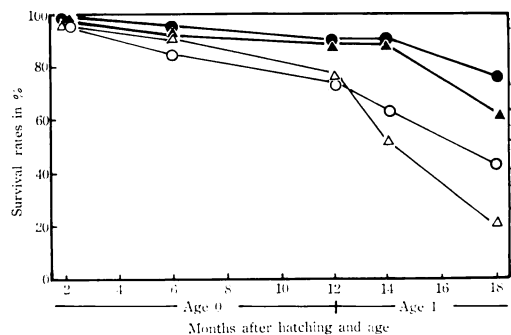


Fig. 1. Survival rate of the *Gnathopogon* × *Pseudogobio* hybrids compared with the parent species. Hollowed circles, *Gnathopogon elongatus elongatus* ♀ × *G. elongatus elongatus* ♂ (control); hollowed triangles, *Pseudogobio esocinus* ♀ × *P. esocinus* ♂ (control); solid triangles, *G. elongatus elongatus* ♀ × *P. esocinus* ♂; solid circles, *P. esocinus* ♀ × *G. elongatus elongatus* ♂.

Table 1. Comparison of weight in several parts of body in the *Gnathopogon* × *Pseudogobio* hybrids and the parent species. The figures except for body weight and length are the average. Condition factor is calculated $W/L^3 \times 1,000$, where W is body weight in g and L, body length in cm.

Crosses	Number of specimens	Total body weight (g)		Body length (cm)		Viscera weight (g)	Gonad weight (g)	Condition factor	Gonad weight / Total body weight (%)	Body weight - Viscera weight / Total body weight (%)
		Range	Average	Range	Average					
<i>G. elongatus</i> <i>elongatus</i> ♀										
× <i>G. elongatus</i> <i>elongatus</i> ♂	{ ♀ 9 ♂ 9	3.3 ~ 7.2	5.4	5.4 ~ 7.2	6.2	1.61	1.44	22.7	26.7	70.2
		2.1 ~ 4.8	3.9	4.5 ~ 6.6	5.6	0.74	0.37	22.2	9.5	81.0
× <i>P. esocinus</i> ♂	{ ♀ 1 ♂ 8 H 1	6.0 ~ 14.8	11.9	7.2 ~ 9.2	8.5	1.46	0.99	19.4	8.3	87.7
			9.6		8.1	0.78	0.04	18.0	0.4	91.9
			7.9		8.4	0.82	0.48	13.3	6.1	89.6
<i>P. esocinus</i> ♀										
× <i>P. esocinus</i> ♂	{ ♀ 5 ♂ 9	16.5 ~ 19.2	17.7	9.6 ~ 10.6	10.2	4.44	3.45	16.7	19.5	74.9
		10.5 ~ 18.0	13.6	8.2 ~ 11.6	9.6	1.39	0.58	15.4	4.3	89.8
× <i>G. elongatus</i> <i>elongatus</i> ♂	{ ♀ 0 ♂ 10 N 1	4.0 ~ 17.1	12.2	6.4 ~ 10.2	8.8	0.96	0.04	17.9	0.3	92.1
			16.9		11.0	2.08	0	12.7	0	87.7

H: hermaphrodite, N: neuter

In the reverse cross, female *P. esocinus* × male *G. elongatus*, hybrids hatched normally and the fry had a much higher survival rate than did the controls (Fig. 1). Again, some of the hybrids died at second year due to the technical mistake. However, eleven hybrids survived to third year. Ten were males and the remaining one is apparently neuter because no gonads were observed. Average body weight of male hybrids was slightly lower than that of the controls, although greater than that of paternal species. Their condition factor was higher than that of the controls (Table 1).

No hybrid male from both combinations produced spermatozoa even when they reached three year-olds, though the control males produced spermatozoa at the second or third year. The ovary of one hybrid female was filled with semi-ripe eggs. However, in one hermaphroditic hybrid, the anterior part of gonad was prevailingly testicular and the posterior region was chiefly ovarian.

Anatomical investigation at just three year-olds revealed that the hybrids from both combinations had a lower value of gonad weight against total body weight than that of the con-

trols. On the other hand, the percentage of the body weight minus viscera weight, included gonad weight, to total body weight was greater in the hybrids than with the controls as given in Table 1. It is sure in both sexes of the hybrids and also in hybrids of neuter and hermaphrodite.

It has been known that F₁ hybrids between some species or genera of fishes are either sterile or their sex ratio skewed. Moreover, these hybrids sometimes show heterosis. In the Centrarchidae, Hubbs and Hubbs (1933) reported that the hybrids between *Apomotis cyanellus* and *Eupomotis gibbosus* were infertile and showed greater growth rate than that of parent stocks. Krumholz (1950) obtained vigorous intergeneric hybrids between female *Lepomis microlophus* and male *L. macrochirus*. The hybrids were relatively larger and heavier than individuals of the same age groups in either of the parent species taken from similar ponds. In the Cichlidae, Hickling (1959; 1960; 1968) reported that 98 to 100 per cent of the hybrids between local strains of *Tilapia mossambica* were males and grew faster than either parental stock, when a male of the African strain was

crossed with a female of the Malayan strain.

Chervinski (1967) reported that crossing with *Tilapia aurea* males and *T. nilotica* female produced 83% of male hybrids, and the reverse cross yielded 63.5% of males. Both kinds of hybrids grew better than *T. aurea*. Lessent (1968) reported that hybrids between male *Tilapia nilotica* and female *T. macrochir* were 75 per cent of males and 25 per cent of females. The growth rate of these hybrids was barely higher than that of the parental species. In the reverse cross, all hybrids were males and the average growth rate was close to that of the preceding cross. Both reciprocal hybrids were fertile. In the Cobitidae, Minamori (1950; 1953; 1957) obtained sterile hybrids from the reciprocal combinations between *Misgurnus anguillicaudatus* and local races of *Cobitis biwae* or *Cobitis taenia*. These parent species were collected from western Honshu. When females of *C. biwae* or *C. taenia* were crossed, hybrids showed heterosis. In the Cyprinidae, Andriasheva (1968) reported that the crossing of the European cultivated carp, *Cyprinus carpio*, with the Amur wild carp causes heterosis, and that hybrids between three species, *Ctenopharyngodon idella*, *Hypophthalmichthys molitrix* and *Aristichthys nobilis*, were larger than parental species in the early try stage. In the present reciprocal crosses between *G. elongatus elongatus* and *P. esocinus*, the survival rates of hybrids were definitely higher than those of the controls. When the female *G. elongatus elongatus* is crossed, average body weight of hybrids at the third year was somewhat greater than that of the controls, while specimens examined were few. These hybrids were predominantly sterile males.

There is no question that hybrids which show heterosis are more suitable than its parental species for pond culture and for stocking lakes or rivers. Hickling (1968) have claimed that, in the case of sex ratio of hybrids skewed to 100 per cent of one sex or when the hybrids are sterile, they are good materials for planned pond stocking with assured control of the fish population.

Be that as it may, the present hybrids showed a lower value of gonad weight against total body weight than did the controls. On the other hand, the percentage of the body weight

minus the viscera, to total body weight was greater in the sterile hybrids than the fertile parent species. This result probably shows that the volume of the muscles and the bones was increased by hybridization, while specimens used here were few. Even if it is true, the cause is not clear at the present time. Although both *G. elongatus elongatus* and *P. esocinus* are not important food fish, the same principle of increased weight of the muscles by hybridization may apply to other fishes as well. If so, it would be economically valuable to raise sterile hybrids of important food fishes such as trout and carp, resulting in the product with higher percentage of muscle per unit of body weight.

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(Freshwater Fisheries Research Laboratory Contribution. No. 304)

(Ueda Branch Station, Freshwater Fisheries Research Laboratory, Komaki, Ueda, Nagano-ken, 386, Japan)

モロコ属とカマツカ属間の不妊雑種について

鈴木 亮

タモロコとカマツカの間で得た交雑種は、正逆組合せ共に対照よりも生残率が高く、特にタモロコ♀×カマツカ♂の場合は、3年魚における平均体重が対照よりも大きかった。雑種のほとんどは雄であり、それらは成熟期に達しても精子を放出しなかった。雑種の生殖腺は発達が悪く、体重に対する生殖腺の重量比が対照におけるよりもはるかに小さく、逆に体重に対して、内臓を除去した部分の重量比は対照よりも大きかった。すなわち、不妊雑種では、可食部の増重がみられた。もしもこのことが、マス類やコイなどにおいてもみられるならば、食用魚生産の上において、不妊雑種が有利であるように思われる。

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