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The Brain Patterns of Hybrids Produced by Back-Cross between the Hybrid, *Carassius* × *Cyprinus* and Its parents

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In our previous hybridization experiments (Masai and Sato, 1964 a, b: 1965: 1966) performed concerning the form variation of the brain in some cyprinid fishes, it was found that the afferent areas in the brain of the hybrid fishes F_1 showed generally a pattern intermediate between that of their parents. A further attempt was made to know what patterns the brain of hybrids would produce by artificial back-cross between the hybrid F_1 and each parent species. As material *Carassius auratus cuvieri* (Gengoro-buna in Japanese, Nakamura, 1969), and *Cyprinus carpio* two years after hatching were used. The artificial crossing was carried out at the Fisheries Station located at Himeji, Japan (Himeji Bunjo, Hyogo Kenritsu Suisan Shikenjo). Male of the hybrid fish F_1 between *Carassius* ♀ and *Cyprinus* ♂ were sterile, and therefore, in back-cross only the female F_1, *Carassius* ♀ × *Cyprinus* ♂, was available, and both hybrids, F_1 ♀ and *Carassius* ♂, and F_1 ♀ and *Cyprinus* ♂ were produced by back-cross. Adult hybrids and parents were fixed with 10% formalin, the brains were removed, and then investigated with a stereoscopic microscope.

According to the previous paper by Masai and Sato (1964 a), the distinguishing characters of the brains of *Carassius* and *Cyprinus* are as follows (Fig. 1). In *Carassius* the vagal lobe is ellipsoid in shape, much swollen dorsally, and covers completely the fourth ventricle as well as the facial lobe, whereas the vagal lobe in *Cyprinus* is relatively thin, diverges rostrally in a V-shape, and the well-developed facial lobe is visible in dorsal view between the vagal lobes of both sides. In the midbrain, the optic tectum in *Cyprinus* diverges distinctly caudally, owing to extension of the valvula cerebelli, in contrast to that in *Carassius*. In the hybrid F_1 produced between female *Carassius* and male *Cyprinus*, the vagal lobes of both sides stand out as an ellipsoid-shaped eminence, but they diverge slightly in the rostral part, and the facial lobe is seen between both vagal lobes. Such a pattern of the vagal lobe in F_1 is considered to be intermediate between that of the parents, and it seems to approach the *Carassius* type. The degree of divergence of the optic tectum is intermediate in various degrees between that of the parents. In back-cross the hybrid fish between F_1 and male *Carassius* shows brain patterns similar to F_1, which approaches the *Carassius* type, even though the pattern of the vagal lobe is intermediate between *Carassius* and *Cyprinus* (Fig. 2a). On the other hand, the hybrid fish between F_1 and male *Cyprinus* shows brain features in which the vagal lobes of both sides diverge in a higher degree than in the hybrid between F_1 and male *Carassius*. Such features of the vagal lobe in dorsal view tend to resemble that of *Cyprinus*. The relatively well-developed facial lobe is visible between the vagal lobes (Fig. 2b). There are no apparent tendencies toward either species in the divergence of the optic tectum in each hybrid produced by back-cross, because it is shown consistently as an intermediate type in various degrees between *Carassius* and *Cyprinus*. No sex differences are recognized in the brain patterns in any of the hybrid specimens.

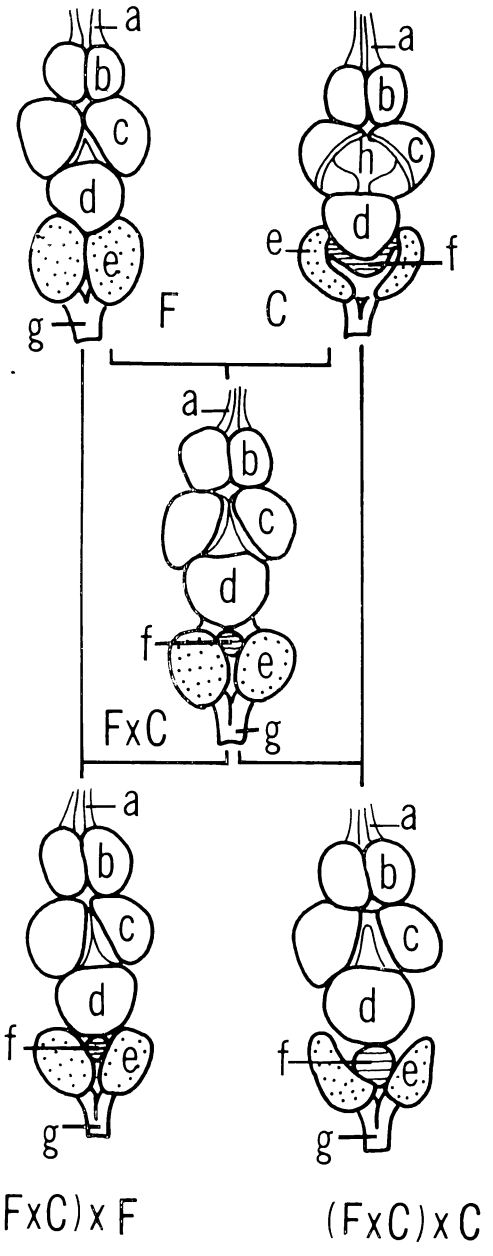

Fig. 1. Dorsal view of brains in *Carassius auratus curieri* (F), *Cyprinus carpio* (C) and hybrids; the olfactory bulb and a part of olfactory tract are not presented. a, olfactory tract; b, telencephalon; c, optic tectum; d, corpus cerebelli; e, vagal lobe; f, facial lobe; g, spinal chord, h, valvula cerebelli.

As for the variations of the brain form in back-cross, the hybrid fish which is produced by cross between F_1 and *Carassius*, shows brain characters, in particular the medulla oblongata, approaching the *Carassius* type, whereas the hybrid which is produced by cross between F_1 and *Cyprinus* shows the features of the medulla oblongata to be close to the *Cyprinus* type. From this hybridization experiment, the brain patterns revealed in the hybrid produced by back-cross are presumed to be influenced by introgression of the genome of *Carassius* or *Cyprinus*. Furthermore, it is of interest that the vagal lobes, which participate in feeding behavior (Grimm, 1960) are modified by back-cross.

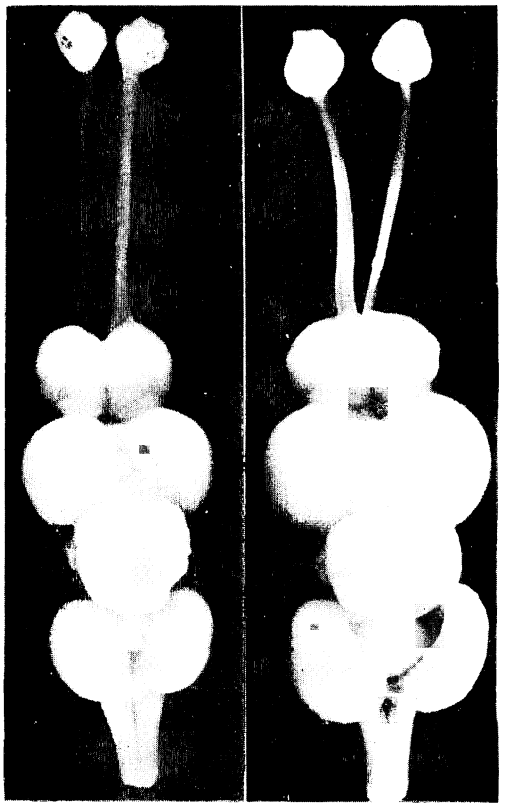

Fig. 2. Brains of back-cross hybrids: a, (F×C)×F; b, (F×C)×C. See Fig. 1.

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コイとフナとの雑種の戻し交雑による脳の形態

正井秀夫・佐藤やす子

フナとコイの人工交雑による F_1 の脳外形は両親の中間型であるが，F_1♀（♂は不妊）をフナ♂またはコイ♂と戻し交雑した雑種では延髄の外形殊に迷走葉がそれぞれフナまたはコイに接近する．

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