Japanese Journal of Ichthyology
Vol. XIII, nos. 4/6
July 31, 1966

魚 類 学 雑 誌
第13巻 第4/6号
1966年7月31日発行

The Brain Patterns of Fish Hybrids, *Gnathopogon elongatus elongatus* × *Biwia zezera* and its Reciprocal

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It has been reported by SUZUKI (1962 and 1963a) and the authors (1965a and 1965b) that the intermediate types can be produced in the behavior and brain patterns by artificial crossing between the species, which show different behavior patterns and the brain characters. The authors performed the further investigation concerning the influence of the brain patterns on the behavior of the fish hybrids produced artificially between parents presenting very different brain patterns and behavior.

Material and Method: Reciprocal crossings were carried out between *Ganthopogon elongatus elongatus* and *Biwia zezera* at Aichi Gakugei University, Okazaki, Japan. Hybrids and parents were fixed with 10% formalin, the brains were removed and then investigated with a stereoscopic microscope. The authors wish to express their sincere thanks to Dr. R. SUZUKI, Aichi Gakugei University for his kind collaboration in producing the hybrids and observation of the hybrids' behavior.

Observation: (Figs. 1-6) The general external features of bony fish brains have been described by many investigators, and here will be presented only the characteristics of the brains of *Gnathopogon elongatus elongatus* and *Biwia zezera*, necessary for comparison with the brain of the hybrids.

Ganthopogon elongatus elongatus: The olfactory bulbs lie close to the nasal sac and are connected with the telencephalon through the very short olfactory tracts. The telencephalon is elongate elipsoid in shape, and the sulcus ypsiformis is slightly recognizable. The optic lobe is oval and well developed, and does not diverge caudually. The corpus cerebelli is flattened. The vagus lobes are less developed, and the facial lobe is seen as a spherical swelling, surrounded by the vagus lobes. The characteristic of the brain of *Gnathopogon* is that the optic lobe and the telencephalon are relativery large, while the vagus lobes are less developed in proportion to the dimension of the whole brain. Both sight and smell seem to be used in feeding by *Gnathopogon*. Ecologically, *Gnathopogon* swims in the surface zone of shallow water, and according to SUZUKI's observation (1963b), as soon as food is dropped into the water, *Gnathopogon* swims up towards the water surface to feed.

Biwia zezera: The olfactory bulbs are situated close to the nasal sac, and the olfactory tracts are short. The telencephalon shows a slender triangular form, and

hardly displays the sulcus ypsiformis. The optic lobe is much developed and in particular, a large median notch appears in the posterior ridge of the optic lobe, within which the small triangular, flattened corpus cerebelli is fitted. The vagus lobes on each side are much swollen and diverge rostrally, so that the relatively small facial lobe is seen in a dorsal view. As for the brain patterns of *Biwia*, the vagus lobe and the optic lobe are relatively large, while the corpus cerebelli and the telencephalon are less developed. Judging from the high development of the vagus lobe and the optic lobe, taste and sight are presumed to play an important role in seeking food. *Biwia* (SUZUKI, 1963b) always dwells on the bottom and feeds on the bottom after the food sinks, when the food is dropped into the water.

As for the hybrids, *Biwia* ♀ × *Gnathopogon* ♂ and its reciprocal, the features and the sizes of the olfactory bulbs, the telencephalon, the optic lobe, the corpus cerebelli and the facial lobe resemble those of *Gnathopogon*, while the notch of the posterior ridge of the optic lobe is deepened, as is in the case of *Biwia*, and the vagus lobes are swollen in a degree intermediate between both parents. As a whole, the brain patterns of those hybrids are intermediate between the parental ones. In addition, the behavior of these hybrids (SUZUKI, 1963b) is also intermediate, that is, when food is dropped into the water, they feed sometimes on the bottom, as does *Biwia* and sometimes rising up from the bottom, as does *Gnathopogon*.

Summing up concerning the hybridization *Gnathopogon elongatus elongatus* and *Biwia zezera*, the intermediate types are shown in the brain patterns, as well as in behavior, as are in the cases of the hybridizations between *Gnathopogon elongatus elongatus* and *Pseudogobio esocinus* (SUZUKI, 1963 a and MASAI and SATO, 1965a) and between *Gnathopogon elongatus elongatus* and *Pseudorasbora parva* (SUZUKI, 1962, MASAI and SATO, 1965b).

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Explanation of figures

Fig. 1. Dorsal view of the brain of *Gnathopogon elongatus elongatus.*
Fig. 2. Lateral view of the brain of *Gnathopogon elongatus elongatus.*
Fig. 3. Dorsal view of the brain of *Biwia zezera.*
Fig. 4. Lateral view of the brain of *Biwia zezera.*
Fig. 5. Dorsal view of the brain of the hybrid.
Fig. 6. Lateral view of the brain of the hybrid.

Abbreviation

CC: Corpus cerebelli	FL: Facial lobe	OB: Olfactory bulb
OL: Optic lobe	TC: Telencephalon	VL: vagus lobe

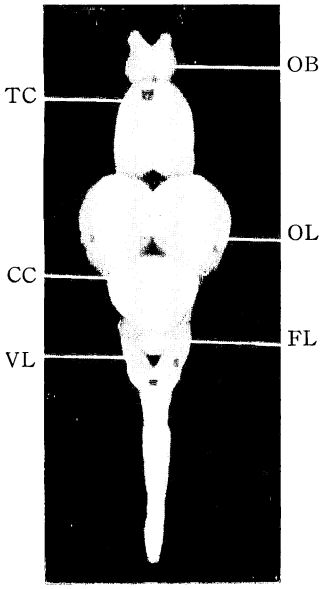

Fig. 1

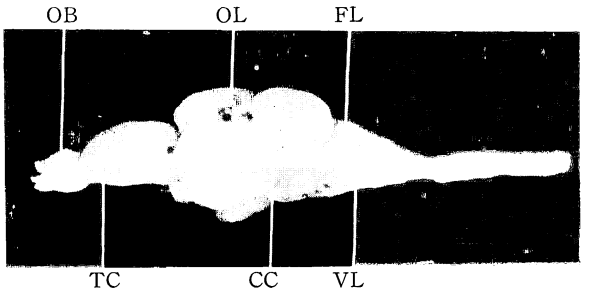

Fig. 2

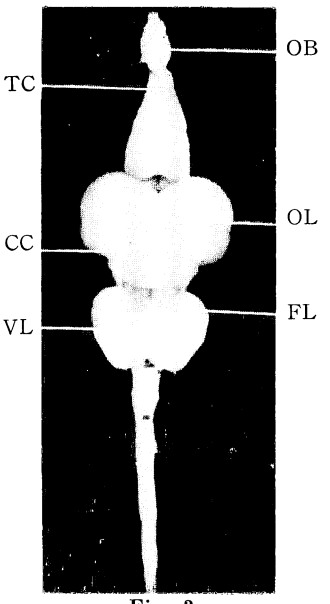

Fig. 3

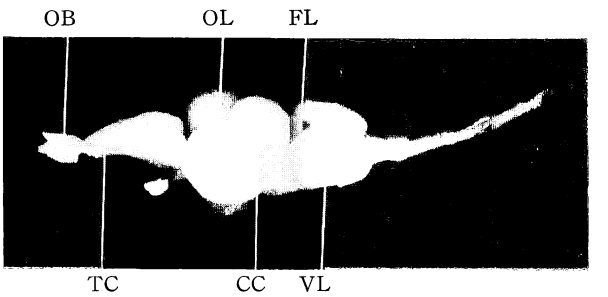

Fig. 4

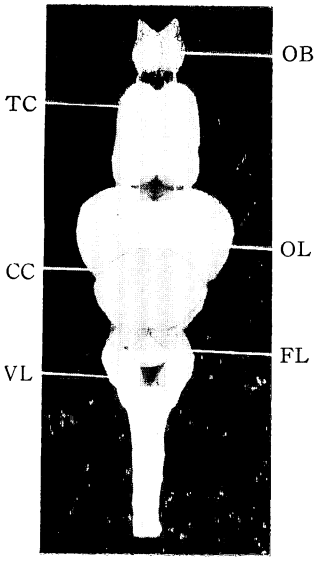

Fig. 5

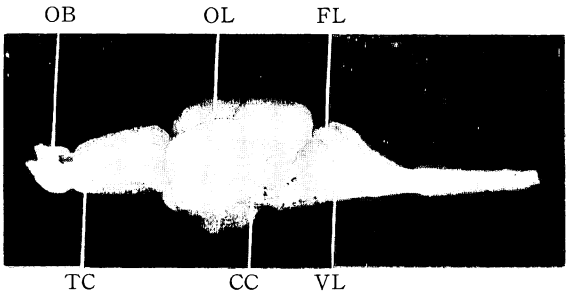

Fig. 6