

Inbreeding depression in the convict cichlid, *Cichlasoma nigrofasciatum* (Baird and Girard)

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Convict cichlids, *Cichlasoma nigrofasciatum*, inbred for four and five generations exhibited moderate and severe morphological deformities. Deformed fishes were characterized by a more vertically sloping forehead, irregular jaw, hyoid, opercula and fin structure, reduced growth and irregular swimming behaviour. Inbred fish (F_4 , F_5) did not differ from F_3 s in their age of maturation or the average size of their first broods. Brood survival was 18.7% in F_5 inbred fish, compared to 75.5% in F_3 s.

I. INTRODUCTION

Recently, there has been a widespread effort among fish biologists to reach agreement on a suitable model fish species for use in laboratory research involving reproductive biology, embryology and physiology, particularly in relation to toxicity tests. Major criteria for the model species include its ease of maintenance in the laboratory, its commercial availability, its ability to reproduce reliably and in large numbers, and its ability to inbreed for many generations without a significant incidence of deformities. Laale (1977) proposed the use of the Zebra fish, *Brachydanio rerio*, however, recent investigations have documented inbreeding depression in the species (Piron, 1978a; Mrakovic & Haley, 1979). Zebra fish, inbred four generations, exhibited vertebral abnormalities, a lack of swimbladders, protrudent jaws, opercular deformities, oedema and behavioural irregularities.

Piron (1978b) suggested that the convict cichlid, *Cichlasoma nigrofasciatum*, may serve as a suitable model species for laboratory toxicity research. The species is easily obtained, bred and maintained in the laboratory, and demonstrated no significant incidence of abnormalities following three generations of inbreeding.

The current study reports the results of inbreeding *C. nigrofasciatum* for five generations in our laboratory. Significant inbreeding depression was exhibited in the inbred F_4 and F_5 generations of our laboratory stock, prompting a re-evaluation of the limitations of breeding convict cichlids for use as a subject in laboratory toxicity tests.

II. MATERIALS AND METHODS

All inbred generations were derived from a single pair of convict cichlids (P_1), purchased locally from a commercial fish dealer. The P_1 male and female were assumed to be siblings

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since all fish within the stock tank were of fairly uniform size. The P_1 male was normally pigmented and the female was xanthic. All crosses between offspring, involving two normally pigmented fish, resulted in both normal and xanthic fry. All subsequent generations (F_2 to F_5) resulted from full sibling matings. Fish were selected from a brood and paired for breeding at the first visible evidence of sexual character divergence (Piron, 1978*b*). Each fish was permitted to spawn only once, and normally pigmented and xanthic fish were randomly paired.

The breeding aquaria were 38 l capacity and contained tap water, aged at least 48 h and maintained at $23 \pm 1^\circ \text{C}$. Aeration was provided in each tank via an airstone. The bottom of each tank was covered by 15 mm of fine gravel and contained an overturned clay flower-pot (8.5 or 11 cm diameter) as a spawning site. All aquaria were maintained on a fixed photoperiod (L : D; 13 : 11). Adult fish were fed Tetra Min Staple Food (TetraWerke; W. Germany) and Bait Food (Jungle Laboratories Corp., U.S.A.) once or twice daily. The eggs were counted within 24 h of the completion of spawning by each pair. Fry were given live, newly-hatched brine shrimp once daily, for 2 weeks after they had entered the free-swimming stage. Two-week-old free-swimming fry received crushed Tetra Min Staple Food. The brooding pairs were permitted to remain with their fry for 30 days following the initiation of spawning, after which they were removed, and fry were counted and placed in 110 or 228 l aquaria. Fry were examined and measured for total length at 5 months of age.

III. RESULTS

No major deleterious inbreeding effects were noted until the F_4 and F_5 generations. Of the surviving (5 months) fry from nine F_4 broods, 26.4% were moderately deformed and 58.1% were severely deformed. Moderately deformed fish exhibited abnormal fins (often shortened with an absence of dorsal spines), a pronounced vertical slope of the forehead, shortened, flared opercula (exposing the gills at all times) and a permanently depressed hyoid apparatus (see Fig. 1). The position of the spinous dorsal fin frequently deviated laterally from the dorsal midline of deformed fish. Severely deformed fish were characterized by the same abnormalities, but in a more pronounced form. Severely deformed fish frequently exhibited moderate lordosis (see male in Fig. 2) and abnormal swimming behaviour, wherein the head remained lowered and the lateral undulations of the body appeared grossly exaggerated. Of the surviving F_5 fry (five broods), 17.6% were moderately deformed and 65.9% showed severe deformities. All deformed fish appeared to develop normally until the end of their most rapid growth phase (2–3 months). There was no relationship between the incidence of deformities and the colour morph of the fish.

Each F_4 breeding pair contained at least one deformed partner, and each was successful in spawning. All normal and deformed fish appeared to exhibit normal communication behavioural patterns including lateral and frontal threat displays, charges and tail-beats (Baerends & Baerends von Roon, 1950). There was no mortality among the spawning pairs, and injuries in the form of torn fins were infrequent during the study. Of 18 F_4 spawns, seven pairs cared for their fry for 30 days, 10 destroyed their brood within 4 days after hatching, and one resulted in 86 fungused and four fertile (viable) zygotes. Brood survival (to 5 months) was 18.7% for the seven cared for F_5 clutches, compared to 75.5% for F_2 fry. The mean total length of 85 F_5 fish was 26.6 mm at 5 months of age, whereas 129 F_2 fish averaged 57.0 mm after 5 months. There appeared to be no difference in the timing of the onset of sexual maturity (3–6 months) between any of the inbred generations.

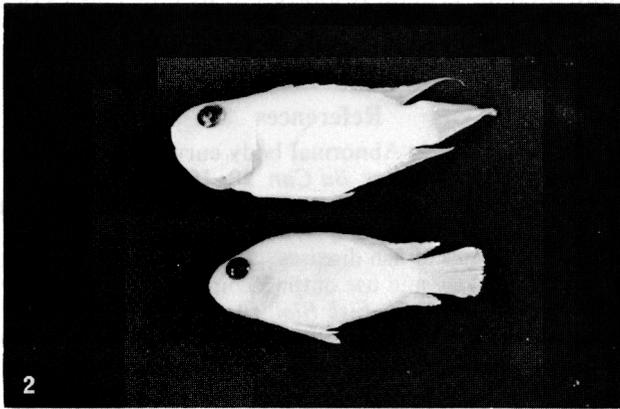
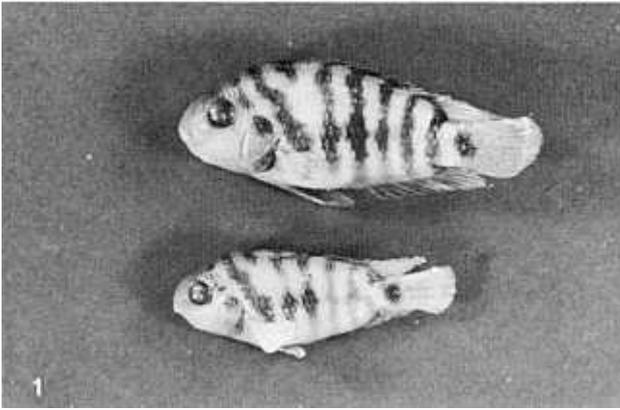


FIG. 1. Preserved F_4 male (top) and female (bottom) convict cichlids showing pronounced vertically sloping forehead, deformed fins, hyoid and opercula.

FIG. 2. Preserved F_4 xanthic male (top) and female (bottom) convict cichlids showing fin, hyoid and opercular deformities. The male exhibits a moderate degree of lordosis.

IV. DISCUSSION

The inbreeding depression observed in the convict cichlid is comparable to the results obtained from inbreeding other teleosts (Gordon, 1953; Aulstad & Kittelsen, 1971; Piron, 1978*a*; Mrakovic & Haley, 1979). Contrary to the aspirations of Piron (1978*b*), the convict cichlid appears to be unable to survive extensive laboratory inbreeding without deleterious genetic effects. The variety of morphological and behavioural abnormalities observed in our F_4 and F_5 inbred generations indicate that a number of genetic factors may act singularly or together. The delay in the onset of abnormalities in the inbred fish suggests that the genetic factors implicated by Austed & Kittelsen (1971) for inbred *Salmo gairdneri*, may occur in convict cichlids.

The value of the convict cichlid as a subject in laboratory toxicity research should not be entirely diminished by the findings of the current study. We agree

with Piron (1978*b*) that major emphasis should be placed on the effect of toxicants on the reproductive biology of fishes, particularly mating and parental care behaviour. The convict cichlid is easily spawned and maintained in the laboratory, exhibits easily recognizable, stereotyped behavioural patterns, and is currently the subject of a growing behavioural literature. We suggest that viable laboratory populations of convict cichlids may be maintained by outcrossings or backcrossings after every two generations of inbreeding.

It is doubtful if a universally acceptable laboratory model fish species exists, or if indeed it would be entirely beneficial to pursue such a standard. Information concerning the physiological and behavioural responses of a number of fish species to environmental toxicants is valuable in documenting the variability of reaction modes along taxonomic lines. Furthermore, many fish species need to be researched due to their local ecological or commercial importance. Species such as the convict cichlid, may serve as standards by which certain taxonomic groups can be compared for general responses to specific classes of environmental toxicants.

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