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COLOUR AND LEVELS OF AGGRESSION IN THE MIDAS CICHLID

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Abstract. Previous work established that gold morphs of the Midas cichlid (*Cichlasoma citrinellum*) dominate normal ones of about the same size. Left unresolved, however, was whether the gold morphs dominate because they are inherently more aggressive or because the gold colour inhibits aggression. The issue was clarified here by comparing levels of aggression within groups of golds only, normals only, and golds plus normals. At first the groups of golds were the least aggressive. But 2 days later the levels of aggression in the other groups fell to about that of the golds. We conclude therefore that the gold colour inhibits attack, but that this effect is only discernible in groups when they are establishing inter-individual relationships disappearing when the groups stabilize. We suggest that gold coloration inhibits attacking by stimulating fear responses.

The Midas cichlid (*Cichlasoma citrinellum*) is a Nicaraguan fish of moderately large size, having a shape and behaviour typical of so many of the *Cichlasoma* from Central America. Most individuals are cryptically coloured, and we call these normal morphs. In some of the lakes around 7 to 10 per cent of the adults are conspicuously coloured, the most common being a gold morph (Barlow 1976).

Previous studies have shown that gold morphs dominate normal ones of comparable size (Barlow & Ballin 1976). This could result from either the gold colour inhibiting aggressive behaviour in the other fish, or from the gold fish being inherently more aggressive. The issue could be clarified by comparing the amount of aggression within groups consisting only of gold morphs to that within groups of exclusively normal ones. If the golds are more aggressive there should be more attacking among them. But if gold inhibits aggression, then there should be more attacking within the groups of normal morphs.

The gold morphs also grow faster than the normals in mixed groups; but when gold and normal fish are raised separately they grow at the same rate (Barlow 1973). That the different morphs grow at comparable rates when apart is puzzling. If the golds are the more aggressive morph they should have grown less rapidly because of greater metabolic cost, injury, and possible disturbance of their endocrine physiology. Conversely, if gold inhibits attack then the non-inhibited and hence more aggressive normals should have grown the more slowly.

The puzzle could be resolved if the differences in aggression were manifest only when a group is first put together. Our earlier work (Barlow & Ballin 1976) indicated that some components of aggression, i.e. approaching and contesting tend to be greatest initially, but become relatively stable within a few days. The plan, therefore, was to compare levels of aggressive behaviour in groups of Midas cichlids having different colour compositions, and on the first and third days of being together. A group consisting half of normal and half of gold morphs was included as a control.

Methods

All the Midas cichlids were juveniles, siblings raised from a pair of gold adults that were descendents of fish from Lake Masaya, Nicaragua. They were maintained in three aquaria (tanks): each 30 × 60 × 30 cm deep (54 litres); fine gravel on the bottom was 3 cm deep; two plastic tents served as hiding places. Three sides of each aquarium were masked by blue cardboard, decorated with disruptive abstract black drawings of plants; the front glass was equipped with a viewing port that permitted the observer to look at the animals while remaining unseen. The water was tap-water plus 5 g marine salt per litre; the temperature was 28° ± 1°C. Illumination was by means of one 40-W incandescent bulb; the light came on at 08.00 hours and went off at 20.00 hours. Food was given twice daily, in the morning and late afternoon.

Procedure

Three groups were selected such that each contained four fish closely matched in weight. One group had all gold morphs, another all normals, and a third contained two gold and two normal fish. In random order, one group was placed in an observation tank at 10.00

hours, and the next two groups in the other tanks at successive 30-min intervals. Three hours later, for each group, they were observed for 30 min. Two days later, day 3, each group was again observed for 30 min at the same time of day.

Thirteen such trials were carried out, but the analysis is based on the nine trials in which all three groups were successfully recorded. In a few of the early trials some groups became so fearful that the fish remained almost motionless. Usually the animals could be coaxed out of their fearful state by offering them *Artemia*, an attractive live food. In each of four trials, however, one group remained fearful and those trials were abandoned. Commencing with trial six, we altered the environment through the addition of 'dither fish' (Barlow 1968) behind a translucent screen; no trials were lost thereafter.

Criteria for Scoring Action Patterns

The action patterns were tallied as occurring without regard either to duration or to whom the behaviour was addressed. Thus the scores are the sums of the behaviour for all four fish in each group. The action patterns have been described in more detail by Barlow & Ballin (1976). Only the following were employed in the present study:

(1) Flee: An accelerated swim away from another fish; (2) Attack: This includes charging, biting at, and biting, so it corresponds to overt attack in the previous study; (3) Contest: As before, this includes frontal display, lateral display, tailbeat, and mouthlock, with the first two actions contributing most of the data.

Results

Frightened Fish

In all four of the trials that aborted because the fish were too frightened to interact, the frightened group was the gold one.

Flee

On day 1 most fleeing occurred among normal plus gold morphs, less among normals, and the least among golds (Fig. 1, $P < 0{\cdot}05$, Table I). On day 3 the gold group showed no change in the amount of fleeing compared to day 1; in the normals and gold plus normals, in contrast, it dropped to about the level shown by golds. There were no significant differences between the three groups on day 3.

Attack

Attacking on day 1 exhibited almost the same pattern as fleeing. There was a progressive increase going from golds, to normals, to golds plus normals (Fig. 1, $P = 0{\cdot}006$, Table I). The gold group remained at the same level on day 3 as on day 1, just as with fleeing. The pattern was not so consistent, however, for normals, and golds plus normals. But there were no significant differences between the three groups on day 3.

Contest

This measure indicates the undecided or ambivalent aggressive encounters among the fish (see discussion in Barlow & Ballin 1976). Understandably, then, contesting was high on day 1 because the fish were resolving their aggressive relationships.

Contesting occurred at a low frequency, however, compared to fleeing and attacking (note the differences in scale in Fig. 1). This is for two reasons: First, except for tail beating, a single occurrence of contesting may persist for several seconds but be tallied as one. Second,

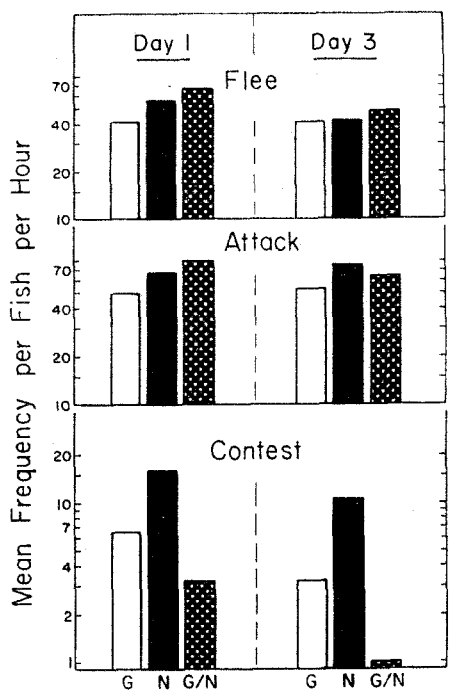

Fig. 1. The mean frequency per fish per hour is presented on a log scale to emphasize patterns of differences rather than absolute amounts. The open bars represent behaviour in the groups consisting of four gold fish (G), the solid bars that for groups of normal fish (N), and the spotted bars for groups of two normal plus two gold fish (G/N).

when two fish first meet they usually contest often; thereafter one is more apt to chase, the other to flee.

The low frequency of occurrence of contesting meant that sampling error was greater. While the differences between the three groups were relatively much larger than with the other measures, it was not possible to establish statistically reliable differences (Table I). On the other hand, the pattern of differences between the three groups over days 1 and 3 were so consistent (Fig. 1) and in keeping with previous work (Barlow & Ballin 1976), that we are persuaded the differences are real. Also, in the additional four trials that were not included in the analysis, because of the golds being fear struck, the amount of contesting in golds plus normals was always much lower than in the normals, as in Fig. 1.

The major conclusion to draw from contesting is that it was much lower in the mixed colour groups than in the pure colour groups. Further, contesting was greatest, and remained greatest, in the groups of normal morphs. Finally, contesting was high initially but declined rapidly as inter-individual relationships became established.

Discussion

The results accord with our favoured hypothesis that gold coloration inhibits attack; this also fits the recent findings of Leong (1969). There was no evidence here that gold morphs are more aggressive than normal ones. Furthermore, the differences were detectable only on the first day; all groups reached similar levels of attacking and fleeing by day 3.

The differences in contesting are also consistent with our premise that gold coloration facilitates dominance. The least contesting occurred in those groups having fish of mixed colours because the colour difference biases the outcome in favour of the gold morphs. And normal fish contested more among themselves than did golds, which agrees with our hypothesis that gold coloration inhibits aggression.

The fear-struck groups of gold morphs might also be accounted for by the effect of gold on fear responses. The underlying behavioural mechanism, for the inhibition of attack caused by gold coloration, seems to be the lowering of the threshold for fear in the perceiver. If so, then being in a tank in which all the other fish are coloured gold might just sufficiently lower the threshold of fear in each of the fish, that, coupled with the positive feedback of reciprocal fear responses, they could become overwhelmed by fearful behaviour.

The pattern of changes in behaviour through time agreed well with earlier results (Barlow & Ballin 1976). The level of attacking and fleeing, for example, changed little, declining a small but statistically insignificant amount. But, as before, contesting decreased sharply.

The findings, therefore, are consistent with the predictions. The gold morphs showed less overt aggression among themselves than did the normal fish, but the difference was clear only initially. After that, all groups were about equally aggressive. Thus the effect of gold coloration appears to be to inhibit attack by stimulating fear. Gold fish become dominant to normals because the normals alter their behaviour toward them, not because the golds are inherently the more aggressive.

Table I. Calculated *P*-values for Differences in Ranks, Comparing Data from Groups of All Gold, All Normal, and Normal Plus Gold Morphs (Friedman Two-way Analysis of Variance)

Day	Flee	Attack	Contest
1	$0{\cdot}031>P>0{\cdot}019$	$P=0{\cdot}006$	$P=0{\cdot}107$
3	$0{\cdot}865>P>0{\cdot}814$	$0{\cdot}187>P>0{\cdot}154$	$0{\cdot}278>P>0{\cdot}187$

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