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Aggressive behaviour of two swordtail colour breeds (*Xiphophorus*, Poeciliidae) in a prior residence situation

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Abstract

Males of two swordtail colour breeds (*Xiphophorus*) were tested for differences related to aggression in a prior residency situation. The median latency time of the first dominance sign, the first attack, and the first approach was significantly shorter in the red than in the black breed, while these differences were not present when resident and newcomer or the larger and the smaller member of the pair were compared, either in the two breeds separately, or in the two breeds combined. The significance of these differences in agonistic behaviour is discussed in relation to resource holding power and colour variants in fish. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

In dyadic conflicts in swordtail fish (*Xiphophorus*, Poeciliidae) the larger individual usually wins (Ribowski and Franck, 1993), and size has often been found as one of the most reliable indicators of resource holding power (RHP; also named resource holding potential) in conflict situations (Parker, 1974). RHP or fighting ability can depend on factors intrinsic to the contestants such as size, age and sex, but can also be influenced by extrinsic factors such as familiarity with the area in which the contest takes place (Braddock, 1949; Heuts, 1979; Beaugrand et al., 1996), prior exposure to the opponent (Zayan, 1974) and prior dominance experience (Thinès and Heuts, 1968; Beaugrand et al., 1991, 1996). These factors may cause asymmetries in motivation, resulting in differences in RHP. For a more comprehensive account we refer to Heuts (1979) and Beaugrand et al. (1991, 1996).

Besides these well studied factors Barlow (1983) reported differences in RHP related to colour

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variants in a non-poeciliid fish. The gold colour variant of the polychromatic Midas cichlid was, e.g. dominant over the normal colour morph.

Swordtail fish (*Xiphophorus*) is a genus of tropical Poeciliidae found mainly in Central America. They are popular aquarium fish and are widely used in behavioural experiments. A wide range of colour breeds, due to hybridisation of *X. helleri* with *X. maculatus* (Dzwillo and Villwock, 1975), are readily available from retailers. During non-experimental observations in our community aquariums we noted differences in aggression intensity between a black and a red colour breed. To find out whether these differences were consistent we performed a series of experiments with the two breeds.

2. Materials and methods

2.1. Subjects and material

The subjects of the study were adult male swordtails from our laboratory stock. All fish had a fully developed sword but differed in size. Two colour breeds, black and red, and the wild coloured breed, were used. The black breed has a black body coloration with green iridescence except for the pale belly. In some animals some red is present on the head and/or sword. This black breed might be similar to the Berlin cross, in which the females, but not the males, show a lowered fecundity (Pinter, 1975). The red variant is almost entirely red apart from longitudinal bands on the sword.

The fish were normally maintained in several large community aquariums. At least a week prior to testing the adult males were isolated in identical Plexiglas aquariums ($25 \times 18 \times 16$ cm^3). In the experiments ten black, 12 red, and eight wild coloured individuals were used. The floor was covered with fine sand and each aquarium contained a few small plants. Water was maintained at $\sim$22°C and was charcoal filtered. The fish received Tetramin flake food daily, always after the experiments.

2.2. Procedures

In order to elicit a dyadic conflict we applied a prior residence schedule. Prior residency, defined as familiarity with the surrounding in which the contest takes place, favours dominance of the resident over the intruder, and has been well documented in swordtail fish (Beaugrand et al., 1996).

A resident–intruder pair was constituted by introducing an intruder into the aquarium of a resident fish. Both resident and intruder were netted out of their aquariums and introduced into the aquarium of the resident fish (similar as described by de Boer and Heuts, 1973). Firstly, we tested red residents against black newcomers and vice versa, and subsequently we tested the red and black colour morphs against wild coloured newcomer. The same fish could have been used in more than one experiment, but always after an isolation period varying between one day and a week. A resident–intruder pair may constitute of fish slightly differing in size, larger individuals of either colour or residency category were approximately as frequently used as smaller ones.

Immediately after the introduction continuous recording started. The following behavioural patterns are considered in this paper:

(i) A dominance sign is a suddenly accelerated approach towards the opponent which is associated with, or immediately followed by, rapidly swimming away or slowly swimming away with depressed back fin of the approached fish. The dominant partner is that individual that first scores six successive dominance signs (de Boer and Heuts 1973; Ribowski and Franck, 1993).

(ii) An attack is a suddenly accelerated approach without regard of the behaviour of the approached fish. An attack can include a bite or a bite attempt.

(iii) An approach is a slow-speed swimming movement towards the opponent without the acceleration that characterises an attack.

(iv) Swimming away is a low-speed swimming movement away from the opponent.

For statistic analysis Siegel (1956) was used, and significance is assumed when $P < 0.05$ in a two-tailed test.

Table 1
Median latency times (min) of several behavioural patterns for two colour breeds of swordtail fish in a prior residency situation

	Red (*n*)	Black (*n*)	Mann-Whitney *U*	*P*-values
1st Dominance sign	14 min 00 s (12)	33 min 00 s (11)	25.5	<0.02
1st Attack	5 min 00 s (13)	32 min 00 s (11)	22	<0.02
1st Approach	1 min 45 s (16)	7 min 50 s (8)	29	<0.05
1st Swimming away	5 min 00 s (15)	12 min 35 s (9)	43	n.s.

3. Results

In the experiments prior residency indeed favoured dominance (data of black and red colour breed pooled; resident versus intruder 16:5; binomial test, $P < 0.05$). Relative size also favoured dominance in the pooled data (large versus small 16:5; binomial test, $P < 0.05$).

Although there was a significant prior residence effect, the latency times of the first dominance sign, the first attack, the first approach and the first swimming away showed no significant difference between residents and intruders. A similar non-significant difference in these four behavioural parameters was found when comparing the larger member with the smaller one.

Table 1 shows that the colour breeds did differ significantly in latency times of first dominance sign, first attack, and first approach but not of first swimming away. Thus, the red breed showed a shorter latency time compared to the black breed for those behavioural patterns that are associated with dominance, aggression and approach. In addition we found a positive correlation between first attack and the most attacks, i.e. the fish that attacked first also attacked most (binomial test, 20:3, $P < 0.001$). Furthermore, those individuals that scored the first dominance sign were most likely to end up being the dominant partner, i.e. being the first to score six successive dominance signs (binomial test, 24:1; $P < 0.001$).

In the subsequent experiment, when tested against a wild color newcomer similar differences in latency times of aggressive behavioural patterns between the red and the black breed were found; the most relevant of which is a significant higher frequency of first attacks during the first four minutes of the experiment in the red males compared to the black males ($\chi^2_{\text{Yates correction}}$, 5.2; $P < 0.05$).

4. Discussion

In accordance with previous studies in *Xiphophorus* and other fish our experiments showed that prior residency favoured dominance as did relative size. In addition to this there was a significant difference in agonistic behaviour between our two colour breeds. The males of the common red aquarium breed attacked earlier and showed a shorter latency time for the first dominance sign than the black breed (Table 1). In our previous studies on the red *Xiphophorus* breed (Heuts, 1968, 1979; Thinès and Heuts, 1968) we made a distinction between two groups of factors that influence the agonistic behaviour, i.e. (1) constant individual properties (typically those related to body size, age and sex) and (2) experiential factors such as prior residency and previous fighting experience. Resource holding power expressing itself in a dominance and aggression advantage can be regarded as being determined by these two groups of factors. Colour variation as far as it is a constant individual trait (as in our aquarium breeds) should be classified in the first group. Intra-individual colour variation in time (which we will not further discuss) clearly belongs in the second group, and has been demonstrated to be associated with attack rate and the winning of fights (see, e.g. Rasa, 1969, 1971; Morris et al., 1995a,b).

To our knowledge, differences in agonistic behaviour between different coloured breeds of *Xiphophorus* have hitherto not been reported.

Since we demonstrated a correlation between coloration and attack readiness, an individual's colour might be indicative of its RHP. These findings might be comparable with those of Barlow (1983) in that morph coloration in Midas cichlids caused asymmetries in fighting dominance.

In animals with relatively fixed adult size, size itself might not always provide enough information in order to assess the RHP of your opponent. Under these conditions it might be favourable to be able to use an even more constant trait, such as body coloration, as an additional indicator of RHP. However we were not able to demonstrate a clear difference in RHP or dominance between the two colour breeds, despite a significant difference in behavioural patterns related to aggression and approach. The observed differences might therefore relate to two different fighting strategies, immediate versus delayed attack, both having an equal probability of gaining dominance. The behavioural differences between the two breeds might be related to colour-linked genes, and while selecting for colour, breeders could also have selected for differences in agonistic behaviour. However, we do not have any information on the genetic make-up of our laboratory stock.

In the wild males live in largely overlapping home ranges, forming stable dominance relationships (Ribowski and Franck, 1993). In agreement with Beaugrand and Zayan (1985) true territorialism, i.e. specific area linked dominance, has never been observed in *Xiphophorus* (Heuts, 1968). Beaugrand (Beaugrand et al. 1996) studied wild populations of *X. helleri* during the dry season and observed a size related stratification: large fish shoal in the centre of what is left of the river, while small fish distribute themselves near the banks and in bays of the mainstream. When the river level falls, pools of varying size and depths are formed and small groups of similar sized fish become isolated. Within these small groups, individual differences other then size itself, may play a role in determining the hierarchy formation (Beaugrand et al., 1996). Under these circumstances, slight variation in body coloration, and/or the correlated differences in agonistic behaviour, among which readiness of prompt attack, might be of influence in gaining dominance.

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