The Effect of Changing Environmental Stimuli on *Betta Splendens* Behavior

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Abstract

Changing environmental stimuli affects the behavior of the Siamese fighting fish (*Betta splendens).* Analyzing the effects is important as it provides a snapshot of changing behavior in regards to territory, mating and agonistic responses due to changes in the environment. The research was conducted within the BSU aquatics lab and Sattgast room 267. *Betta splendens* were randomly selected from a local vendor and were given 24 hours to adjust to surroundings. Measurements, in five minute intervals, were based on amounts of agonistic response in five different environmental scenarios. It was concluded that changing environmental stimuli has a minimal effect on overall *Betta* behavior. Percentage of total agonistic response was anal, caudal, dorsal fin flare 6%, operculum flare 15%, facing 22%, biting 18%, side/side 20%, and tail slap 7%. These results help to provide insight into the differing responses of the *Betta* to females, males, and fish of a non-related species.

Introduction

The behavior of the Siamese fighting fish is highly aggressive, often displaying and attacking the image of a conspecific. The aggressive display is used to acquire and protect territory, attract females and exhibit dominance (Craft et al 2003.) According to Lacey (1972), male aggressive posturing is easily recognized and consists of the erection of anal, caudal and dorsal fins, erection of the operculum, facing and side-to-side motions toward the image, biting, tail slaps, and change in body color. Displaying not only shows aggression, but also conveys information that attack is imminent (Baenninger 1984.) A male's behavior towards another male differs from his behavior towards a female, although a large degree of aggression is seen in both instances. Highly aggressive males may attack females before copulation (Bronstein, Jones-Buxton 1996), but attack other males much more readily and aggressively (Matos and McGregor 2002.)

The display of the *Betta splendens* changes in response to variables in its social and physical environment. Males in engaging in battle secrete substances that are shown to inhibit aggressive responses of other males and raise the acidity of the surrounding

water (Baenninger 1968.) The audience or surrounding species also affects the amount of aggressive posturing by the *Betta*. If another male *Betta* is present during a fight, the fighting males will exhibit more aggressive displays and biting, whereas if a female is present there is less aggression and more fin displays (Matos and McGregor 2002.) Males will actively seek out other males to display to and engage in combat over territory. Baenninger (1984) suggests that males spend more time looking at or seeking out an image of a conspecfic than seeking out other images. *Bettas* will also attack non *Betta* images such as angular shapes and images with bright colors. The color red elicits the most aggressive response (personal observation). Though *Bettas* are aggressive by nature, when surrounded by other males for an extended period of time, habituation may occur which leads to a decline in aggressive behavior (Dunham and Halperin 1994.) This habituation has been shown, however, to have no affect on the dominance of some males (Meliska and Meliska 1976.)

The acquisition and sending of information for *Bettas* carries heightened importance, especially when the surrounding environment changes how the information is sent or received. This may cause the fighting fish to display more or less aggression. Simple displays of *Bettas* may infer who will be winner in a fight (Evans 1985), which may give observers to a fight information on the competitors. It has been shown that if a male can witness the fight of a future opponent, it is more likely that he will win the subsequent fight, via increased displays and aggression (Clotfelter and Paolino 2002.) Females, if given the opportunity to witness a fight between males, will preferentially pick the winner over the loser, while a female who has not seen the fight will have no preference (Herb et al 2003.)

At present, only social evidence has been given that indicates that the environment has an effect on *Betta splendens* behavior. This experiment hopes to provide information on how both the social and the physical environment affect the rate and frequency of aggressive reactions. The major objective of this experiment is to see how each variable affects behavior differently and to what extent. To assess this behavior I conducted a series of experiments using males, females, unrelated species of fish, substrate and aquatic plants, in three differing scenarios.

Methods

Behavioral studies were performed on six male Siamese fighting fish (*Betta splendens*) purchased at a local supplier along with five females and 2 species of feeder included in the study. Males were kept in isolated one gallon 9x6x7 inch tanks while females and feeder fish were placed in separate 5 gallon 14x8x10 inch tanks at 20 C in the Bemidji State University Aquatics Lab. Removable partitions were placed between all of the tanks to prevent any interaction prior to the experiments. Species were exposed to 12 hour photoperiod conditions and were fed Wardley *Betta* pellets or Tetramin flakes once daily.

Experimental Setup: A 5 gallon 14x8x10 inch tank was used in each experiment. A clear plastic shield and an opaque partition were placed down through the center of the tank, splitting it into two equal sides. The partition was removed for the duration of each test and was replaced between tests.

Control: Male *Bettas* selected randomly and placed in opposite sides of the test tank were exposed to an image of a conspecific a series of ten times for approximately five minutes per exposure. Behavioral responses tested for were tail slap, bite, operculum

flare, side-to-side motions, facing motions, dorsal, caudal, anal and pelvic fin erect. Actions were documented for number of times exhibited. All males were tested in this way.

Test 1: Two randomly selected males were placed in opposite sides of the test tank with small rocks covering the bottom. Males were given a five minute period to adjust to the new environment and are then exposed to an image of a conspecific a series of ten times for five minutes per exposure. Agonistic display features were documented for number of times exhibited. Two plants were placed in each side of the tank and another five minute period is allowed to elapse.

Test 2: Two males were selected at random and placed into opposite ends of the test tank. A randomly selected female was placed in the tank with one of the males and given a five minute time period to adjust. The opaque partition was then removed and the male with the female was exposed to a conspecific a series of ten times for five minutes per exposure. This test was repeated until all males have been with a female and were tested for response.

Test 3: Two males were selected at random and placed into opposite ends of the test tank. Five feeder fish (species unknown) were placed in each side of the tank with the males. The partition was then removed and males were presented with images of the conspecific a series of ten times for five minutes per test. It is important to note that all males must be tested for response to each series.

Results

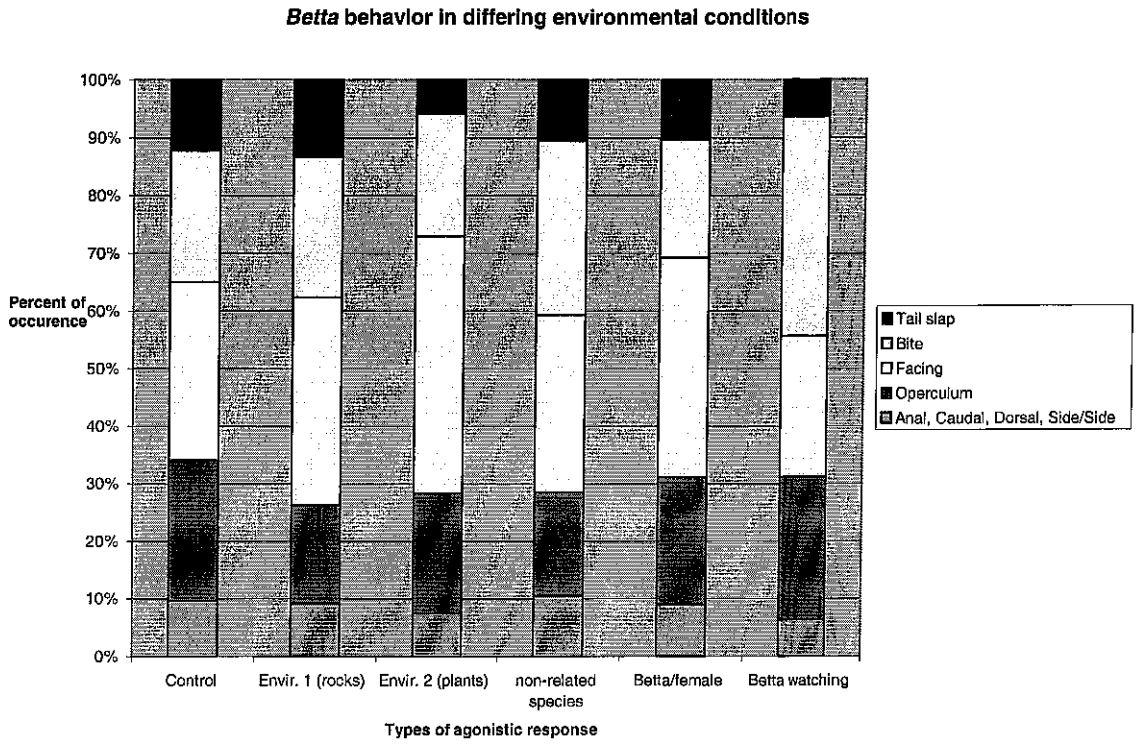

Figure 1: Comparison of means between control test and varied series

The amount of total reaction of *Bettas* when presented with an array of different environmental scenarios did not vary significantly, but small differences can be seen. For example, tail slapping in the *Betta* watching series (1.0) is less evident than in the control test (1.9). The environment with plants elicited the least reaction (Anal, Caudal, Dorsal .68, Operculum 1.9, Facing 4.1, Bite 1.9, Side/side 3.8, Tail slap .53) while the environment containing only rocks was consistent with the control test, 1.5, 3.8, 4.8, 3.5, 5, and 1.9 respectively for each of the above reactions (Fig 1). Fin flaring is the highest in the control experiment (1.5) and lowest in each subsequent experiment (environment with rocks 1.5, environment with rocks/plants .7, non-related species 1.4, *Betta*/female 1.0, *Betta*/watching 1.1). Facing reaction was the highest in the environmental experiment containing plants and rocks with a mean of 5.8 (Fig 1).

Betta response to an unrelated species of fish and females showed differences as well. In the non-related species experiment there was a heightened bite response in comparison to the control test and a diminished flare response in comparison to the control test. In the *Betta*/Female and *Betta* watching experiment, males placed with females had a heightened facing response in relation to males watching females as well as the control test. Those watching other males with a female, however, had a higher bite response than either the male with a female or the control test (Fig 1).

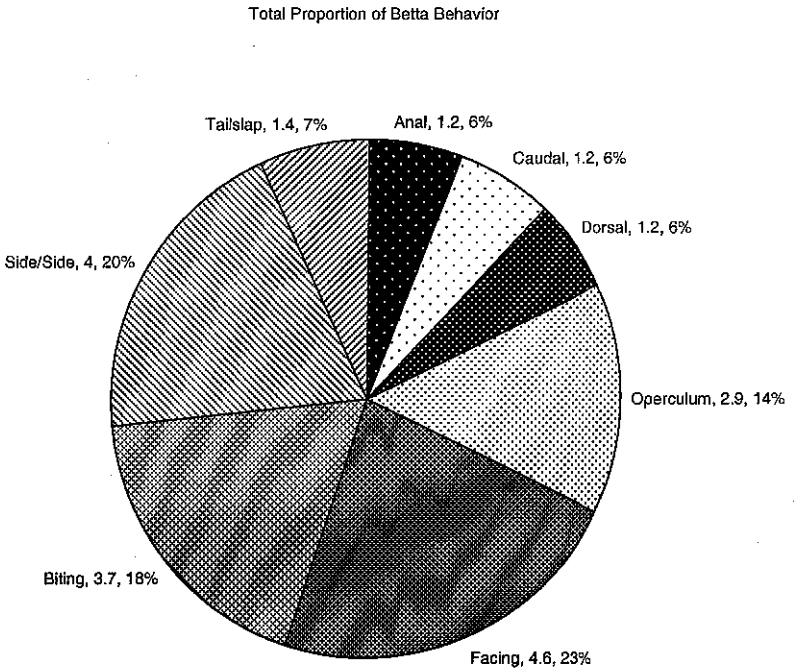

Figure 2: Values are means of total proportion of Betta behavior in all series of tests

Facing motions elicited the highest percent of total reaction (22%) while each individual flaring motion of the anal, caudal, and dorsal fins gave the lowest reaction (6%)(Fig 2). Flaring of all fins, one of the primary agonistic responses, comprises 33% of total reaction (Fig 2). There were many occasions of total absence of reaction in each series. Experimental series with rocks and two plants consistently gave the weakest

results for all average agonistic responses in comparison with the control test (Table 1). Agonistic responses given in the environmental series containing only rocks were consistent with or higher than the control test.

	Control	Environment 1 (rocks)	Environment 2 (plants)
Fin flare	1.5	1.5	.68
Operculum	3.8	2.7	1.9
Facing	4.9	5.8	4.1
Bite	3.6	3.9	1.9
Side/side	5	4.3	3.8
Tail slap	1.9	2.1	.5

Table 1: Comparison of means in environmental series vs. control test

Discussion

In order to test the effect of different environmental stimuli on the frequency of *Betta splendens* agonistic behavior, I conducted a series of experiments designed to test a single stimulus on behavior at a time. It was concluded that different stimuli in the environment had little effect on total response, but that small differences did occur within these responses.

My study shows that subordinate males readily used plant life or the corner of the aquarium to cover themselves during an aggressive display with a dominant male. The environmental series with rocks did not allow for any cover, thereby forcing the subordinate males to display, while the series with plants provided areas that obstructed the view of the dominant male and hid the subordinate male. This explains why the series containing plants gave the least total aggressive response. Males displaying to other males of a different species present elicited a more aggressive response than those with females present. This supports current research stating that males will respond with more flaring but less violent aggressive reactions because the males do not want to injure the

female or scare her away (Matos and McGregor 2002). This was not a factor with a non-related species, allowing the males to bite and flare fins more times in an encounter. Within the experiment where females were present, offending subordinate males (watching a male with a female) would display to a female when the male with her was not engaging in battle with him. It is my belief that the subordinate male will utilize every opportunity he has to display to the female because he hopes to mate with her, and as a subordinate male, he would not often get the chance to encounter a receptive female. This is supported by instances where the subordinate male has a female in the tank with him during an aggressive encounter. These males paid little or no attention to the more dominant male in the opposite side of the tank, and focused only on the female.

Subordinate males frequently exhibited horizontal striping and lessening of agonistic response during a test series to certain other males, and highly aggressive behavior to other subordinate males. This supports the idea that dominance is established quickly and consistently between males in multiple encounters (Bronstein 1985). Many males eventually ceased displaying towards each other, showing little interest or aggression; this occurred in each series. There are multiple explanations for this occurrence, one of them being habituation of the fish to another males presence. Meliska and Meliska (1976) state that after prolonged repeated exposures to other males, *Bettas* tend to lower the amount of agonistic response elicited. Another explanation is that there was free-flowing water between the sections that males were placed in. This would have allowed hormones released by the fish during displays to circulate through the tank and accumulate as the series progressed. The accumulation of hormones in the water may have suppressed aggressive behavior (Baenninger 1968). A final explanation is that the

fungus *Icthyophonus* had found its way into the test population and caused difficulty breathing by clogging the gills, leading to eventual death. The progression of this illness caused the fish to eventually do nothing but lay at the bottom of the tank gasping for air. All of the test subjects had to be replaced multiple times to compensate for this.

I believe that my data would have shown different results had the subjects not succumbed to *Icthyophonus* and multiple series of new subjects had not been used. The results show that there are many things to take into consideration when analyzing *Betta splendens* behavior, and that not only do the presence of other species and females have a distinct impact, but that plant life and substrates present are equally important if not more so. This holistic approach to the analysis of behavior may give a clearer, precise picture of how *Bettas* behave in varying conditions.

Works Cited

Baenninger R. 1968. Fighting by *Betta splendens*: effects on aggressive displaying by conspecifics. Psychonomic Science 10:185-186.

Baenninger R. 1984. Consequences of aggressive threats by *Betta splendens*. Aggressive Behavior 10:1-9.

Bronstein P. 1985. Predictors of dominance in male *Betta splendens*. Journal of Comparative Psychology 99:47-55.

Bronstein P. 1988. Socially mediated learning in male *Betta splendens*. III. Rapid acquisitions. Aggressive Behavior 14:415-424.

Bronstein P. 1994. On the predictability, sensitization, and habituation of aggression in male bettas (*Betta splendens*). Journal of Comparative Psychology 108:45-57.

Bronstein P., Jones-Buxton R. 1996. Sensitization of escape in female *Betta splendens*. Aggressive Behavior 22:431-435.

Craft B., Velkey A. and A. Szalda-Petree. 2003. Instrumental conditioning of choice behavior in male siamese fighting fish (*Betta splendens*). Behavioral Processes 63:171-175.

Clotfelter E., Paolino A. 2003. Bystanders to contest between conspecifics are primed for increased aggression in male fighting fish. Animal Behaviour 66:343-347.

Evans C. 1985. Display vigor and subsequent fight performance in the siamese fighting fish, *Betta splendens*. Behavioural Processes 11:113-121.

Fantino E., Weigele S. and D. Lancey. 1972. Aggressive display in the siamese fighting fish (*Betta splendens*). Learing and Motivation 3:457-468.

Halperin J., Dunham D. 1994. Social overstimulation reduces subsequent aggression in *Betta splendens*. Aggressive Behavior 20:135-142.

Halperin J., Giri T. and D. Dunham. 1997. Different aggressive behaviors are exaggerated by facing vs. broadside subliminal stimuli to socially isolated siamese fighting fish, *Betta splendens*. Behavioral Processes 40:1-11.

Halperin J., Giri T., Elliot J. and D. Dunham. 1998. Consequences of hyper-aggressiveness in siamese fighting fish: cheaters seldom prospered. Animal Behavior 55:87-96.

Herb B., Biron S. and M. Kidd. 2003. Courtship by subordinate male siamese fighting fish, *Betta splendens*: their response to eavesdropping and naïve females. Behavior 140: 71-8.

Matos R., McGregor P. 2002. The effect of sex of an audience on male-male displays of siamese fighting fish (*Betta splendens*). Behavior 139:1211-1221.

Matos R., Peake T. and P. McGregor. 2003. Timing of presentation of an audience: aggressive priming and audience effects in male displays of siamese fighting fish (*Betta splendens*). Behavioural Processes 63:53-61.

McGregor P., Peake T. and H. Lampe. 2001. Fighting fish *Betta splendens* extract relative information from apparent interactions: what happens when what you see is not what you get. Animal Behaviour 62:1059-1065.

Meliska J., Meliska C. 1976. Effects of habituation on threat display and dominance establishment in the siamese fighting fish, *Betta splendens*. Animal Learning Behavior 4:167-171.

Wallen K., Wojciechowski-Metzlar C. 1985. Social conditioning and dominance in male *Betta splendens*. Behavioural Processes 11:181-188.