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AGGRESSIVE BEHAVIORAL EFFECTS OF DISPLAY WATER
BY DOMINANT AND SUBORDINATE SIAMESE FIGHTING FISH
(BETTA SPLENDENS) ON CONSPECIFICS

by

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A thesis

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Abstract

Recent evidence indicates that several species of fish are sensitive to chemical as well as visual cues in the maintenance of dominance hierarchies. Aggressive displaying in the Siamese fighting fish (Betta splendens) was studied as a function of water cues emitted either by dominant or subordinate conspecific fish. Following combat to establish dominance, combatants were allowed to display in separate tanks to prepare display water for conspecific test fish. Frequency and duration of mirror image display was measured in the water treated by the dominant or subordinate combatants. Results indicated that the experimental display water suppressed aggressive display more than fresh water. On the first day after the fight, displaying in water of dominant combatants was reduced substantially more than that in the water of subordinate combatants. The reverse was found two days after combat. Results were discussed within the context of methodological and species specific considerations.

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It is generally assumed that dominant and subordinate status are communicated by visual cues in the lizards, birds, wasps, lobsters, primates, and fishes (Brown, 1975). However, Todd (1971) has demonstrated that a change in dominance of the yellow bullhead (Ictalurus natalis) can be detected chemically through the sense of smell. The loss of a fight by a dominant bullhead led to a discriminable change in the content of the water which affected the aggressive behavior of conspecific bullheads. In a contrived situation, Todd (1971) allowed a dominant bullhead to lose a fight in a separate tank with another bullhead. Upon return to the colony tank, this dominant fish was now attacked by the previously subordinate fish. It was hypothesized that the lost fight changed the chemical odor of the fish. This hypothesis was supported by the finding that the destruction of nose tissues led to failure of social adaptation (Todd, 1967). Fish without the sense of smell failed to recognize territory and dominance hierarchies and they were more prone to aggression.

Recent research (Fantino, Weigele, and Lancy, 1972) has indicated that the male Siamese fighting fish (Betta splendens) will display aggressively to such visual stimuli as its mirror image, a model of itself, or another male Siamese fighting fish. The aggressive display, however, has been suppressed with exposure to synthetic chemical compounds such as lysergic acid diethylamide (LSD 25) (Abramson & Evans, 1954), catechol amines (Baenninger, 1968a), chlordiazepoxide (Librium) (Figler, 1973; Figler, Klein & Thompson, 1975), Liethylamine HCL (Thor, Weisman & Bashka, 1967), and tranquilizing drugs (Walaszek & Abood, 1956). Other research (Baenninger, 1968b; Ingersoll,

Bronstein, & Bonventre, 1976) has shown that exposure to water chemically altered by conspecific fights suppressed aggressive displaying.

Experiments by Simon (1975) have shown conditions under which chemicals do not alter display. Simon (1975a) found that the 21-day old habitat water of the individual Siamese fighting fish did not induce aggressive display behavior of a subsequent conspecific inhabitant. Moreover, display behavior remained unaffected when a conspecific inhabitant was exposed to water in which there was previous display by another individual (Simon, 1975b).

Although Simon failed to show eliciting properties of display water, he did account for the relative position of the display fish on a dominance hierarchy. It has been hypothesized that fight water provides cues beneficial to species survival through reduction in aggressivity (Baenninger, 1968b). Neighboring Siamese fighting fish do not participate in a fight between two individuals. Because the Siamese fighting fish is one of the few species that will fight a conspecific to the death, mass fighting would lead to extinction of the species. Chemical cues in the fight water seem to temper the aggressiveness.

It is proposed that combatants release pheromones instrumental in chemical suppression of aggressive behavior. It is hypothesized that dominant individuals produce the largest quantity of pheromones, thereby suppressing its enemy into subordination. It follows that each fish would be immune to its own individual pheromone. Since water can not be separated for dominant and subordinate individuals in a fight, the present experiment allowed active mirror image displaying to occur in separate tanks. Subsequent conspecific inhabitants of these test tanks were then measured for aggressive display.

Method

Subjects

The subjects were twelve adult male Siamese fighting fish (Betta splendens) obtained from a local supplier two days prior to the start of the experiment. Four pairs of fish were randomly selected as "combatants." The four remaining fish were used for testing. All twelve fish were kept visually and chemically isolated in separate home tanks. They were fed Kordon staple flakes daily and were maintained in water at a room temperature of 25 C.

Apparatus

Three tank types were used in the experiment. The home tanks were rectangular and made of opaque plastic with a volume capacity of 465 ml (9x9x6 cm). They were housed on three shelves with four tanks per shelf. The display tanks were rectangular and made of clear plastic with a volume capacity of 225 ml (5.5x5.5x7.5 cm). Individual mirrors (5x7 cm) were placed flush against one side of each display tank and were held in place by the cohesion of the water. Finally, the fight tanks were rectangular and made of clear plastic with a volume capacity of 480 ml (12x6.5x6.5 cm). Tap water (dechlorinated by aeration only) was used in all the tanks. Normally open push button switches which were connected to 4 channels of a 20-channel Esterline Angus event recorder were used to record display behavior.

Procedure

Four volunteer observers were obtained from an introductory psychology class at Appalachian State University. Prior to the start of the experiment, a description of aggressive display was provided and the observers were

instructed to activate the recorder for the duration of each display. To obtain a reliability measure, the observers measured display behavior by one of two combatants in a fight. Perfect agreement between observers was obtained. A target fish was randomly assigned to each observer for the remainder of the experiment. Observers were naive as to the water conditions throughout the study. Experimental sessions were conducted 24 hours apart to insure optimal consistency in display behavior (Hinkel & Maier, 1974).

On Day 1, the four test fish were transferred from their home tanks and placed in separate display tanks containing fresh water. After a 15-minute acclimation period, mirrors were manually placed in each display tank and the fish displayed for 30 minutes. This 30-minute mirror image exposure in fresh water was not measured for aggression, but was administered to stabilize aggressive display behavior. All test fish were returned to their home tanks.

On Day 2, the test fish were administered the same procedures as Day 1. Display data were recorded by the observers. Following return of the test fish to their home tanks, dominance positions were established for the combatants. Each of the four pairs of combatants was placed in separate fight tanks for a 45-minute fight. Fighting consisted of biting and displaying of gill membranes. The dominant fish was designated as the one which displayed and bit numerically more times than the other fish. By the end of each fight, the dominant fish displayed actively while the subordinate fish was relatively inactive. The fish were returned to their home tanks.

On Day 3, water to be used in the display tanks was prepared by placing either a dominant or subordinate combatant into the display tanks with the mirror in place for 45 minutes. Immediately following the 45 minute display, the dominant and subordinate fish were removed and replaced by the 4 test fish.

A mirrorless 15-minute acclimation period was permitted and aggression was then measured during a 30-minute period in which the mirror was in place. The fish were returned to their home tanks. The same procedure performed on Day 3 was repeated on Day 4. The test fish exposed to the water of dominant combatants on Day 3 were exposed to the water of subordinate combatants on Day 4 and vice versa. A summary of the four day procedure appears in Table 1.

Insert Table 1 about here

Test and combatant fish were given a one-minute dip in fresh water during transfer from their home tanks to the display tanks. This procedure was designed to lessen the possibility of chemical contamination from home tanks.

The two measures of aggression for each individual test fish were frequency and duration of gill membrane extension. The duration measure was recorded in length of ruled sections logged on the Esterline Angus graph paper. The frequency measure was recorded by the number of displays per trial.

Results

Due to the small number of subjects and trials, no statistical analysis of the data was attempted. Figure 1 shows frequency and duration of display behavior as a function of the water conditions. Display behavior was

Insert Figure 1 about here

suppressed within the context of both the dominant and subordinate water conditions when compared to fresh water. Although the difference does not

appear substantial, display behavior in the water of the dominant combatants was slightly less than that in the water of subordinate combatants.

Figure 2 shows frequency and duration of display behavior as a function of time averaged across experimental water conditions. Display behavior decreased over time with the largest difference occurring between Day 2 and 3 (the fresh

Insert Figure 2 about here

water and first day of display water). Figure 3 shows frequency and duration of display behavior as a function of both dominant and subordinate water conditions and time. Aggressive display behavior in subordinate water conditions

Insert Figure 3 about here

was lower on Day 4 than Day 3. Moreover, it exceeded that of the dominant water condition on Day 3, as predicted. The reverse was true on Day 4. The opposite effect was found under dominant water conditions. Display on Day 4 exceeded that of Day 3 and fish in the dominant display tank exceeded those in the subordinate tanks on Day 4, but not on Day 3. The differences between days were less marked under dominant than subordinate conditions.

Discussion

Previous research with another species (Ictalurus natalis) indicated that peers were more likely to attack a dominant fish following a loss in a fight in a separate tank (Todd, 1971). Emitted chemical changes were postulated as cues for the change in hierarchial standing. Research by Simon (1975) did not support the chemical trace theory with Betta splendens. The Simon studies

utilized display rather than fight water and ignored the possible effect of dominant versus subordinate fish. The present research was designed to study the display behavior on conspecific Betta splendens in the display water of fish determined to be dominant or subordinate as defined by the result of a fight. The display water of both dominant and subordinate combatants appeared to suppress display of conspecific fish. The water of the former produced a greater effect one day after a fight while the water of the latter produced a greater effect on the second day after a fight. The results are clouded by a potential effect of passage of time, but are of considerable heuristic value.

Although the test fish were presented the display water of dominant and subordinate combatants in counterbalanced order, the fresh water condition was present on Day 2 for all subjects. A decrease in performance on subsequent days (and water conditions) may be attributable to factors such as habituation.

The time between display of combatants and the measure of display of the test fish was immediate, a constant. The time between the fight of the combatants and the opportunity of the combatants to display (to prepare test water) was a variable (24 hours for Day 3 test conditions and 48 hours for Day 4 test conditions). Although no measure was taken of the display behavior of the combatants during test water preparation, it is possible that time since the fight, as well as the results of that fight, affected that behavior and subsequent chemical cues in the test water.

Several assumptions, about which no data are documented, must be made in order to interpret the present findings. One set of assumptions include that: a) twenty four hours following a fight, the subordinate fish will display less than the dominant fish, b) chemical cues will be available in the water proportionate to the amount or type of display, c) test fish will be less

aggressive (display less) in the presence of cues from dominant fish than subordinate fish, d) the display behavior of dominant combatants will decrease slightly with the passage of time (48 hours) while that of the subordinate combatant will increase substantially, and e) the temporally induced change in display of combatants results in the release of chemical cues which effect the behavior of conspecific fish in the opposite direction.

On the other hand, if it were discovered empirically that the dominant combatant displayed less than the subordinate when test water was being prepared, a releasor effect might be postulated. Perhaps test fish display more in the water of a dominant than a subordinate combatant. A dynamically oriented scientist might postulate that the subordinate combatant compensates for the fight loss with exuberant display while the victorious fish experiences catharsis which suppresses display on the following day. Forty eight hours later, the performance of both combatants modulates due to disinhibition.

The procedure of allowing the combatants to display in order to prepare test water may also affect the performance of the test fish. The chemicals released by the fight loser may be altered as a result of the display to its mirror image. Perhaps the subordinate is now a victor (over its image) chemically. It is suggested that future research be conducted in which the combatants are immediately separated following a fight and that test fish are placed into the home tanks of the loser or winner at various intervals following the fight. Display behavior of the test fish could be assessed to its mirror image (in the absence of the combatants) or to the combatant itself. Only in research in which fights (rather than display) were used to prepare test water was there an effect on conspecific display.

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Table 1

Experimental Procedure

	<u>Fresh Water</u>	<u>Fresh Water</u>	
Day 1	Test fish A & B	Test fish C & D	Measurement not taken
Day 2	Test fish A & B	Test fish C & D	Measurement taken

Note: Combatant pairs fight to establish dominance

	<u>Subordinate Water</u>	<u>Dominant Water</u>	
Day 3	4 of the combatants displayed		
	Test fish A & B	Test fish C & D	Measurement taken
Day 4	Other 4 combatants displayed		
	Test fish C & D	Test fish A & B	Measurement taken

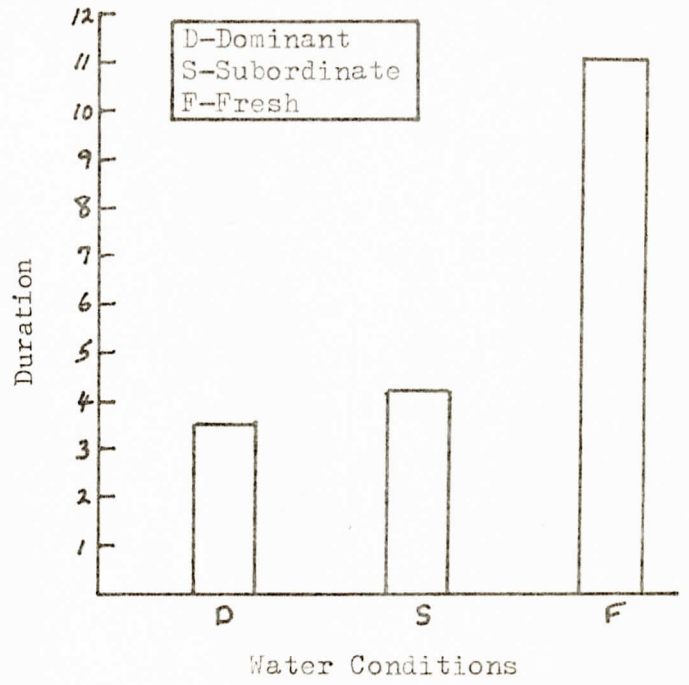
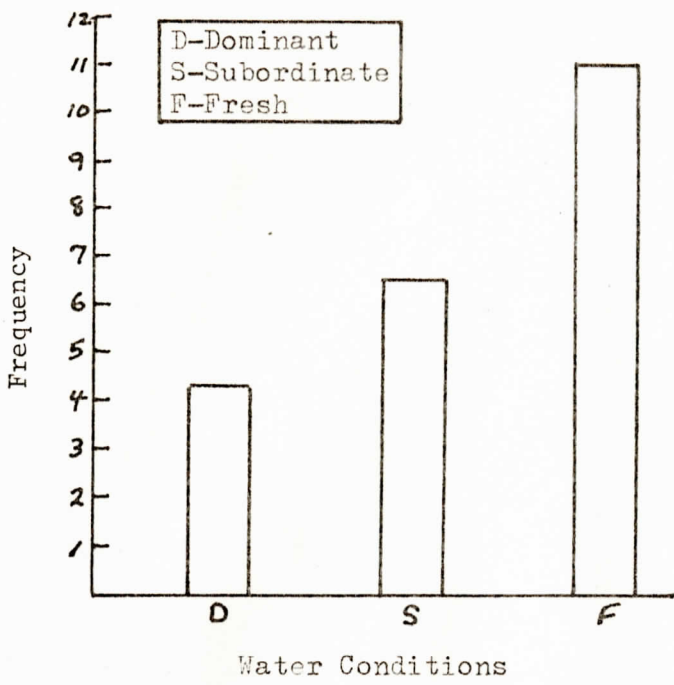


Figure 1. Display behavior as a function of water conditions.

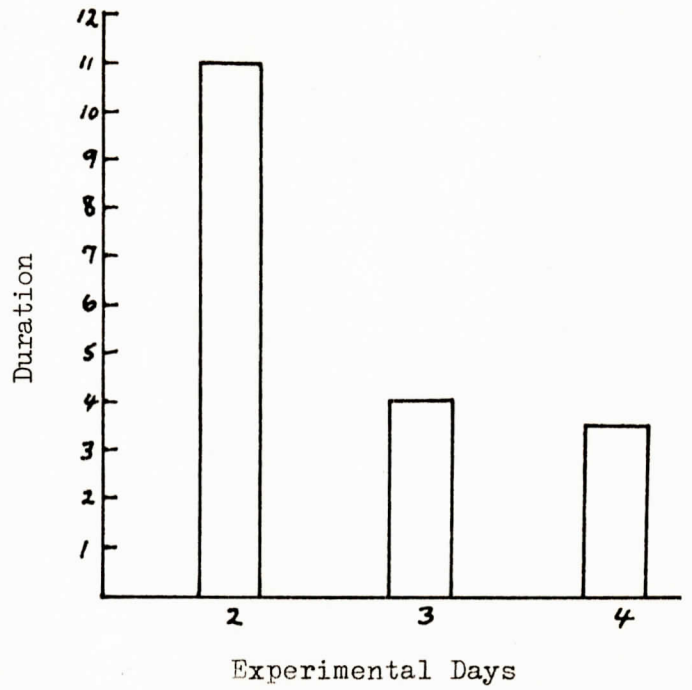
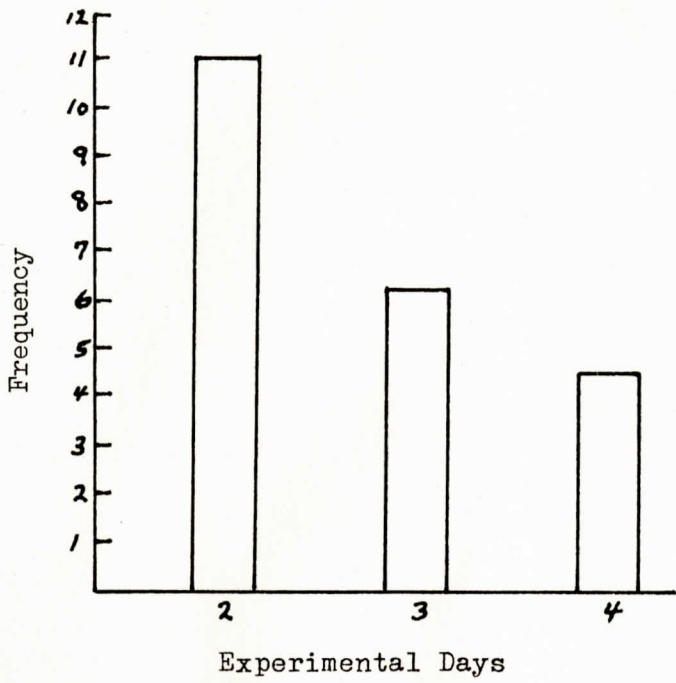


Figure 2. Display behavior as a function of time.

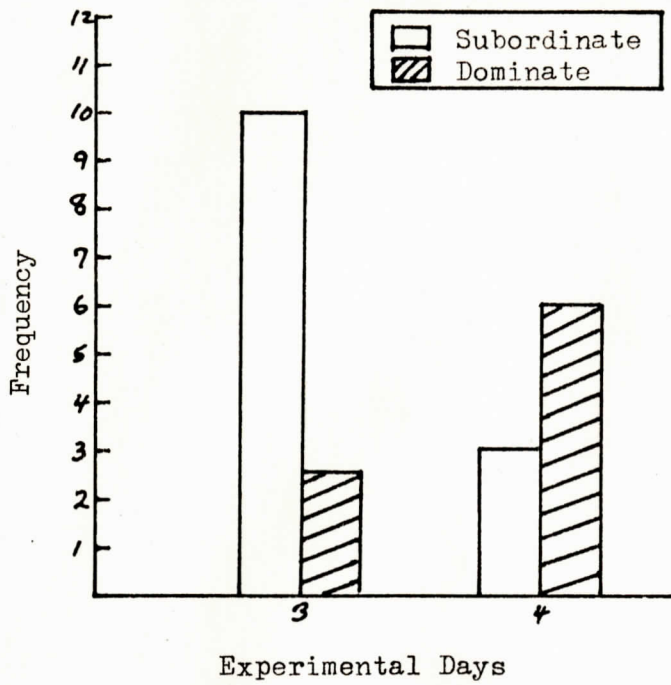


Figure 3. Display behavior as a function of dominant and subordinate water conditions and time.