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"Bubble-Nest Building and Visual Reinforcement in Siamese Fighting Fish *(Betta splendens)*"

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Abstract

Male Siamese Fighting Fish (Betta splendens) were presented with models of male Bettas contingent and non-contingent on occurence of an operant response. The relative amount of nest building and responding co-varied with the manner in which the model was presented. The effect also varied with the order of contingent and non-contingent model presentation.

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Adult male Siamese Fighting Fish (*Betta splendens*) produce mucous-covered bubbles which collectively form a protective nest for developing embryos. Nesting behavior involves a highly stereotyped chain of responses; the fish breaks the surface of the water to get air, drifts down about an inch, and expels one or more bubbles. This sequence is repeated until a tightly packed mass of bubbles is afloat on the surface. If mating has occurred, the fertilized eggs are carried in the male's mouth to the nest and then expelled with an encasing bubble which adheres to the bubble nest (Braddock and Braddock, 1959).

Braddock and Braddock (1959) reported that nest building behavior was not effected by the presence of other fish in the aquarium. Our own observations suggested that nest building frequently occurs when the fish is presented with its own mirror image or a model of another male. Previous studies have shown that the presentation of the visual image of another male *Betta* can also act as a reinforcer for an operant response (Thompson 1963, Thompson & Sturm 1965). The present study determined whether the amount of nest building varied as a function of response contingent versus non-contingent presentation of a model of a male *Betta splenden*.

Method

Two adult male Betta's, obtained from a local aquarium supply store were placed in separate tanks and maintained in visual isolation from other Betta's for seven days. The tanks containing the fish were then placed in an apparatus used for the investigating conditioned and unconditioned aggressive behavior of Betta splendens (see Figure 1) (Sturm, Grabowski and Thompson, 1966).

The aquarium water temperature was maintained at 26 C. The fish were fed frozen brine shrimp from 8:30 to 9:00 and 4:00 to 4:30 each day during a nine-day adaptation period and twenty-nine day experimental period. After feeding, the remaining food, debris and one-third of the water were evacuated from the tank. Feeding and cleaning operations were followed by one hour experimental sessions. Tap water which had been aerated and heated for two days, and cooled to room temperature, was used to refill the tanks after the sessions.

A rectangular frame, 2" x 3", consisting of 1/4" (i.d.) white translucent tubing and a 2" x 3" cover of 1/8 transparent lucite was floated on the surface of the water during trials. The float was placed at the end of the tank where the model is removed from view.[2] Photographs of the bubble nest constructed beneath the float were taken at the end of each session. The photographs were enlarged and an Ott Polar Planimeter used to obtain a measure of the nest area. The figure obtained was divided by the total area available for nest building in the frame (Figure 2).

In accordance with Thompson and Sturm's (1965) data (indicating highest operant response rate occurred with reinforcing models of the color least like that of the subject), dark blue models with

red opercula were selected since the fish were predominantly light red.

Table 1 shows the number of days and sessions for each fish and the order under each condition. The response channel (c in Fig. 1) was present during contingent model presentation and extinction and absent during non-contingent periods.

The number of non-contingent model presentations for #5 was the same as the number of contingent model presentations for fish #1 on the previous day.

Results

Fish #1: Figure 3 shows the means and ranges for AM and PM operant responses and nesting behavior measures. Table 2 gives the data in tabular form, with six sessions combined, and shows ranges and means for these periods.

During the period of response contingent model presentation for fish #1, the channel swimming response rate remained at or near the operant level, but the first response always occurred within 3 minutes by session 6. The nesting behavior measure was initially low but increased through the eighteen sessions of this period. In sessions 17 and 18, (ninth day) the nesting areas were relatively large and approximately equal.

During the first six sessions of extinction the response rate increased, and then decreased in sessions 7 and 8. The nesting area decreased over the first four days of extinction but remained large with little variability between sessions on the same day.

After extinction through the 17th session, the response rate oscillated and then declined through the end of the study.

The nesting behavior measure continued to decrease and showed increased variability between days and sessions on the same day from extinction session 9 through the end of the study with the exception of a sharp rise in rate on day 19 of extinction. The following day this measure decreased to near zero.

Fish #5: Figure 4 presents the means and ranges for AM and PM operant responses and nesting area.

The nesting area remained small during the 18 sessions (nine days) of non-contingent model presentation. In sessions 11 through 18 there was little difference in this measure between days and almost no difference between sessions on the same day.

During the four day period when the model was no longer presented the nesting area showed an increase in variability.

The swimming operant response rate of this fish during 24 sessions of contingent model presentation showed interday and intra-day differences in sessions common in the early development of performance of this operant.

The nesting behavior continued at a low level during these sessions but showed more variability than it had during the later sessions of non-contingent model presentation.

In extinction the response rate showed the increase that was initially seen in the extinction sessions with #1. This was followed by a decrease in rate. The nesting measure which had remained low previously, increased in extinction, but continued to show variability.

Discussion

Observation of the behavior of fish #1 and the data for the period of contingent model presentation suggest that a chain developed which precluded high channel swimming response rates.

After the emission of the first response, the fish traversed the length of the tank (also the path of the model-Fig. 1), thus reaching the nesting area provided by the nesting frame, and then emitted the previously described responses of nesting behavior. Later in the session the channel swimming response would again be emitted, thereby initiating the chain. It appears that the opportunity to engage in the nesting behavior was functioning as a reinforcer for this fish, and that the chain which developed involved either a susperstitious first member (i.e., swimming through the channel), or the model was an eliciting stimulus for nesting behavior, as well as the reinforcer for the first member. The latter explanation seems most likely since presentation of the model to the fish during a short post experimental study, elicited nesting behavior. An important factor in the development of this chain appears to be the order of the experimental conditions. Fish #1 which had the period of contingent presentation first, did not develop this chain during contingent presentation.

Most prominent in the observed behaviors of #5 during the period of non-contingent presentation was that of swimming along the front of the tank from one end of the tank to the other. As this behavior decreased there was a slight increase in the nesting behavior. Another increase occurred but was followed by a decrease when the model was no longer presented. The nesting behavior which did occur may have been elicited

by the model presentation.

It is likely that the low operant rates of fish #1 during contingent model presentation and to some extent the low level of nesting behavior by #5 were due to incompatible concurrent behaviors. Thus a high rate of emission of one response resulted in a lower rate of the other. In the case of #1, high levels of nesting behavior resulted in low channel swimming response rates. The low nesting behavior levels in the non-contingent period for #5 may have been due to the above mentioned behavior of repeatedly swimming along the front of the tank while the later high channel swimming response rates precluded the possibility of high nesting behavior rates.

Figure 5 shows the data given in table one. There appears to be an inverse relationship between the amount of nesting behavior and the channel swimming response by fish #1. Such interactions are not uncommon with other concurrent responses (Catania, 1966).

The results indicate that a relationship exists between nesting behavior and response contingent presentation of a model of a male Betta. The relationship is not dependent on the number of responses and reinforcements alone. One response and subsequent reinforcement appear to be a sufficient condition for the occurrence of nesting behavior. Non-contingent presentation of the model does not appear to be a sufficient condition for the development of a high level of nesting behavior. Non-contingent presentation prior to contingent presentation appears to have an adverse effect on the development of the chain of behaviors which lead to a high rate of occurrence of nesting behavior. This study also demonstrates the feasibility of objectively evaluating nesting behavior using a photographic technique with planimeter-measured nest area.

Table 1

Fish	Condition	No. of Days	No. of Sessions	Response Channel
#1	contingent	9	18	present
	extinction	20	40	present
#5	non-contingent	9	18	absent
	"extinction"	4	8	absent
	contingent	11	22	present
	extinction	4	8	present

Table 2

Condition	Sessions	$\bar{X}$ No. R's Range	$\bar{X}$ Nesting Meas.	Range
contingent	1 thru 6	3.66	2.11	.4 to 4.8
	7 thru 12	3.00	3.32	2.1 to 5.0
	13 thru 18	1.66	6.66	2.5 to 8.9
extinction	1 thru 6	3.50	7.8	7.4 to 8.1
	7 " 12	1.83	7.2	6.8 to 9.5
	13 " 18	2.00	6.9	4.5 to 9.5
	19 " 24	3.33	5.6	3.7 to 7.5
	25 " 30	6.50	2.5	.9 to 4.3
	31 " 36	4.33	3.2	1.7 to 4.4
	37 " 40*	2.76	3.2	.2 to 9.0

* Last case has only four sessions.

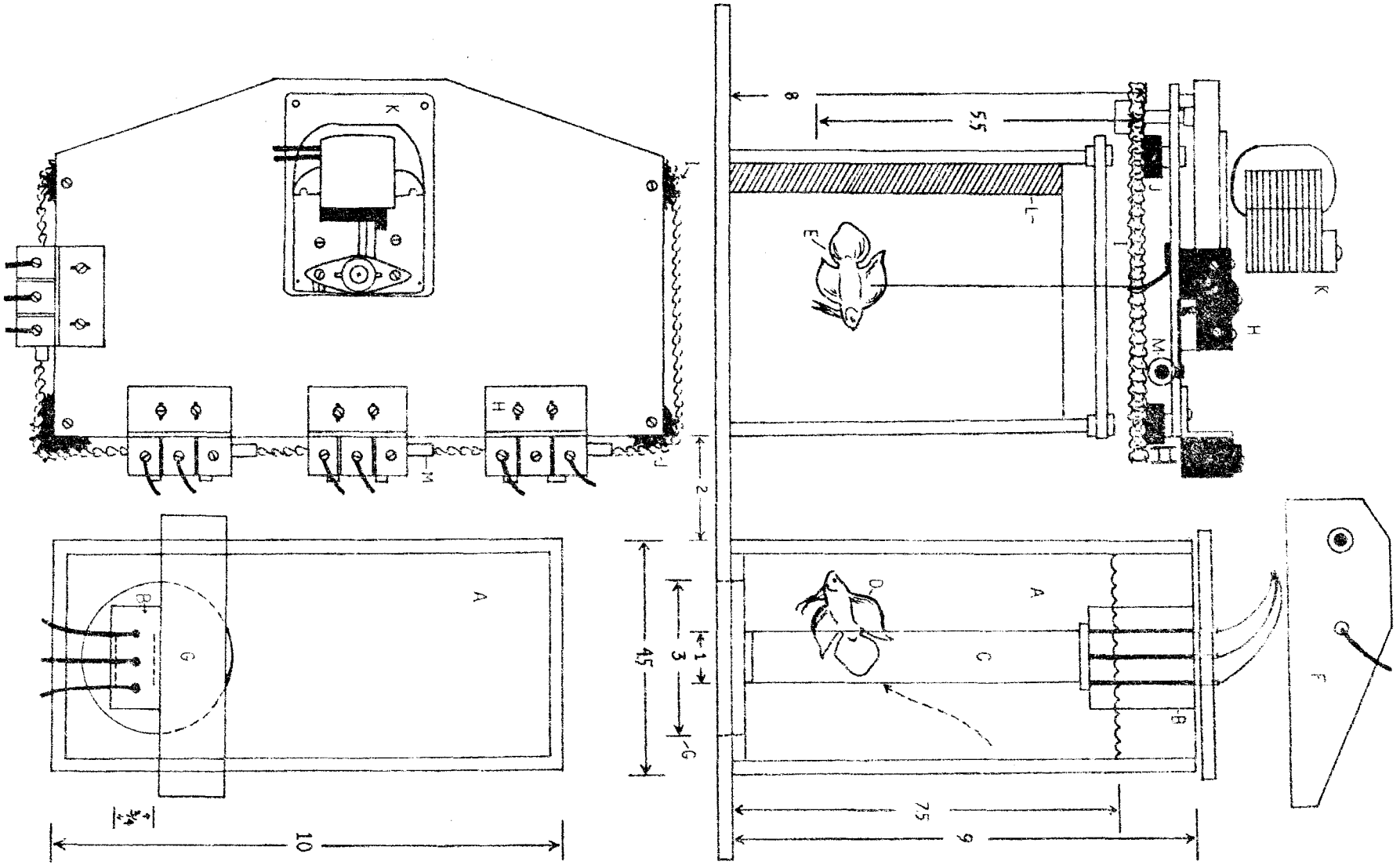
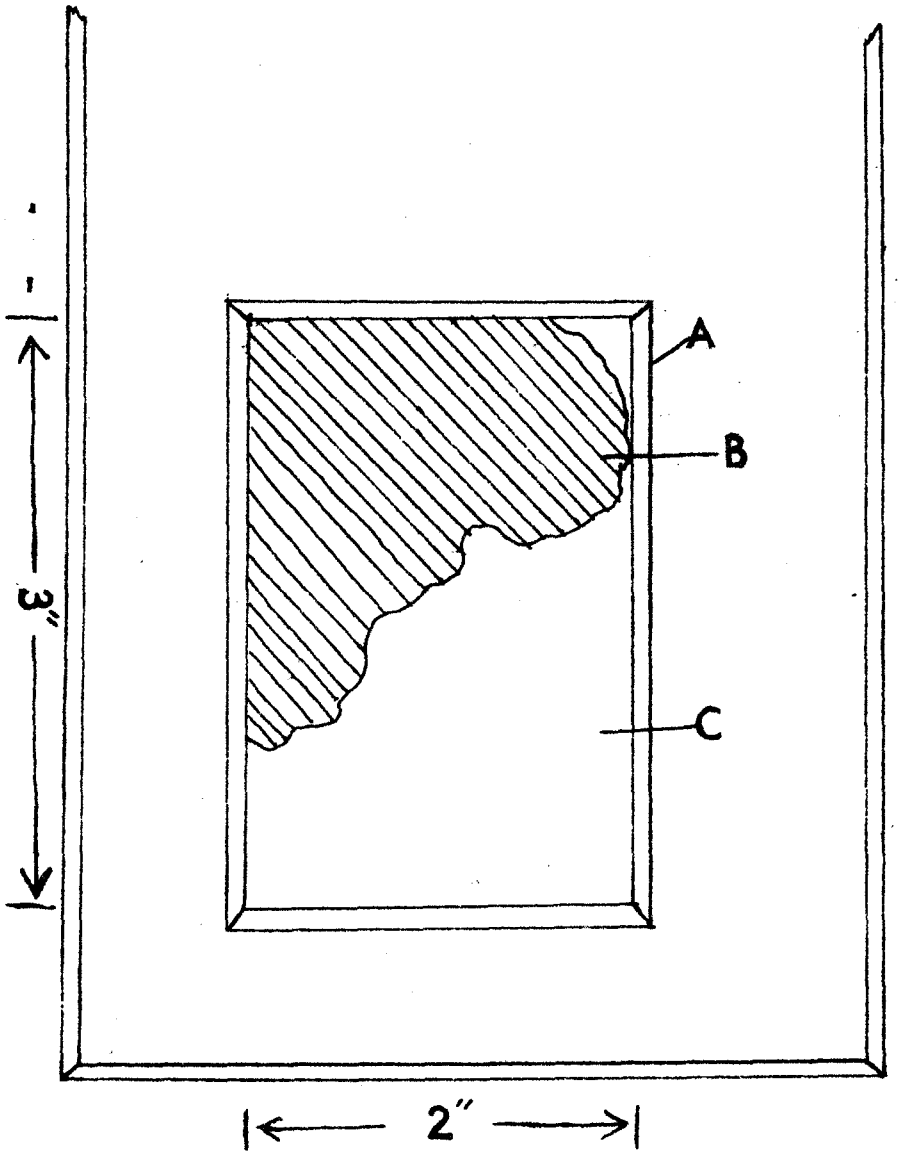


Fig. 1. Apparatus for studying visual reinforcement in fighting fish. (All dimensions in inches.)

A. Aquarium
B. Opaque lucite block
C. Response chamber
D. (male Betta)
E. Visual reinforcing model
F. Overhead lamp
G. Lucite strip attaching response-detector to aquarium lid
H. Microswitch
I. Sprocket chain
J. Gear
K. Motor
L. Opaque Screen
M. Microswitch roller



A. Lucite covered frame, 2 inches X 3 inches

B. Area covered by bubble nest (shaded)

C. Area inside frame, not covered by bubble nest

Ott Polar Planimeter scale values read 1/4 of the percentage of total area covered by the bubble nest. Thus, scale values (indicated on the ordinate of Fig. 3 and 4) should be multiplied by 4 to yield percentage of available area covered by bubble nest.

Fig. 2. Approximate location and method of calculating relative bubble nest area using an Ott Polar Planimeter.

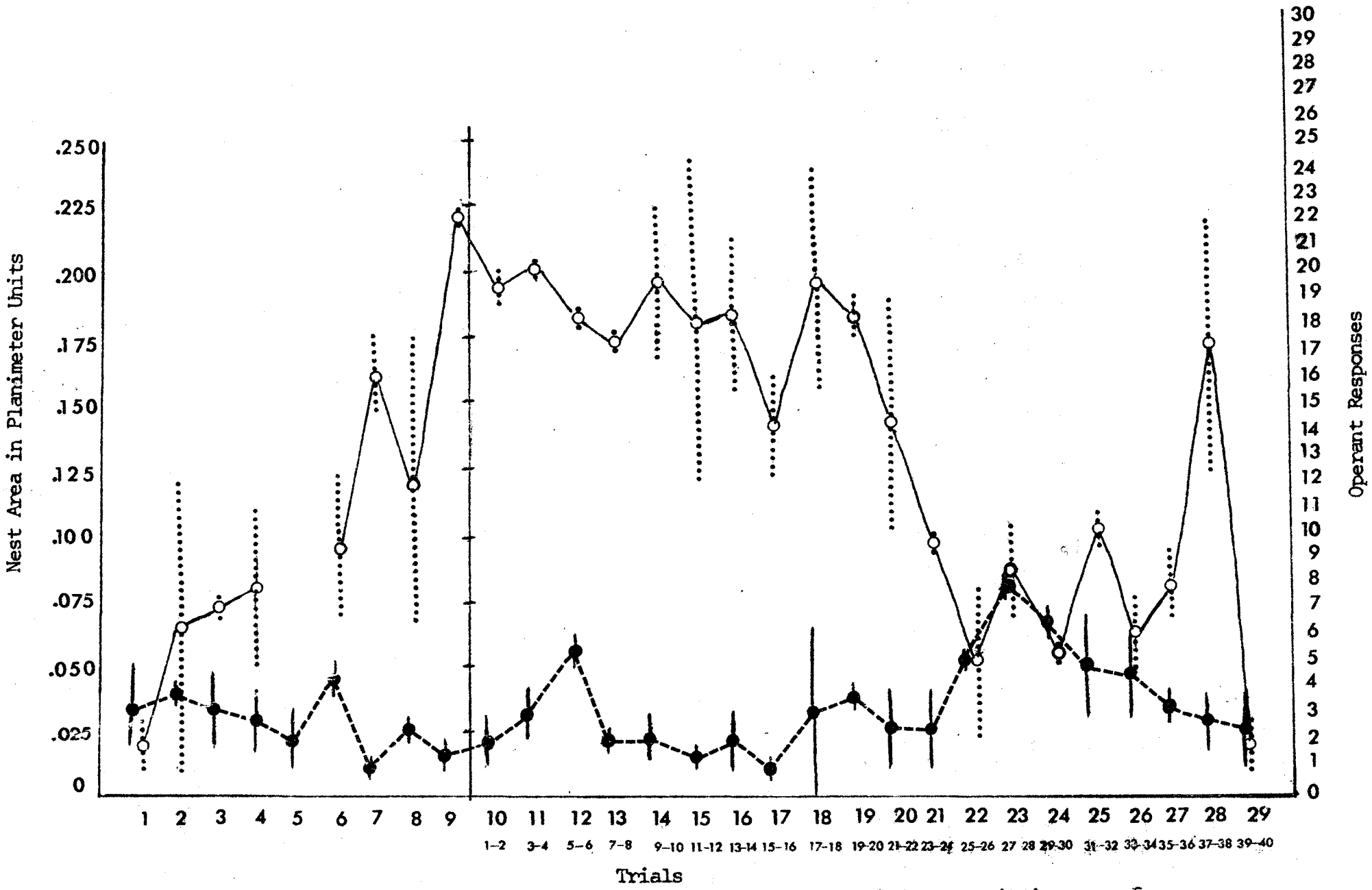


Fig. 3. Mean and ranges of operant swimming responses and relative nest building area for Fish #1. The dotted line indicates mean operant responses of morning and afternoon sessions on a given day, and the solid line presents relative nesting area.

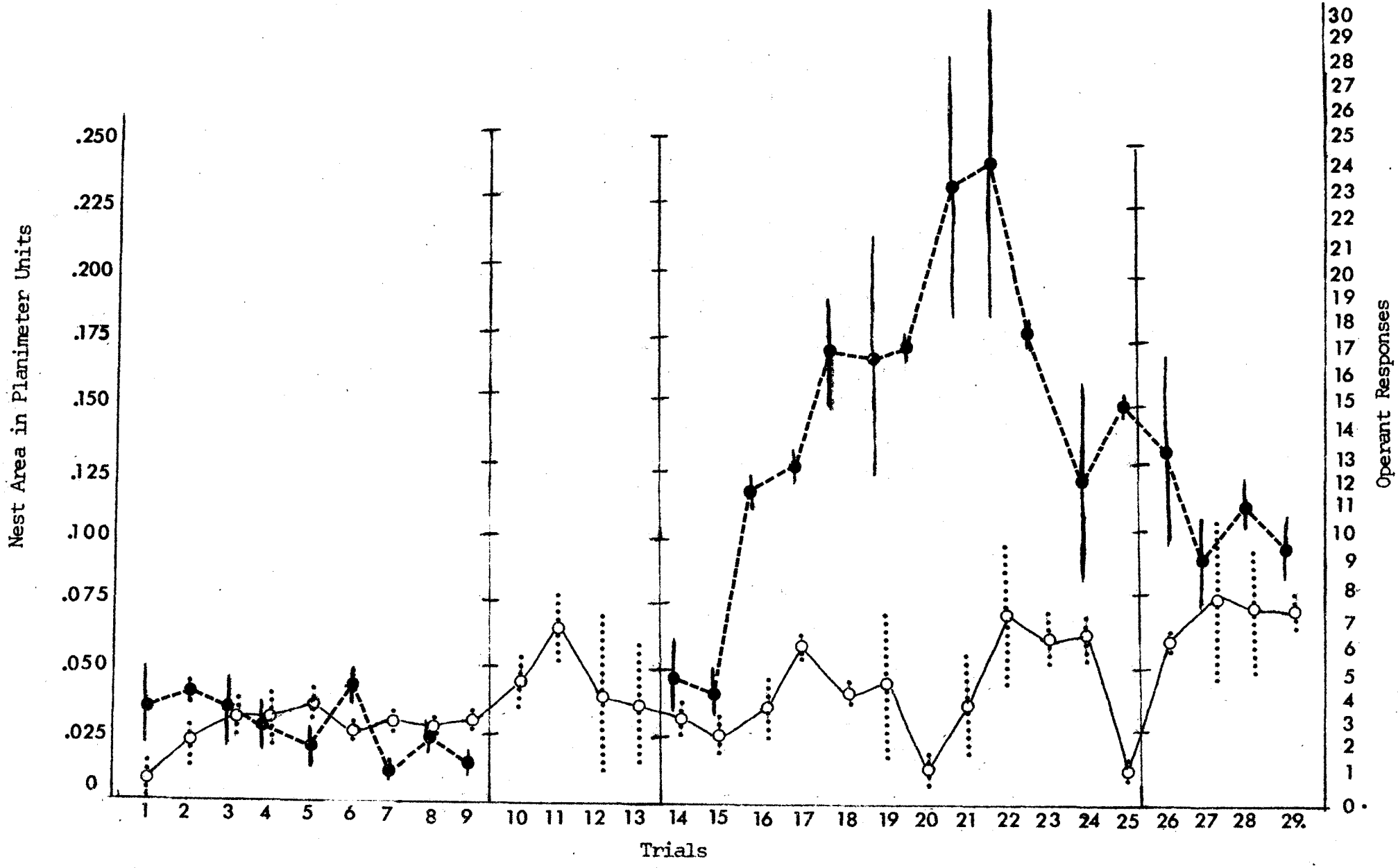


Fig. 4. Mean and ranges of operant swimming responses and relative nest building area for Fish #5. The dotted line indicates mean operant responses of morning and afternoon sessions on a given day. and the solid line presents relative nesting area.

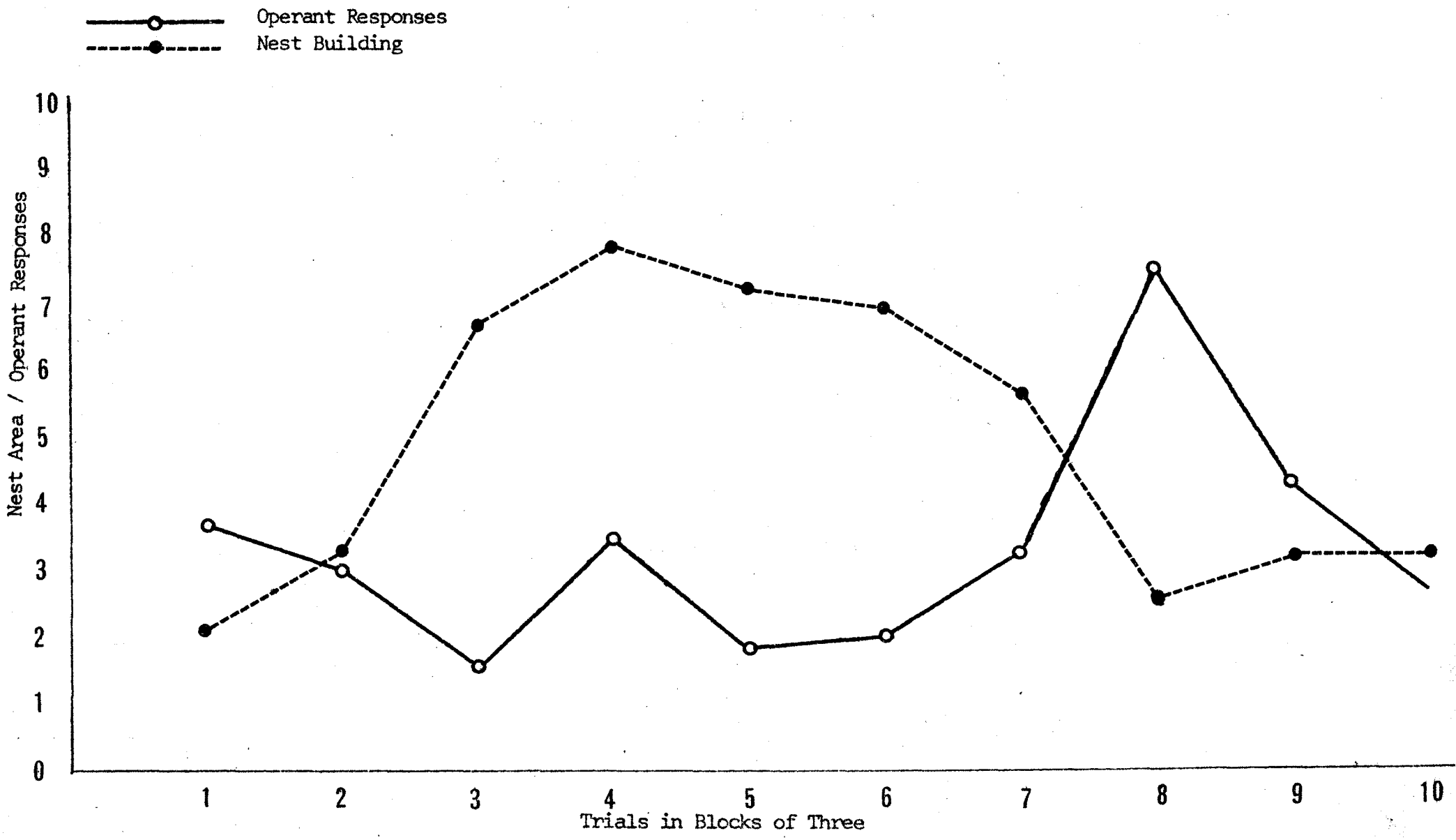


Fig. 5. Mean channel swimming and nest building for Fish #1 grouped by three day periods, and expressed on a common scale of one to ten. Scale values of 10 indicate 100% of the nesting was covered or 10 operant responses were emitted per session.

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Footnotes

1. This research was supported in part by Research Grant GB 4518 from the National Science Foundation

2. Bubble nests are usually constructed beneath objects floating on the surface of the water, such as leaves.