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Highly Repetitive Object Play in a Cichlid Fish (*Tropheus duboisi*)

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Abstract

Whether play occurs in fishes has long been a contentious issue, but recent observations document that social, object, and locomotor play can all be found in some species of teleosts. However, quantitative studies and those documenting individual differences are rare. We recorded hundreds of occurrences of an unusual behavior in three male *Tropheus duboisi*. The target behavior of attacking and deflecting an object that rapidly returned to its upright position not only fit the criteria for play behavior, but differed quantitatively and qualitatively among the individuals. This behavior has not been observed in other species of cichlids and other kinds of fishes. The presence or absence of food or other fish either within the aquarium or visible in an adjacent aquarium had no marked or consistent effect on the occurrence of the behavior. Various explanations for the origin and function of the behavior are discussed.

Introduction

Behavior patterns labeled as play are enigmatic phenomena that typically have been restricted to mammals and perhaps birds (Bekoff & Byers 1981; Fagen 1981). Claims for play in non-endothermic vertebrates and invertebrates have been largely dismissed as anecdotal, anthropomorphic, developmentally immature instincts, or otherwise misinterpreted (Fagen 1981; Burghardt 2005). Fish are one of the groups in which play has been controversial and generally discounted (Beach 1945; Burghardt 2005), although both Fagen (1981) and Burghardt (2005) cited intriguing early papers on mormyrid (weakly electric) fishes, which are known for complex and intelligent behavior (c.f., Burghardt 2005). Yet the typical and implicit anthropomorphic criteria for play in the past precluded serious consideration of these and other piscine examples of putative play (Burghardt 2005).

However, more precise definitions of play and the opportunity to obtain extensive video recordings of behavior have allowed scientists to provide convincing documentation that play behavior can occur in a taxonomically diverse array of vertebrate and invertebrate species (Burghardt 2005; Graham & Burghardt 2010; Pruitt et al. 2012). In any event, quantitative data on play of any kind in fishes are rare, although the observational data that are available fit the five criteria for play recently advanced as definitive (Burghardt 2011). Here, we present data, based on many hours of video recording, on a peculiar interaction with an object in a cichlid fish, repeatedly striking a bottom-weighted thermometer. Seen thus far only in *Tropheus duboisi*, the behavior was found in three individuals housed similarly without any conspecifics. The behavior seems to satisfy the five play criteria (Table 1). We describe the phenomenon, present quantitative data, evaluate the effects of feeding and agonism, and consider various alternative explanations of the behavior.

Methods

Subjects and Housing

The fish were three male adult captive-bred *T. duboisi*, approximately 13 cm in length, of Lake Tanganyika origin, studied, and filmed individually in the same tank over approximately a 2-yr period. They will be referred to by numbers in the order studied. They were housed in an approximately 60-l aquarium

Table 1: A listing of the five criteria used to define play behavior in animals and the reasons thermometer knocking by *Tropheus duboisi* meets them

Criterion	Fit
1. The behavior is incompletely functional in the behavioral context in which it is expressed	No obvious function of the behavior is apparent, although the behavior may be derived from agonistic charges
2. The behavior is voluntary, spontaneous, or rewarding	The behavior occurs without setting events such as competitors or food deprivation
3. The behavior differs from ethotypic functional versions in form, targeting, or ontogenetic timing	The behavior differs from other contexts in which it might occur such as mating, feeding, and fighting
4. The behavior is repeated with some regularity, but is not rigidly (pathologically) stereotyped	All the fish engaged in the behavior repeatedly, and the attacks were variable in execution and timing
5. The behavior is initiated in the absence of severe chronic stress such as disease, crowding, hunger, and predation	All fish were in fine condition in appropriate environments isolated from social stress induced by conspecifics or predators

(51 cm long, 46 cm high, and 25 cm wide). Water was maintained at a pH of 7.8–8.0 and a temperature that ranged from approximately 25°C in winter to approximately 27°C in summer. An Aqua-Clear biological and mechanical outside filter was used with a 50% water change every 2 wk. Fluorescent lights over the tank were on a 0900 to 2200 schedule.

The tanks were furnished with crushed coral substrate, Texas limestone holey rock, and plastic plants. The fish were fed Spirulina flakes, algae wafers, and True Life Spectrum Cichlid Formula. This species is an algae gleaner in the wild and not a predator. On the bottom of the tank, near the side being filmed and roughly centered, was a submersible commercial bottom-weighted thermometer 11.4 cm in length and having a mass of 13.2 g. The thermometer was in the tank continually during all the days of the observation, but on a few instances was moved to a corner of the tank through activities of the fish.

Two tanks of the same size were placed next to one another. There were sometimes fish of other species (see below) in the adjacent (left) tank during some of the observations, and during some of these, there was an opaque barrier so the focal fish could not see the adjoining tank and fish. Thus, we have observations where the *Tropheus* could see other fish. Some of these fish were ignored, while others elicited frequent attention, even charges. These events were used to assess the possible role of agonistic social interactions in mediating responses to the thermometer. During some of the observations, feeding occurred in which food flakes slowly sank, and these occurrences were used to assess whether feeding behavior mediated responses to the thermometer.

During the tests with Fish 1, the adjacent tank contained a cichlid *Petrochromis trewavasae*. This fish was larger than the *Tropheus*. During the tests with Fish 2, the adjacent tank contained the *Petrochromis* and a group of small cichlids (*Julidochromis transcriptus*). During the period the observations were recorded, the tank with Fish 1 contained a catfish *Synodontis brichardi* that was somewhat longer than the *Tropheus,* and several (3–4) cichlids of much smaller species *J. transcriptus*, *J. ornata*, and *J. marlieri*. Only the *Julidochromis* were in the tank with Fish 2. With both fish, a cardboard partition blocked the view of the adjacent tank in some tests (Table 2).

During the tests with Fish 3, the adjacent tank only contained a large (30 cm long) *Pterygoplichthys gibbiceps* catfish that ignored the *Tropheus* and vice versa. The visual barrier was not used. The tank where Fish 3 resided was less cluttered with objects and retreats and contained no other fish. During some taped sessions with Fishes 2 and 3, the animals were, or had recently been, fed with the flaked diet. Details of all trials are noted in Table 2.

Video Recording

Filming usually commenced in early afternoon (1225–1425) with three exceptions (0915, 1045, 1900). A VHS video camcorder was placed approximately 60 cm from the front of the tank containing the thermometer and fish. An observer started the tape and then generally sat quietly watching the tank during the 2 h or so that each tape lasted. However, the knocking on the thermometer was quite audible, especially when it hit the glass side of the tank, and could be heard even when the observer was in an adjoining room well out of sight of the fish. The fish apparently paid little attention to the observer when he was in the room; together, these observations rule out any concern that the behavior was considerably influenced by the human presence.

Video recordings were taken with a VHS camera in durations of 123–163 min (mean duration 156) on several different days for each animal. Fish 1 was recorded for 247 min over 2 d 15 d apart, Fish 2 was

Table 2: Subjects, conditions, and data on contacts with thermometer, wall orientation, and chases of other resident fishes

							Thermometer contacts (play)				Facing/touching left wall				Small fish chases			
Fish	Tape #	Tape length (min.)	Food	Barrier	Adjacent fish visible	Min. object available	N	Rate/min	Duration (s)	Mean duration	N	Rate/min	Duration (s)	Mean duration	N	Rate/min	Duration (s)	Mean duration
1	1	123	N?	N	Y	123	24	0.19	99	4.13	119	0.97	4070	34.2	3	0.02	7	2.33
1	2	124	N?	Y	N	124	129	1.04	432	3.35	0	0	0	0	2	0.02	5	2.50
2	1	163	N?	N	Y	163	61	0.38	280	4.59	45	0.28	301	6.69	4	0.02	3	0.75
2	2	163	Y	N	Y	163	124	0.76	505	4.07	168	1.03	1489	8.86	12	0.07	27	2.25
2	3	163	N?	Y	N	163	105	0.64	425	4.05	11	0.07	54	4.91	11	0.07	14	1.27
2	4	163	Y	Y	N	163	125	0.77	815	6.52	12	0.07	57	4.75	6	0.04	8	1.33
2	5	163	N	N	Y	163	124	0.76	696	5.61	108	.66	2510	23.24	13	0.08	24	1.85
3	1	163	N	N	Y	154	59	0.38	134	2.26	30	0.18	70	2.33	Small fish absent			
3	2	163	Y	N	Y	163	35	0.21	261	7.46	30	0.18	483	16.1				
3	3	163	N?	N	Y	163	117	0.72	807	6.90	25	0.15	284	11.36				
3	4	163	N	N	Y	163	122	0.75	487	3.99	66	0.41	806	12.21				
3	5	163	Y	N	Y	163	395	2.43	1435	3.63	33	.02	46	1.39				

recorded for 815 min on five occasions over 12 d, and Fish 3 was recorded for 815 min on five occasions over 8 d.

Data Analysis

The VHS video tapes were transferred to DVDs, and the behavior recorded by VD using Noldus Observer V. 5 program with subsequent analysis of some trials by GMB and undergraduate assistants for reliability. The following ethogram was employed to evaluate the thermometer-directed behavior of the focal fish (sole *Tropheus* cichlid in the tank).

1 Attacking the thermometer (ATT): Any contact between the head of the focal fish and the thermometer that resulted in visible movement of the thermometer. Attacks separated by more than 1 s were counted as separate events. In this way, the duration of more lengthy interactions could be assessed.

2 Charging the small *Julidochromis* fish housed in the same tank (CHG): Rapid approach toward the small fish followed by the latter changing the speed and/or direction of its movement, apparently to avoid the attack. This was only possible with Fish 1 and 2.

3 Facing (FAC): Orienting toward the glass side separating the two tanks, with the focal fish's rostrum within 2 cm of the glass or touching it, and the body of the focal fish being within 45° of horizontal position. This was recorded regardless of whether there was a fish visible in the adjacent tank or if a cardboard partition separated the two tanks.

4 Other (OTH): Primarily swimming, feeding, or resting.

This classification left little room for error or personal bias. Interobserver reliability tests conducted on a 20-min part of one of the tapes (with approximately 120 separate behaviors) showed very high agreement between observers: Cohen's kappa 0.983 for recording the number of behaviors 1–3 and complete agreement in classifying behaviors 1–3 recorded by both observers. For duration, reliability was lower (estimates of durations of behaviors differed by 3–25%), but still acceptable. However, counts were the main measure of interest.

Noldus Observer V. 5 was used for recording and analyzing observations and calculating numbers and durations of behaviors as well as rates per minute and mean durations. Additionally, lag sequential analysis was used to determine whether any behavioral sequences occurred more frequently than expected by chance. In particular, we wanted to see whether attacking the thermometer or the small fish was particularly likely to follow wall-facing behavior, which would suggest that these attacks were acts of redirected aggression, with the cichlid in the adjacent tank being the original target. The observed and expected frequencies were compared using chi-square test with significance value of 0.05.

Results

ATT behavior satisfied the five play criteria (Table 1; Burghardt 2005) and is depicted in Fig. 1. All three fish pushed the thermometer repeatedly, although rates and duration of contacts differed (Table 2). The attacks were variable in execution, and there were consistent individual styles in the way the three males attacked. For example, Fish 1 primarily attacked the top of the thermometer and deflected it; the thermometer then bounced back and was often deflected again. This could occur several times in rapid sequence (bout). Fish 2 also performed in this way but, in addition, would often rotate (swirl) around the thermometer while engaging in a bout of several quick contacts. Fish 3 performed the most intense interactions. Not only did he often nudge the base of the thermometer as well as the top and midsection, but would frequently hit the thermometer so hard that it rose up in the water and then was literally batted around the tank, often to one side and across the entire length of the tank to the other corner. Sometimes, it would be lodged in the corner in such a way that it could not be interacted with. On one occasion, the observer moved the thermometer back to the center only to have the fish, within 20 s, begin batting it again.

With Fish 3, there were a few cases when the thermometer was out of view of the camera at a side until adjusted, or the thermometer was lodged so that the fish could not easily access it. When this occurred for more than several minutes, the frequency rate was adjusted to reflect this. Also, when the thermometer was moved close to the glass wall of the tank, the attacks produced a loud clacking sound when it hit the side. This sound did not deter attacks, but whether it facilitated them could not be determined in this observational study.

Fig. 1: A cichlid fish, *Tropheus duboisi* number 1, striking a bottom-weighted thermometer that would immediately right itself. It was often struck repeatedly in bouts (Photo by Ann Hawthorne).

No clear relationships were found between the level of thermometer contacts and the presence of food or other fish either in the home or in adjacent tanks. We will discuss the behavior of each fish briefly.

Fish 1 was only taped for two sessions and with only 2-h tapes. The first session allowed him to view the larger fish in the adjacent tank, which frequently approached and charged Fish 1 when he was closest to him. Fish 1 responded by facing the other fish for long periods and charging at it. Play with the thermometer (ATT) did occur with 24 bouts, but many more bouts of FAC took place with a mean duration of over 30 s. During the second session, when the view of the adjacent fish was blocked, FAC did not occur at all while thermometer play was almost five times as frequent as during the first session. Chases of the small fish in the home tank were rare during both sessions. Significantly, they were not affected by the presence or charges of the larger fish in the adjacent tank.

Fish 2 was recorded for five sessions, and two of these involved barriers blocking the view of the adjacent fish, the most aggressive of which was the same species as with Fish 1. Only this fish elicited FAC by Fish 2. In contrast to Fish 1, however, blocking the view of the adjacent fish did not lead to an increase in ATT, although during one session, the amount of FAC was the highest recorded (168), and during the next session, with the barrier, FAC was very low (12). There were 61, 124, and 124 ATT when the adjacent fish was visible and 105 and 124 when it was not. As with Fish 1, the visibility of the adjacent fish did not affect chases of the small fish in the tank with Fish 2. The presence of food did not seem to affect ATT frequency for Fish 2. The presence of food led to an increase in FAC in tape 2 and a great decrease in tape 4. Both Fishes 1 and 2 gave comparable rates of ATT averaging approximately 65 per h.

Fish 3 was generally much more active with the thermometer, increasingly so as the sessions progressed. This may be due to the fact that it had access to the thermometer for a shorter time before filming began after being moved to the small tank, although the thermometer was continually present. Fish 3 was always exposed to a fish in the adjacent tank, but this was a large catfish that was seemingly oblivious to the *Tropheus* and vice versa. Nonetheless, Fish 3 did spend some time facing the left wall, but there were few touches or lunges at the left wall. Furthermore, the fish spent about as much time at the right wall. As the tank, when it housed Fish 3, was more sparsely furnished than the tanks occupied by Fishes 1 and 2, and the rate and duration of ATT was unrelated to FAC, the presence of the adjacent catfish bore no relation to ATT. In addition, during sessions 2 and 5, when food was provided, the number of ATT was, respectively, the highest (395) and near the lowest (30) of the five sessions. In addition, Fish 3 would at times repeatedly lift up small pebbles in his jaws, rise up in the water column, and eject the stones, generally near the left wall and thus erecting a small berm near the front left corner of the tank.

To more closely look at the sequential relationship between ATT and FAC in the three fish, we carried out a lag sequential analysis. We asked whether ATT occurred more frequently before or after a FAC event for 11 of the 12 sessions. This was, in effect, asking whether ATT or FAC preceded or followed each other more often than did ATT precede or follow another ATT as would be expected by chance given the relative occurrences of both (Table 3). The results for Fish 1, which had only two sessions, are clear. With the barrier in place, no FAC occurred at all. When Fish 1 could see the adjacent fish, ATT neither preceded nor followed FAC more than expected by chance.

With Fish 2, only two significant lag patterns were seen and these were on tapes 2 and 5. FAC was followed by ATT significantly more often than expected by chance on both tapes. There was no barrier during these sessions. Food was provided on tape 2 but not on tape 5.

Fish 3 was the most different. Except for tape 5, FAC led to fewer ATT than expected. With all tapes, ATT led to a decrease in FAC with ATT more likely to be followed with another ATT.

Discussion

The thermometer-attacking behavior reported here satisfies the five play criteria. Being found in all three fishes, it seems to tap into the behavioral repertoire and motivation systems of the animals in similar, though not identical, ways. The behavior is one that is repeated often and is not just a sporadic or desultory response to a novel object that soon disappears due to habituation. In this sense, it is comparable to the object interactions recorded in *Octopus vulgaris* (Kuba et al. 2006).

However, labeling a behavior as play does not explain it, just as labeling a behavior as learned, instinctive, or any of a myriad of other labels does not end scientific inquiry. The categorization of a behavior with a validated label helps us primarily by focusing attention on attributes, causal mechanisms, and adaptive functions that might otherwise have been missed. As play seems to be derived from species' typical behavior and underlying evolved and physiological systems, it is useful to see what may be happening in the current example with our *Tropheus*. Determining the adaptive function of even the well-studied examples of animal play behavior is notoriously difficult (Martin & Caro 1985; Pellis & Pellis 2009), and that is an issue too premature to address with this initial study.

Table 3: Sequential lag analysis of ATT and FAC behaviors for all tapes showing whether each behavior is more likely to follow the other or itself. Analysis not appropriate for fish 3 Tape 1 due to interruptions caused by thermometer movement

					FAC→ATT		FAC→FAC			ATT→FAC		ATT→ATT		
Fish	Tape #	Barrier	FAC	ATT	Expected	Observed	Expected	Observed	p	Expected	Observed	Expected	Observed	p
1	1	N	119	24	18	17	91	92	0.8	16	19	4	1	0.1
	2	Y	0	129	0	0	0	0	1	0	0	120	120	1
2	1	N	45	61	23	24	17	16	0.7	25	25	34	34	1
	2	N	168	124	62	78	84	68	**0.00**7	66	74	49	41	0.13
	3	Y	11	105	8	8	1	1	1	9	8	86	87	0.7
	4	Y	12	125	11	10	1	2	0.3	10	9	108	109	0.7
	5	N	108	124	48	61	42	29	**0.006**	62	70	54	46	0.13
3	1	N												
	2	N	30	35	11	0	10	21	**0.0001**	14	0	16	30	**0.0001**
	3	N	25	117	18	5	4	17	**0.0001**	20	7	96	109	**0.0014**
	4	N	66	122	40	14	22	48	**0.0001**	41	15	77	103	**0.0001**
	5	N	33	395	2	3	29	28	0.5	30	4	361	387	**0.0001**

Significant p values are in bold.

Is the behavior related to feeding? This seems very unlikely as this species is an algae gleaner and does not attack other animals for food. It is alert to the presence of people outside the tank. For example, if they approach, and the fish is food motivated, it may approach the front glass. If no food is forthcoming, he soon gives up and resumes other activities. If a person approaches with a strange object, such as carrying a coat, the fish dashes for cover and then emerges after a few minutes (such behavior also occurs in the large community tank, again suggesting that the isolated *Tropheus* are not behaving atypically in general). Thus, novel objects outside the tank do not trigger the behavior either. Additionally, the presence of food did not have a dramatic or consistent effect on thermometer-directed behavior.

It is also unlikely that knocking the thermometer is derived from sexual behavior, as such attacks do not seem to occur in courtship in this species. JBM has observed mating in this species. The male approaches the female and vibrates his body vigorously. If she is ready, the female follows him as he continues to vibrate his body; they circle and she lays a few eggs. On the next pass, he fertilizes the eggs and she circles again and picks them up in her mouth. The interaction with the thermometer was definitely not courtship. When courtship occurs in a large community tank with many other species and conspecifics, the male is very aggressive to tank mates, chasing them away and then returning to the female and resuming vibrating. No male vibrations ever occurred with the thermometer.

What about male–male aggression or territorial defense? Lag sequential analysis clearly shows that at least for Fish 1 and 3, thermometer attacks were not a form of redirected aggression. But this is only a part of the story. All the three males had been previously removed from the community tank because they were frequently chasing other fishes including unreceptive conspecific females. This leads to the possibility that the fish may be redirecting attacks to the thermometer that would otherwise be directed at fish that could be dominated. Although there is some evidence for this in Fish 2, the opposite was found in Fish 3. However, Fish 3 never charged at the adjacent fish, and there were no small fish in his tank that he could charge or chase. Furthermore, the intensity and frequency of the behavior seem to argue against this. However, it seems likely that the play behavior with the thermometer can be enhanced through the relative social isolation. Fish 3 was the only fish without companions, but none of the fish had conspecifics present. Stimulus deprivation or boredom has been posited as a factor in the increased prevalence of play in captive animals (Burghardt 1984), and this could be operating here.

Supporting this interpretation is the observation that when the thermometer was placed in a large community tank containing at least 2 dozen taxa, including *T. duboisi* and another *Tropheus* species, the thermometer was totally ignored by both male and female fish of all species. For example, Fish 3 never responded to the thermometer in the multispecies aquarium. In this rich social and physical environment, all of the cichlids (and other species) were preoccupied with trying to defend themselves, chasing tank mates, or foraging/competing for food. It was only when *T. duboisi* were isolated in the small tanks that this behavior was expressed. Attacking other fish involves a quick jab, so thermometer attacks could be derived from agonistic behavior systems. In the socially bereft tank, we may be seeing the result of a highly motivated, low threshold behavior that may be influenced by 'boredom' and deprivation (Burghardt 1984). This fits the attributes of primary process play, which has its origins in behavioral processes outside functional consequences (Burghardt 2005, Table 5.1).

Criterion 5 in Table 1 is that play is initiated when the animal is relatively unstressed. Evidence that the fish were not stressed includes their voracious feeding behavior, attentiveness to people outside the tank that might signal providing food, and rapid returning to thermometer displacement after the object was repositioned. In addition, based on years of experience rearing and housing many cichlid fish species by JBM, stressed cichlids constantly hide and show little interest in food. These conclusions are supported by research on other cichlid species (Baretto & Volpato 2011; Martins et al. 2011).

But why was the behavior only directed toward the thermometer? There were sticks, plants, hiding areas, rocks and pebbles, and other non-animate objects in the tank that were never manipulated. One exception was that Fish 3 often picked pebbles up in his mouth, swim up, and then dropped them at a distance, especially on the side of the tank facing the catfish (a frequent reproduction-associated behavior in mouthbrooding cichlids). Furthermore, the other objects in the tank were never attacked, even when the thermometer was removed on occasion. Was there something unique about the thermometer?

Probably, the most salient feature of the thermometer was its 'reaction' or response—it bounced back after being knocked and, as Fish 3 discovered, could be moved around the tank where it always alighted in the bottom-weighted position. The quick righting response, in particular, seemed the primary stimulus factor that maintained the behavior. Being critically anthropomorphic, we can hypothesize that the bouncing back was a simulated counterattack by an opponent that was never successful! Given that these were fish that had dominated and chased virtually all other fish in the community tank, such successful attacks, albeit against a 'toy', could indeed be reinforcing and maintain the behavior for long periods in spite of the fact that the toy never 'voluntarily' moved away. Most novel objects are played with for only short periods before habituation, unless there are many ways of responding to them and they also respond in turn (e.g., Kuba et al. 2006). Balls have this feature; octopus have been observed to repeatedly grab floating objects and pull them underwater and then release them so that they would pop back to the surface and stimulate more behavior toward them by the octopus (Kuba et al. 2006). Such reactive features are shared by many of the toys which are most successful with companion animals, children, and others.

In sum, we are left with a behavior that seems clearly rewarding to the fish, and it seems that the counter response made by the thermometer is the salient feature, as no other fixed object or stick in the tank led to such responses. What remains most intriguing, however, is that all other fish presented with this kind of thermometer that JBM has used in keeping dozens of species, singly and in groups, over decades, have never reacted in ways as consistent and fascinating as did *T. duboisi*.

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