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Problem of Reptile Play: Environmental Enrichment and Play Behavior in a Captive Nile Soft-Shelled Turtle, *Trionyx triunguis*

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Giving captive animals the opportunity to interact with objects in a "playful" manner is often considered a method of environmental enrichment. However, the occurrence of play in nonavian reptiles is controversial and poorly documented. Similarly, the role of environmental enrichment in fostering psychological well-being in reptiles has been little studied. For several years, an adult, long-term captive, Nile soft-shelled turtle, *Trionyx triunguis*, at the National Zoo (Washington, D.C.), was provided objects such as balls, sticks, and hoses in an attempt to reduce self-mutilation behavior. The turtle spent considerable time with the objects, and the level of self-mutilation behavior decreased greatly over many months. Video recordings made in various contexts were analyzed in detail, and an ethogram of this turtle's behavior was developed. The turtle interacted with the objects (e.g., basketball, hose, stick) for 20.7% of the time it was observed and was active for 67.7% of the time. Both figures are unusually high for any animal, especially a turtle. The relative lack of play in ectothermic reptiles is supported by the surplus resource theory of play, which considers the joint effects of parental care, metabolism, endothermy, and arousal in providing the context in which playfulness could be manifested and promoted in vertebrate evolution. The existence of vigorous playlike behavior in a member of an ancient reptilian lineage indicates that, in the right circumstances, object play can be performed by reptiles and that having the opportunity to do so may be beneficial in captivity.

Key words: reptile, captive maintenance, psychological well-being

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INTRODUCTION

The rapid recent growth of interest in the exhibition, breeding, and conservation of ectothermic reptiles has led to this dedicated issue of *Zoo Biology,* among other recent volumes [Murphy et al., 1994; Schaeffer et al., 1992; Warwick et al., 1995]. The physical requirements of nonavian reptiles as ectotherms and their often extreme reliance on habitat characteristics have been recognized and utilized in feeding, breeding, rearing, and exhibition. The complex social interactions of many reptiles and the implications for group housing of captive reptiles also are being recognized [Alberts, 1994]. Measures of stress due to physical and social factors are being developed that should aid dramatically in improving the welfare of captive reptiles. But phenomena of a seemingly more learned or psychological nature often have been neglected [but see Burghardt, 1977; Greenberg, 1992; Chiszar, et al., 1995; Warwick, 1995]. In this report, we discuss the relevance to captive management of ectothermic reptiles two phenomena generally discussed only with birds and mammals. One of these, environmental enrichment, is a common means of avoiding boredom or stress, as indicated by stereotyped or maladaptive behavior directed at self or conspecifics [Markowitz, 1982]. The second is playfulness, a concept rarely invoked in discussions of nonavian reptile (hereafter, reptile) behavior. We focus on a presumed example of play and show that it is related to the possible role of environmental enrichment in the well-being of captive reptiles.

The evolutionary origins of playful behavior are among the major unresolved issues in our understanding of play [Bekoff and Byers, 1981; Burghardt, 1984]. The issue is no doubt clouded by the lack of a widely accepted definition of what constitutes play. Most attempts to apply the evolutionary approach to play have dealt primarily with the function of play and how such functions might be determined [Martin and Caro, 1985] or computer modeled [Fagen, 1981]. Since play is unequivocally documented in both mammalian and avian taxa [Ficken, 1977; Fagen, 1981; Ortega and Bekoff, 1987], the presence of play in the ectothermic reptile grade of organization is of critical interest. For example, is playfulness a plesiomorphic trait (or set of traits) that existed in the common vertebrate ancestors of birds and mammals, or has it arisen independently in various lineages? Yet, play in reptiles is poorly documented indeed, leading Burghardt [1988] to predict, on physiological, psychological, and life history grounds, that typical vigorous play in reptiles, whether locomotor, object, or social, should be rare and occur only in specific contexts in which those factors facilitating play in mammals and birds are also present to some extent.

In his exhaustive survey of the literature on animal play, Fagen [1981] could locate only two examples of reptile play, anecdotal reports of object play in a captive Komodo monitor lizard [*Varanus komodoensis,* Hill, 1946] and a field observation of an American alligator (*Alligator mississippiensis*) repeatedly attracted to, and snapping at, water dripping from a spout [Lazell and Spitzer, 1977]. Reptiles are generally thought not to be capable of sustained vigorous activity because of metabolic constraints [Bennett, 1982]. On these and other grounds, Burghardt [1984] concluded that play behavior was "rare to non-existent in poikilothermic (cold-blooded) vertebrates." Here, we report on detailed videotaped observations of object play in a Nile soft-shelled turtle, *Trionyx triunguis.* Our goal is not to define this behavior as *play* unequivocally, but to evaluate whether it meets criteria used in claims for mammals and birds that the animals being observed are engaging in play.

The evaluation of whether any given behavior patterns fall under the rubric "play" cannot be evaluated without information about other aspects of species biology and behavior. Thus we first review what little is known about this species in field and captivity. We then provide an ethogram and activity budget of the captive individual we observed, including the playlike elements. We seek to answer whether any of the observed behaviors correspond to established definitions and characteristics of play. We also compare our results to the prior reported instances of reptilian play and consider the factors that may have led to the manifestation of such behaviors in these species. Finally, we address some possible implications of our results for enriching the lives of captive reptiles.

NATURAL HISTORY OF *TRIONYX TRIUNGUIS*

The Nile soft-shelled turtle is among the largest of the soft-shelled turtles, with a carapace length up to a 95 cm and a mass of 90 kg [Ditmars, 1933; Ernst and Barbour, 1989]. Recent phylogenetic analysis [e.g., Meylan, 1987] suggests it should be the sole member of the genus *Trionyx* and considered an early offshoot of the group. The species, also known as the African soft-shelled turtle, is an aquatic turtle whose native range covers much of the African continent except the waterways of southern and northwestern Africa. It also exists along the coasts of Israel, Lebanon, Syria, and Turkey. The usual habitat is slow-moving fresh water, such as a large river, stream, pond, or lake, but it also enters brackish water where its range meets the sea [Ernst and Barbour, 1989]. Aquatic oxygen respiration is known in this species [Stone et al., 1992].

Very little is known about the life history of this species [Ernst and Barbour, 1989]. Individuals are usually seen only when basking on mud banks or sand bars, when females lay their eggs (~25–100) on shore, or when they are trapped in the nets or hooked on the lines of fishermen [Ernst and Barbour, 1989; Kasparek and Kinzelbach, 1991; Leshem, et al., 1991]. *Trionyx triunguis* is apparently omnivorous, feeding on live as well as dead aquatic insects, crustaceans, mollusks, fish, and amphibians and plant items such as palm nuts and dates. Reportedly, the turtle lies in ambush, grabbing its prey when it comes within reach [Ernst and Barbour, 1989]. Pope [1956] observed that soft-shelled turtles swallow their food whole, the front feet helping to manipulate it.

North American soft-shelled turtles (formerly *Trionyx,* now *Apalone,* although the generic designation is still in flux) are considerably smaller but much better known [Webb, 1962]. There is a limited amount of quantitative work on movements and habitat use [Plummer and Shirer, 1975; Plummer, 1977a; Williams and Christiansen, 1981], feeding [Plummer and Farrar, 1981; Williams and Christiansen, 1981], and mating [Plummer, 1977b, 1977c] in North American soft-shelled turtles, but no attempt has been made to determine the activity budget of any species of soft-shelled turtle. They are reported to spend a great portion of the day in shallow water with their shells buried in the mud or sand of the river bottom, occasionally lifting their head upward and extending their nostrils out of the water in order to breath. They do not spend all their lives on the bottom, however, as they are fast and agile swimmers capable of chasing after and capturing fish [Marchand, 1942, in Carr 1952]. As we document here, this vigorous, agile foraging was also common in our captive specimen.

In this study we observed the turtle in his standard exhibition environment, during feeding on live fish, with several different objects, and when the water level was lowered. Objects had been provided to the turtle for several years prior to our study as a deliberate and successful attempt to reduce self-injurious behavior.

MATERIALS AND METHODS

Subject, Housing, and Maintenance

The subject was a male Nile soft-shelled turtle, *Trionyx triunguis*, on permanent exhibit at the National Zoo (Washington, D.C). This turtle, named Pigface, was a captive at the zoo for >50 years. Zoo records indicate that he was acquired in 1940 when his carapace length was ~15 cm. In the 1980s, keepers observed him raking his foreclaws into the flesh on his neck and also biting his forelimbs. Considerable damage to the skin and muscle was observed, along with infection and fungal growth. In July 1986, in an attempt to stop this detrimental behavior, the keepers added several objects to the turtle's tank, including a rubber hoop, a hose, a basketball, and several large sticks. They hoped that the turtle would direct his attention and activities toward these objects and away from himself. Unfortunately, no records are available as to the dates when various objects were provided or the initial behavioral response to them. The level of self-mutilation behavior, as shown by sores and wounds, did decrease. However, it was also noted that when the objects were continuously available for long periods, Pigface would interact less with them, and the self-mutilation would increase. Thus, although the provisioning of objects continued on a fairly regular basis, it was interspersed with breaks of up to several weeks' duration with no added objects.

During this entire period, including the observations reported here, the turtle was housed in a tank with a concrete floor, three concrete walls, and a glass wall for viewing. The tank was 2.9 m wide at the glass viewing end and extended back 3.0 m. The water depth was normally 88 cm. Fresh water (24.4–26.7°C) was added to the tank through a hose. Several hanging plants were suspended over the water surface, but the turtle typically ignored them. During our observations, relatively straight, waterlogged wood branches, ~1 m long and 2.5 cm in diameter, were on the floor in a group toward the rear of the tank. Prior to May 1992, the turtle was fed twice a week by pouring six large (~20 cm long) live goldfish into the tank and allowing the turtle to hunt and chase them. The turtle was also fed a large dead rat once a week. Beginning in May 1992, the turtle was fed three goldfish every day and a small rat once a week.

A little more than a year after the data presented here were collected, the turtle began to feed erratically and visibly declined in vigor. He died on October 21, 1993. The autopsy report indicated heavy nematode parasitism, anemia, and inanition. His carapace length was 79.8 cm, carapace width 60 cm, and his mass was 30 kg. The latter was probably less than during the observation period. His death precluded planned control and experimental studies.

Observational Methods

Preliminary observations were made in December 1991, while an inflated regulation size basketball floated on the water surface in the tank. The turtle interacted with the basketball frequently enough that continuous data recorded over a few days were considered sufficient to obtain quantitative data for analysis. Formal observations and videotaped recordings were made on August 4 and 6, 1992. During these sessions, 167.2 minutes of usable videotaped material were obtained.

The video record included periods when several objects were added to the tank in addition to the sticks that were always present. These objects included an old familiar standard size brown basketball, a new unfamiliar orange basketball of the same size, and a round hoop prepared from a 2 m section of garden hose partially filled with water (so that it would float vertically as well as horizontally), the rubber fill hose, and fish. We analyzed the video, constructed an ethogram, and compiled an activity budget. A sequential record of the video was then constructed identifying where, when, and in what order the activities were performed. From these data, the duration and percentage of time the turtle spent performing each activity, the percentage of time spent interacting with an object when it was available, the frequencies and rates of approaches to the objects, and the frequencies and rates of contact with the objects were calculated.

The turtle was videotaped on hi8mm tape for 22.5 min beginning at 1320 h on August 4, 105.0 min beginning at 0834 h on August 6 (excluding 10 min when the animal could not be seen on tape due to visitors crowding in front of the glass), and for 39.7 min beginning at 1301 h on August 6. The short observation periods on the afternoons of August 4 and 6 were pooled: the conditions of the tank and objects present were the same. On the morning of August 6, three goldfish were introduced to the turtle before the basketball was introduced. The water level in the turtle's tank was also lowered ~25 cm and then a hose was introduced to the tank to refill it. Three fish were again added to the tank ~1015 h. We analyzed the morning and afternoon sessions separately and then together.

Although the plants hindered some observations at the surface, we also attempted to determine the frequency of breathing at the surface and the interval between surfacings for breathing. Records of breathing were made for both afternoon observation periods and the average time between surfacings was calculated.

RESULTS

Behavior Patterns Observed

We classified the turtle's behavior into patterns indicating kind of movement (locomotion) or type of activity being performed.

Locomotion categories (and their abbreviations) were as follows:

1. Resting (rt). Turtle horizontal on bottom of the tank typically with all four limbs touching the substrate. Turtle motionless except for the occasional movement of his head. Resting often occurred with the turtle's head in a corner. When the hose was present and filling the tank, the turtle also frequently rested in front of the hose outlet and manipulated it with his nose and legs and directed the current flow toward his head. Resting was usually followed by standing and swimming.
2. Standing (st). Turtle on the bottom with two or three legs touching. The body was 45° or more from the horizontal, and his head was raised upward and usually appeared to be watching something or getting ready to swim.
3. Walking (wk). Turtle on the bottom and moved slowly forward. The turtle would propel himself forward with all four legs or with only the front legs and drag

the rear legs. When the water level was lowered, this behavior was difficult to distinguish from swimming. Walking usually occurred in the context of either going from an object to a rest area or going from a resting posture towards an object.

4. Floating (fl). Turtle suspended and stationary in the water, although his position was maintained by the gentle stroking of his feet. The turtle's body was usually at a 60° angle to the horizontal with his head up. This is the locomotory posture the turtle used when he was breathing, playing with the basketball, and playing with the hoop.

5. Swimming (sw). Turtle moving through the water propelled by his legs. One front leg and the opposite rear leg were pushed back at the same time, followed by a glide. Then, the other front leg and opposite rear leg were pulled forward and pushed back and the sequence was repeated. The turtle could be very agile and quick when he swam, often changing directions rapidly.

Major activity categories (and their abbreviations) include:

1. Breathing (br). The turtle swam to the surface and floated there while he lifted his nose out of the water and took in air. After ~4 sec, he would sink toward the bottom. It was hard to tell the details of this behavior from the video because there were no closeups of it.

2. Nosing objects (ns). The turtle approached an object with an extended head and touched the object with the tip of his nose for a second or more. This was usually followed by either biting the object, nosing again, or leaving the vicinity of the object. Occasionally, especially with the hoop, the turtle ran his nose along the object for several seconds.

3. Biting (bi). The turtle strikes at the object by quickly extending his head forward while opening his mouth. The jaws are quickly closed and the head retracted. The object is then, if possible, held in the turtle's mouth. Chewing, push/pulling, shaking, and legging usually follow biting.

4. Chewing (ch). The turtle opened and closed his mouth repeatedly on the object (usually a stick) while moving his lower jaw. This behavior and the following three resemble a dog playing with a bone or stick.

5. Push/pull (pp). The turtle had the object in his mouth and pulled his head back into his shell, then extended his neck and pushed the object forward. The pulling back of the object was usually performed at the same time that the turtle was pushing forward on the object with his legs. This and the leg behaviors were often repeated several times.

6. Shake (sh). The turtle had the object in his mouth and would rapidly move his head from side to side.

7. Legging (lg). The turtle used his front legs in conjunction with the chewing and push/pull behaviors to hold down, draw closer, or otherwise maintain contact with an object. The motion of the legs was a forward and outward sweep. The turtle used this motion to tear large rats into smaller pieces.

8. Fishing (fish). When fish were placed in the tank, the turtle immediately ceased all other activities and chased down and captured the fish with great speed and agility using a rapid bite. Once a fish was seized, it was quickly swallowed whole. If no fish were visible, being blocked by the floating vegetation, the turtle actively hunted for them via a very thorough search of the tank, including the corners and the

plants. As soon as he spotted one, a chase again ensued. Hunting continued to occur for a brief period after all fish were captured.

Activity Budget

The turtle was active during 67.7% of the 167.27 min he was videotaped. He spent 20.7% of the time interacting with the inanimate objects in his tank (Fig. 1). This was ~31% of total active time. The proportion of time spent with the different objects is even higher if calculated only for periods that the objects were available (Table 1). When the fish were introduced, the turtle devoted all his attention to them, spending 571 sec hunting for goldfish and 181 sec chasing them when he found them. During periods when fish were present, only 3 sec were not engaged in fish related behavior, and this was when he came up to the surface to breath.

The turtle was observed breathing 12 times for a mean breath duration of 4 sec (s.d. – 2 sec). The mean time between breaths was 315 sec with a s.d. of 182 sec. Some breaths were probably missed when the turtle broke the surface in biting the hoop or basketball. Still, in spite of his almost continuous activity, the turtle could easily go 8 or more min without breathing air.

Responses to Nonfood Objects

The objects (and their abbreviations) that the turtle had access to at various times and the responses noted were:

1. Basketball (bb). The basketball was floating at the top of the tank. The turtle nosed and bit at it, often following the ball as it moved across the surface (Fig. 2). Although the total time with the basketball was not high, a ball was present >90% of the time. There was more time spent with it in the afternoons (7%) than in the morning (1%). The turtle showed no preference for either basketball when both the brown (original) and the orange (new) balls were present (total duration – 2,110 sec). He approached the orange ball 11 times, making contact six times. He approached the brown ball 10 times, making contact six times.

2. Hoop (hp). The rubber hose hoop partially filled with water floated horizontally at the top of the tank and also floated vertically so the turtle could swim through it. The turtle nosed, bit, chewed, shook, legged, and push/pulled the hoop, as well as occasionally swam through it. He also would swim through it, return, and repeat the action. Overall, the hoop was the second most used object after the hose. However, whereas in the afternoons the hoop was responded to 45% of the time it was available, the turtle interacted with it only 6% of the time in the morning, when the hose was also present.

3. Stick (sk). Four or five sticks were always present at the bottom of the tank. The turtle nosed, bit, chewed, legged, and push/pulled the sticks. In the afternoon the turtle spent 18% of his time with the sticks and virtually none at all in the morning session when other interventions were occurring (lowering and raising the water level, adding fish, adding second basketball, etc.).

4. Hose (hs). The rubber hose used to refill the tank in the morning session was lowered from the top of the tank with the outlet resting on the substrate. The turtle nosed, bit, legged, and push/pulled the hose. The keeper sometimes pulled the hose when it was in the turtle's mouth and the turtle was pulled almost out of the water. The turtle responded by trying to swim backward and pull the hose back into the tank,

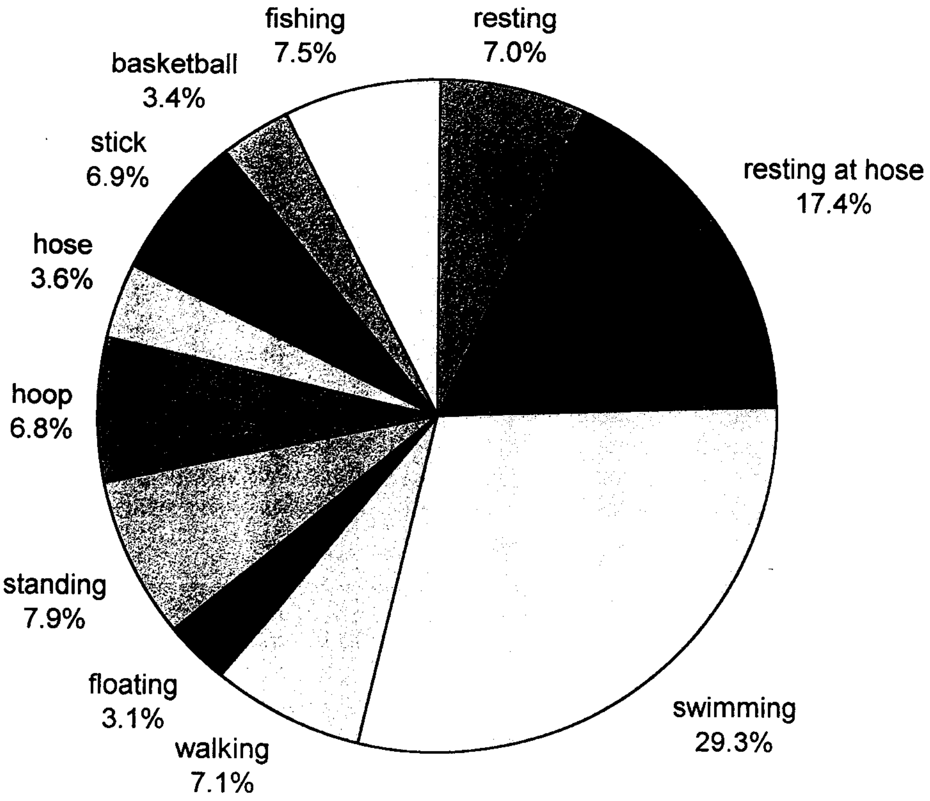

Fig. 1. Activity budget of a captive Nile soft-shelled turtle.

TABLE 1. Activities of a captive Nile soft-shelled turtle based on the time various objects were available

Behavior	Total time(s)	Percent of time activity possible
Rest	698	7.0
Swim	2939	29.3
Walk	713	7.1
Float	316	3.1
Stand	793	7.9
Rest at hose[a]	1741	53.4
Interact with hose[a]	363	11.1
Interact with hoop[a]	686	12.6
Interact with stick	691	6.9
Interact with basketball[a]	339	3.5
Interact with fish[a]	752	99.6

[a]Objects not continuously available.

like a tug-of-war game. This occurred not only in the session we taped but was a common interactive event with the keeper on cleaning days. The turtle interacted with the hose only in the morning session when it was used to refill the tank after the water

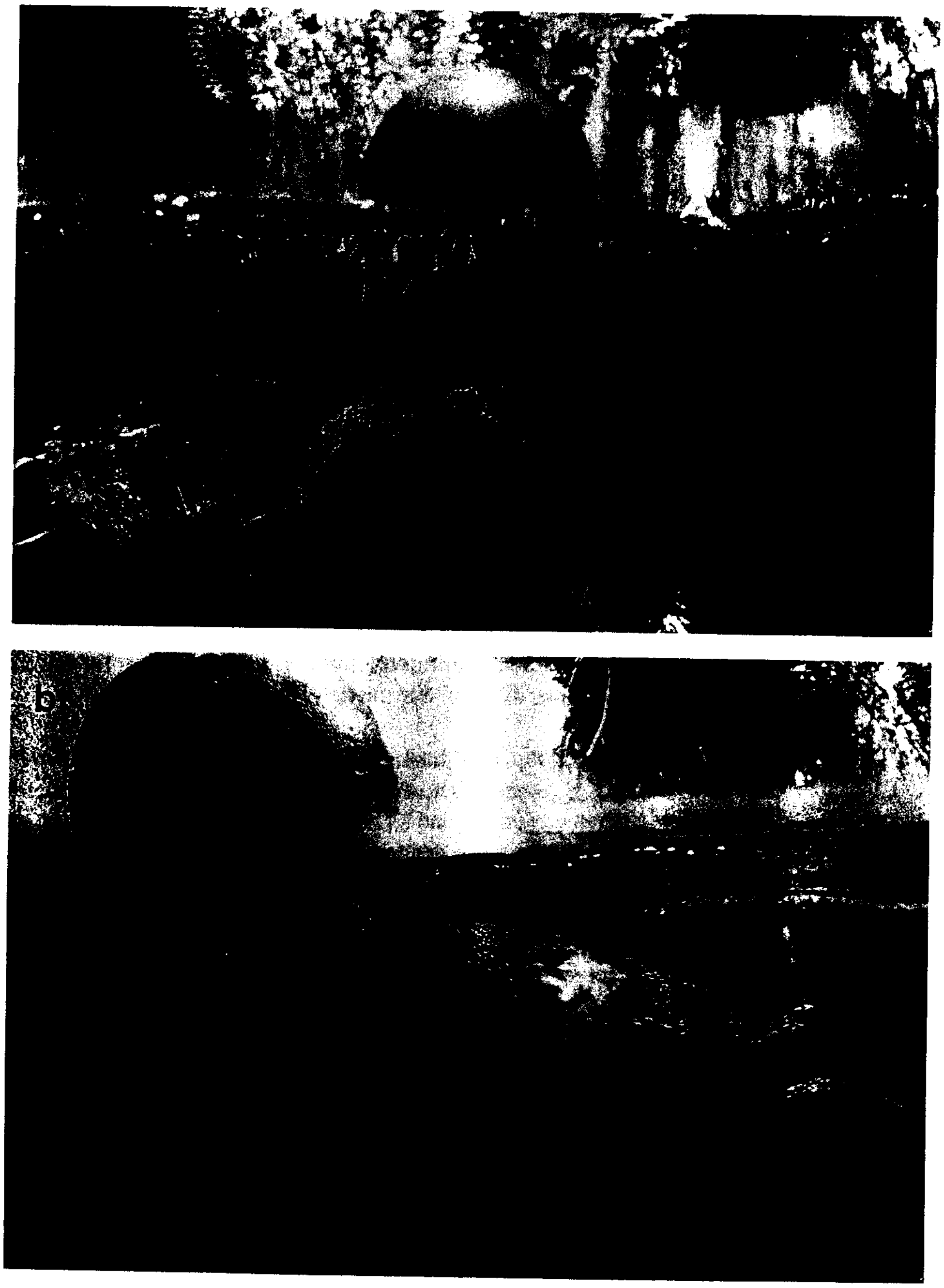

Fig. 2. Approach (**a**) and bite (**b**) at a floating basketball in the tank of a captive Nile soft-shelled turtle. Note damaged tissue on neck.

was lowered. The turtle would generally clamp his jaws on the hose when the hose was moved by the keeper. If the hose was not moving, however, the turtle spent most of his time with his head near the end of the hose where he could feel the water flow

TABLE 2. Approaches and contacts with objects by a captive Nile soft-shelled turtle*

Sessions	Total approaches	Approach rate	Total contacts	Contact rate
Afternoons (2)				
hoop	9	0.43	28	1.34
stick	20	0.32	46	0.74
basketball	26	0.42	21	0.34
Morning				
rest at hose	11	0.20	16	0.29
hose	12	0.22	26	0.47
hoop	14	0.19	22	0.29
stick	5	0.05	1	0.01
basketball	10	0.10	6	0.06
fish	13	3.05	6	1.41
Combined				
rest at hose	11	0.20	16	0.29
hose	12	0.22	26	0.47
hoop	23	0.25	50	0.55
stick	25	0.15	47	0.28
basketball	36	0.23	27	0.17
fish	13	3.05	6	1.41

*Rates are based on minutes available.

as the tank was refilled. He lost interest and moved away if the water was turned off. When the hose was present, almost 65% of the turtle's time was spent with it.

The behavior toward the hoop and basketball were typically short duration events, and thus the number of approaches and contacts reveal the extent of the interaction more clearly than durations alone (Table 2). The turtle approached the basketballs most often but made the most contacts with the hoop (Table 2). Often the turtle would swim up toward a ball and then break away from it at the last moment before making contact. It was not possible to see any prior indication of whether a contact would be made or not, just as often occurs in mammalian object play.

The rate of the turtle's interaction with objects was quite high, particularly in the less disturbed afternoon sessions in which only the hoop, stick, and basketball were present. Over all sessions, the rate of contact varied from once every 6 min for the basketball to more than once every 2 min for the hoop (Table 2). When the fish were present, the contact rate went to its maximum as the turtle caught a fish every 44 sec (including swallowing time).

DISCUSSION

Does the Turtle Play in a Typical Mammalian Way?

There are three main recognized categories of play: social, locomotor/rotational, and object (or discursive) [Fagen, 1981]. Across all these categories some "claimed characteristics of play are: no obvious immediate function; pleasurable affect; sequentially variable; stimulation-seeking; quick and energetically expensive behaviour; exaggerated, incomplete, or awkward movement; most prevalent in juveniles; special "play" signals; a breakdown in role relationships; mixing of behavior patterns from several contexts; relative absence of threat or submission; and the relative absence of final consummatory acts (e.g., biting, intentional injury, killing, eating, or copulation)" [Burghardt, 1984: p. 6].

The turtle's behavior with objects met most of the above listed characteristics that pertain to object play. These include: (1) behavior that has no obvious immediate function and behavior that is (2) sequentially variable, (3) often quick and presumably energetically expensive, and (4) exaggerated, incomplete, or awkward. There also was apparent (5) mixing of behavior patterns from several contexts and (6) an absence of final consummatory acts (e.g. eating), although biting did occur. It also seems reasonable to infer that the turtle was seeking stimulation. Whether the turtle found the activities pleasurable is not known; however, the turtle's active orientation to the water flowing from the fill hose to specific parts of his head indicates it might have been. The turtle's behavior also met all of Hutt's [1966] characteristics for diversive (as opposed to exploratory) object play. The turtle would often repeat, with some variation, the same behaviors and would switch from one object to another.

We conclude from these results that by any traditional criteria the turtle "played" with the various objects in his tank and that this behavior made up a considerable portion of his activity budget (21% of time taped). This is unusual for two reasons. First, reptiles are not usually considered capable of play behavior. Second, this is a very large amount of time spent in play behavior. Mammals, including primates, typically play 1–10% of the time (Fagen, 1981), and this figure usually refers to young animals. Although our data are admittedly derived from <3 hours of videotape taken between 8:30 and 14:00, everyone familiar with the turtle acknowledged that we saw representative behavior.

There are some prior examples of putative object play behavior in reptiles. (Social play in reptiles is even more problematic than object play and is not discussed here.) Burghardt [1984] reported exploration and curiosity in reptiles such as green iguanas that could be precursors of play. Glickman and Sroges [1966] included a variety of reptiles in their comparative zoo survey of curiosity toward introduced objects. Although the modal response by reptiles was zero, they found highest responses in an Orinoco crocodile (*Crocodylus intermedius*) who bit and pushed objects, followed by three lizards, two of which were monitors. The two anecdotal reports of object play cited previously, in an alligator [Lazell and Spitzer, 1977] and in a varanid [Hill, 1946] are difficult to interpret as no filmed records are available, but we assume that the observations are valid. In the alligator example, the repeated, deliberate performance of stalks and snaps at the water drop by an animal apparently almost oblivious to human observers is comparable to the behavior of Pigface.

The main arguments about why play is rare or absent in reptiles were synthesized by Burghardt [1988] into the Surplus Resource Theory (SRT). In brief, the theory has three main premises. First, except for crocodilians, neonate reptiles are not cared for by their parents and must, therefore, devote their activities toward surviving, avoiding predation, and growing rapidly on their own. This allows little time for practicing or perfecting behaviors to be used in the future. Second, reptiles typically are metabolically constrained from performing vigorous, energetically expensive behaviors not immediately beneficial due to their low aerobic capacity and long recovery times after anaerobic expenditures [Bennett, 1982]. A third factor in the origins of play is psychological: animals in boring, unstimulating environments would be most likely to engage in behavior to relieve sensory and response deprivation and to increase arousal.

It might be argued that the behaviors seen here such as those directed toward the stick and basketball were not play, but just misdirected feeding or attack behaviors. But most animal play is highly similar to species typical behavior such as predation, evasion, fighting, and flight [Fagen, 1981]. The prototypical play of cats with prey can actually be derived from a continuous gradient of activation between defense and attack [Pellis et al., 1988]. It is only our ignorance of the proximal control of playfulness that has led to the common view that play is by definition useless or has only delayed, not immediate functions.

If play behavior was to occur in reptiles, Fagen [1981] predicted it would be seen in crocodilians, because of their extensive parental care, and varanid lizards, because of their relatively high, for reptiles, metabolic rate. Thus the two examples Fagen cited fit SRT. What is interesting about these examples and Pigface is that neonates or young animals were not involved. Whereas adult play in mammals, especially in captivity, is not uncommon, play is definitely most conspicuous as a phenomenon of the juvenile period, being transient in many species [Fagen, 1981].

Burghardt [1988] predicted that play might occur in well-fed sea turtles in warm oceans, because of their relatively large size (thus fewer thermal constraints) and the energy-efficient locomotor medium (water). The behavior of Pigface, a member of a large tropical species, even if not a true sea turtle, fulfills this prediction and others as well. For example, the animal's nutritional and thermal needs were met, he was in a rather spartan captive environment, he was in an energy-efficient aquatic medium, and the earlier history of self-mutilation behavior suggests that the animal was either highly stressed, bored, or both. The role of water in facilitating play is shown in the greater amount of aquatic versus terrestrial play in aquatic mammals such as seals [Renouf, 1993].

Evolution of Play

Extant turtles represent the living reptilian lineage (Anapsida) closest to the stem group (Synapsida) leading to the therapsids and modern mammals [Gauthier et al., 1989]. The Testudines lineage may go back to the late Triassic >200 million years B.P. [Rougier, et al., 1995] and the Mammalia at least 200 million years B.P. The soft-shelled turtles (Trionychidae) are themselves an old group. *Trionyx triunguis* is a member of the subfamily Trionychinae that has a cosmopolitan distribution and a fossil record on all continents except for Antarctica [Meylan et al., 1990]. The fossil record for this species is documented from the Miocene, at least 5 million years B.P. [Meylan et al., 1990], and the family's record in Africa may go back to the Eocene (34–55 million years B.P.) [Wood, 1979]. Definite Trionychid fossils are recorded from the Cretaceous and may go back to the Jurassic (>144 million years B.P.) [Meylan, 1987].

Besides being an ancient lineage, soft-shelled turtles possess some exaptations for playfulness. The reduction of shell size and rigidity make soft-shell turtles more vulnerable to predators, such as crocodilians. However, the reduction of shell size also makes them probably the most agile and swift-swimming extant turtles [Webb, 1962; Meylan, 1987]. They can thus exploit fish and other quick prey as well as avoid predation.

The Nile soft-shell is also known to have energetic features similar to birds. "The patterns of growth, O_2 consumption rate, and allocation of energy of *T. triunguis* eggs and embryos were similar to those reported for avian species" [Lesham et al., 1991, p. 568]. Thermoregulation is another constraint put forth to limit the extent of vigorous play behavior in reptiles [Burghardt, 1984]. Studies on the related *Apalone spinifer* [Smith et al., 1981] show that they heated twice as fast as they cooled. The authors concluded that "soft-shelled turtles are potentially excellent physiological regulators. In water, they heat in a smaller fraction of the cooling time than any other comparably sized reptile reported in the literature" [p. 79]. Although the Nile soft-shell is a larger species, there is no reason to doubt that this is another of the conservative features found in this group. Indeed, the Nile soft-shell may be the most adaptable in the family, for it is the only member of the family habitually to go into both brackish and salt water, having also become established in the Mediterranean [Kasparek and Kinzelbach 1991] and in African lakes too alkaline for other soft-shelled turtles [Meylan et al., 1990].

In spite of the ancient bauplan of these turtles and their ancestral closeness to the common ancestor of mammals and reptiles, it is not safe to claim that play is a plesiomorphic character for amniotes, since there is no evidence as yet for playfulness in amphibia. It is also doubtful whether playfulness is synapomorphic for amniotes since there is little evidence from other turtle species, other reptiles (including primitive birds such as ratites) and primitive mammals (e.g., monotremes). It is more conservative to view play in isolated taxa as independently derived when a series of ecological, life history, and physiological factors coincide. But such isolated situations are thereby nonetheless important, for they can allow us to explore the extent of the similarity in underlying mechanisms and in the developmental precursors and functional consequences of such playfulness.

Although play may not be characteristic of turtles—the three species tested by Glickman and Sroges [1966] were virtually nonresponsive—it may be somewhat common in the soft-shell family. Indeed, after mentioning our observations to a herpetological colleague with an extensive collection of live turtles, we were told that he also noted soft-shelled turtles butting at floating food nuggets in a manner similar to how Pigface treated the basketball [G. Seivert, pers. comm.].

Role of Environmental Enrichment in Reptile Exhibits

The turtle's captive environment was the primary contributor of both surplus resources and the lack of stimulation. The turtle's metabolic needs were probably met, at least in calories: he had survived and grown for >50 years. The thermal needs of the turtle were met as well because the tank was kept at a warm and relatively stable temperature. The turtle did not have to expend the energy he would have had to in the wild to find food and places where he could meet his thermal needs. The turtle also did not have to watch for danger. He had no chance to interact with conspecifics. Thus he was probably deprived of stimulation and demands ("bored") and expressed his boredom by scratching and biting himself, until the objects were placed in the tank and diverted his attention away from his own body parts.

The keepers noticed that the severity of the self-inflicted injuries declined after May 1992, when the turtle's feeding schedule was changed and the large rat was eliminated from the diet. The turtle clouded the water when he ate the large rat because he tore the rat apart with his front legs. Perhaps the fouled water harbored bacteria that infected the wounds of the turtle, causing him to scratch and bite himself more. When the turtle was given a smaller rat, he ate it whole, did not cloud the water, and did not injure himself as much. The lessening of injurious behavior could have been due to a decrease in bacteria. However, another possibility might be that the turtle was now being stimulated every day by feeding activity instead of just every other day. Since the feeding activity is the most vigorous activity the turtle performed, this might make a substantial difference in the amount of stimulation the turtle received, including the self-stimulation from performing the highly energetic fishing behavior.

The turtle's negative reaction to the lack of stimulation leads us to conclude that some reptiles may have innate needs for stimulation and activity that, if not expressed, could be detrimental. These may differ quantitatively and qualitatively between active foragers and more sit-and-wait (ambush) predators. The objects that the turtle was given allowed him to perform behaviors that he normally would use in other contexts such as exploring, chasing, attacking, biting, dismembering, and eating. These objects provide energetically and metabolically fit animals with the opportunity to perform behaviors that are part of their normal repertoire and motivational system. The lack of appropriate stimulation blocks their expression. Whether this proves detrimental may need to be assessed in each species [c.f. Chiszar et al., 1993].

A parallel to the tug-of-war and hoop ''games'' we saw is suggested by the persecution of the Nile soft-shelled turtle by fisherman who hate it as an aggressive species that destroys fishing nets [Kasparek and Kinzelbach, 1991]. The turtle's attraction to resting in front of the incoming water outlet might reflect the species typical habitat of rivers and current flow.

Soft-shelled turtles may be capable of a high degree of physiological thermoregulation [Smith et al., 1981], and this may allow them to be more active. Also, soft-shelled turtles have the ability to exchange respiratory gases with water across the skin (cutaneous tissue) and through the cloaca, which enables them to remain underwater for prolonged periods [Stone et al., 1992]. These abilities might enable soft-shelled turtles to be active longer before they become anaerobic and permit the performance of ''superfluous'' behavior not needed for immediate ends. In this way these animals may have some exaptations or preadaptations permitting and, in the captive environment, requiring, playful behavior to maintain well-being.

Unfortunately, *T. triunguis* is rare in captivity and as far as we know is not exhibited by any other North American zoo or aquarium. But discussions with many herpetologists, reptile curators, and others experienced with captive reptiles indicate that what we have observed with Pigface is highly unusual, if not unique. Since mud or sand to bury in was not provided, perhaps the high level of activity we found was due to the lack of an appropriate substrate in which to bury. But that is just the point. A bare concrete bottom in a tank, perhaps necessary for exhibit and cleaning reasons, is itself a clue that some other environmental components should be considered.

We do not want to leave the impression that providing toys for reptiles is the only, or even the preferred, type of enrichment. Although a thorough discussion of the enrichment possibilities for the highly diverse reptile lineages is not possible here, we encourage all who work with captive reptiles to experiment with their enclosures, quantifying and recording what the animals do and how well they do. Take leads from zoo colleagues exploring enrichment in various birds and mammals. Look for measures of well-being beyond appearance, feeding, breeding, and parasites (Burghardt, 1996). There are many surprises left as we try to better understand living reptiles and enhance, from their perspective, the lives they experience in captivity.

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