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Gharial (*Gavialis gangeticus*) Habitat Use and Behavior Analysis in Response to Repeated Aggression



-Leslie Sadowski -

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ABSTRACT

Gavialis gangeticus, the Indian gharial, is the only extant gharial species in the world. The gharial is a large crocodylian in the family *Gavialidae* and is characterized by a long snout. Due to its sparse numbers and increased habitat destruction, its behavior as compared to other living crocodylians remains relatively unknown. This particular specimen, located at the Cleveland Metroparks Zoo, was a female of approximately 28 years. The study was done in order to determine causes for aggression towards certain species of fish in the gharial's enclosure. These species of fish were too large for the gharial to consume and thus would not represent a prey item to the gharial. It was hypothesized that limited enclosure space led to increased aggression in the gharial. However, throughout the course of the study no attacks on fish were recorded, but stereotyped swimming by the gharial was seen. It was noted that the gharial displayed less stereotypical swimming when the public was present than when people were not observing the enclosure. These results suggest that the public could be a source of stimulation for the gharial and thus could reduce negative behaviors in the captive gharial.

INTRODUCTION

The Indian gharial, *Gavialis gangeticus*, is the only extant species of gharial left in the world (Vliet 2001). The gharial is a member of the order Crocodylia, which also includes crocodiles, alligators, and caimans. It is in the family *Gavialidae* and is characterized by its long, narrow snout. The males are distinguished by the large, bulbous

“ghara” on the tip, hence the common name “gharial” (Whitaker 1982). This adaptation is due to the fact that its main diet is the fish that inhabit these rivers, such as tilapia, and that the gharial tends to dwell in fast flowing river systems, although it is often found in out-crops of these rivers where the water flow is slower (Whitaker 1982). It is well adapted for this aquatic environment since the long, narrow snout allows for less water resistance when catching fish. Therefore, the gharial is the most aquatic member of the crocodylians, and also the only member whose diet is mainly characterized by fish (Whitaker 1982).

The only natural populations of gharial are found in India, specifically in the river systems of the Indus (Pakistan), the Ganges (India and Bangladesh), the Brahmaputra (Bhutan), and Mahanandi (Orissa) (Whitaker 1982). The population was nearly decimated in the 1970s, but local organizations were then formed, and are still heavily in existence, in order to breed these animals in captivity and release them back into the wild (Whitaker 1982). Due to the specificity of its habitat and the rather small population, the gharial remains a mystery in terms of its behaviors, and even most basic life characteristics. Captive populations in the United States are minimal, with single specimens at the Cleveland Metroparks Zoo (female), San Diego Zoo, National Zoo, and the largest population at St. Augustine Alligator Farm in Florida. There are many complications in forming a breeding population within the United States, including the difficulty of transporting adults within the country and the necessity of shipping only juveniles from overseas due to the fragility of their snouts. Therefore, there is not currently a breeding couple in the country.

Gharial life spans are thought to be similar to other crocodylians of large size and late maturity and tend to be upwards of 100 years (Whitaker 1982). Their reproductive status is also like other crocodylians, in that size, not age, determines when they become reproductively active. This generally happens upon reaching over 3 m in length for females and 4 m for males, although there have been exceptions to the rule in smaller individuals in India (Whitaker 1982). The average adult size ranges from 3.5 m to 4.5 m (Brazaitis 2001), but males are known to reach 6-7 m (Whitaker 1982). They are believed to be the most timid and least aggressive and territorial of the known crocodylians, however it is to be emphasized again that very few have been studied.

The gharial’s social displays are similar to those of the other members of the crocodylian order. These displays include the dominance display (head and tail emerging erect out of the water or merely a snout lift out of water, and acoustic signals, including subaudible vibrations and grunts/bellows) and other dominance displays such as headslaps and jawclaps (Vliet 2001). Many of these displays are also associated with reproduction, mainly used by males to attract females. Territoriality is also seen amongst males, as is demonstrated by dominance displays, bellows and headslaps/jawclaps. However, the gharial is not believed to be as territorial as other crocodylians. In general, unless finding territory, attracting a mate, or acquiring food, crocodylians conserve energy either in the water, the primary home of the gharial, or by basking on the sandy banks.

Aggression in captivity is seen more often than in the wild due to the restraints on the animal’s territory and habitat. Categories in which environments can negatively affect the captive animal include, but are not

limited to, inconsistencies in substrate, temperature, auditory ranges (specifically infrasonic with respect to crocodylians), lighting conditions, diet, isolation from conspecifics, and cage size (Vliet 2001). The effect of restricted movement due to limited space has frequently been studied, and has been found to be a major contributor to stress and stereotyped behavior (Morgan 2006). Stereotyped behavior consists of any behavior that is uncommon or absent in wild populations or is detrimental to the animal's health. It is also common for animals under a certain type of stress, such as excess noise from humans, to respond to this stressor in a seemingly unrelated manner, like lack of movement. Therefore, it is important to explore all aspects of an animal's environment in order to understand why a negative behavior is being elicited (Morgan 2006). Over the period of 45 days, the gharial at the Cleveland Metroparks Zoo killed a giant gourami, a knifefish, a tinfoil barb, and on two separate occasions bit two giant gouramis. In each of these instances, the fish was not eaten. Thus, the basis of the study was to better understand the basis of the attacks by analyzing the gharial's habitat use, time management, and social behavior.

METHODS AND MATERIALS

The study was done at the Cleveland Metroparks Zoo in Cleveland, Ohio. One female gharial, *Gavialis gangeticus*, inhabited the exhibit (Fig 1).

The subject was obtained in 2003 from Silver Springs after having been in several zoos in the United States. The subject was approximately 28 years old and 2.98 m long from snout to tip of tail; it was believed that the female had not yet reached reproductive status, and most likely will never reach this status due to the size of



Figure 1. Female gharial located at Cleveland Metroparks Zoo.

its enclosure. It was also blind in one eye, which the keepers at the zoo believed was due to an injury at a previous zoo. This disorder, however, had been proven to not affect the captive gharial's ability to consume food or to interact with other specimens in a shared exhibit (Singh 1981). The specimen at the Cleveland Metroparks Zoo had never been heard making any of the audible signals. In fact, gharials in general do not vocalize (Vliet 2001). The gharial had rarely shown dominance displays, one of which was witnessed during observation, allowing accurate descriptions of the specimen's behavior. The exhibit was shared with two female Batagur turtles (also known as Giant River Terrapins), one female and one unknown Callagur turtles (also known as Painted River Terrapins), one Hamilton's Pond Turtle, one female New Guinea Snapping Turtle, one male and one female Orlitas (Giant Malyasian Turtles), one clown knifefish, and fifteen tinfoil barb (though during the experiment one of these was eaten by the gharial).

The habitat was divided into sections. The front of the exhibit consisted of clear glass and the remaining

walls were covered with artificial foliage. The water portion was 9m x 3.5m and approximately 9000 gallons (Fig. 2a-c). The left portion of the land, left of the log

(Fig. 2d) was about 2m x 2m and the right portion was approximately 4.5m x 1.5m (Figs. 2e, f). The land was composed of artificial tan-colored sand. Underwater

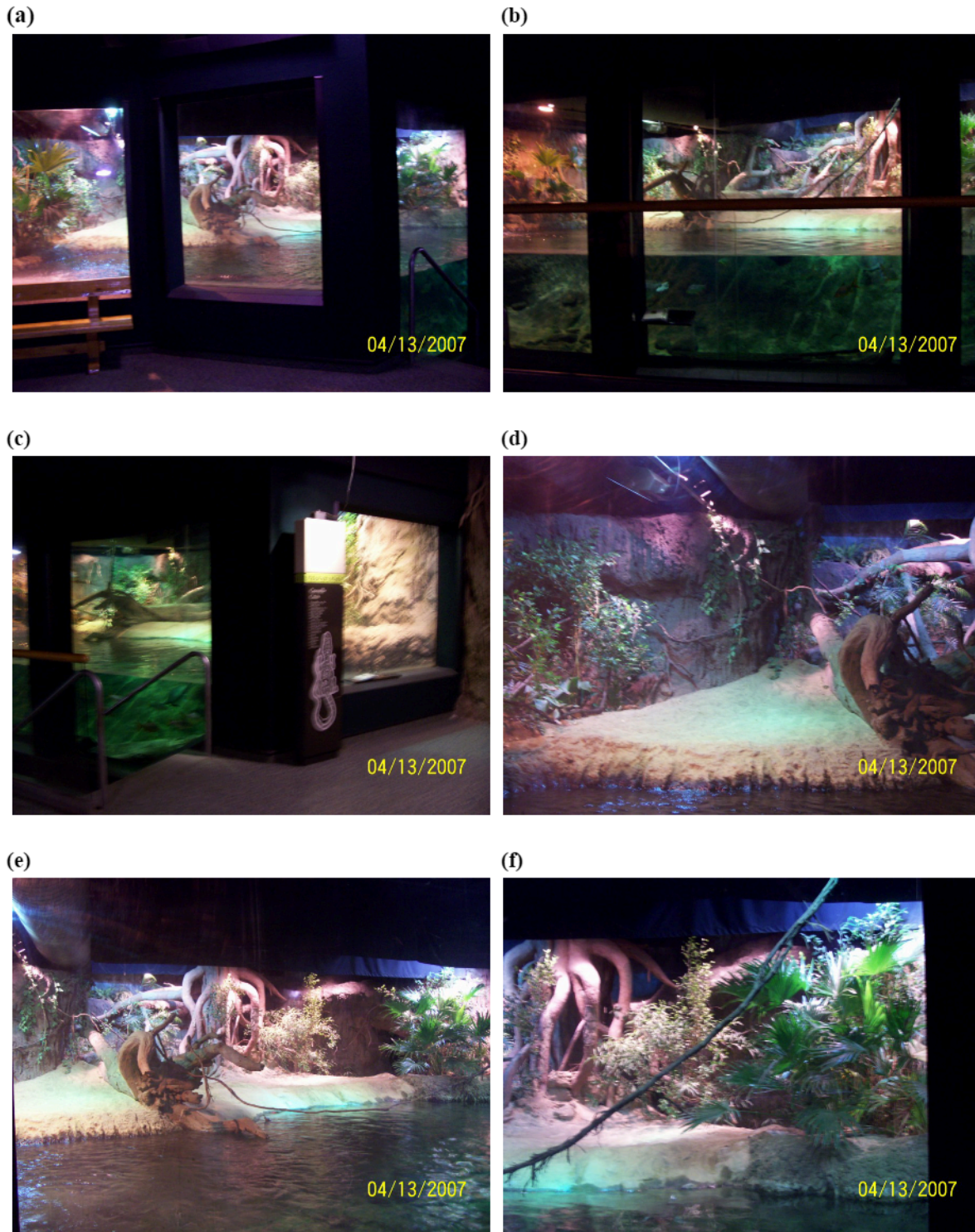


Figure 2. Photographs of the gharial exhibit. (a) left water=LW (b) middle water=MW (c) right water= RW (d) left land=LL (e) middle land=ML (f) right land=RL

were various logs and sticks. In the left front corner of the exhibit was a source of flowing water, which often caused bubbles in the water (Fig. 2a). It was noted that the subject was only fed on Thursday mornings, during which no observation occurred. However, one Friday morning feeding was observed to take baseline information about the feeding behavior of this particular specimen.

Experimental Design. An ethogram was developed based upon previous knowledge of the gharial (Appendix I). Reproductive, social, and territorial displays were kept to a minimum and combined in the categories given in the ethogram due to the lack of other animals. The possibility of these displays shown to human observers was considered, and therefore these measures were not completely left out of the ethogram, however only those that keepers had seen (the dominance displays and general swimming, basking, and passive activities) were developed in the ethogram. Five-minute behavior scans were taken for a period of 120 minutes each day; this was done three days a week, two in the afternoon and one in the morning, from February 5 through April 13, 2007. There were a total of 1260 morning minutes and 2220 minutes of scans in the afternoon. The behaviors studied for the scanning behavior were swimming, basking, feeding, walking (this can be on land or on the ground underwater), interacting with other exhibit-mates, and passivity (which includes any lack of movement). It was decided that interaction with exhibit-mates would be eliminated from further calculations since it never occurred. The position in the habitat was noted: left water (LW) (Fig. 2a), middle water (MW) (Fig. 2b), right water (RW) (Fig. 2c), left land

(LL) (Fig. 2d), middle land (ML) (Fig. 2e), and right land (RL) (Fig. 2f). Also recorded was if the subject was distant ($>1\text{m}$), close ($<1\text{m}$), or touching another species in the exhibit. These three groupings were calculated separately. Each category within the grouping was taken as a percentage of time by dividing the amount of times it was recorded by the total number of scans. These were then averaged, and standard error was calculated.

The all-occurrence behaviors recorded were dominance display, which consists of an erect tail and head (Vliet, 2001) emerging from the water, a grunt, a headslap on the water, and a snap at another animal in the exhibit. The all-occurrence behaviors were simply tallied as a total. The subject was also observed by its keepers to seem to gravitate towards the public presence. Therefore each scan period it was noted if the public was present, and if the subject oriented its body, specifically its snout, toward the visitors.

RESULTS

Very little all-occurrence behavior was seen. The gharial carried out one dominance display immediately after visitors walked by on one afternoon. The only other all-occurrence behavior was a jaw snap at a turtle after it had been swimming around the gharial's snout.

In terms of overall activity, the gharial spent most of its time, about 64%, passive. However, 25% of its time was spent swimming (Fig. 3a). The gharial also spent some amount of its morning and afternoons walking in its enclosure and/or basking on the sand. Approximately 95% of its time was spent in water, which was consistent with the description of the species (Fig. 3b). Also, over half of the gharial's time was spent

close to another species in the exhibit (Fig. 3c). It was noted that this was predominantly near the turtles, as they did not show any aversive behavior towards its presence. Time spent physically touching another ani-

mal was rare, usually observed when the gharial was resting on the bottom of the water and the turtle was either on top of the gharial or touching next to it, usually near the tail.

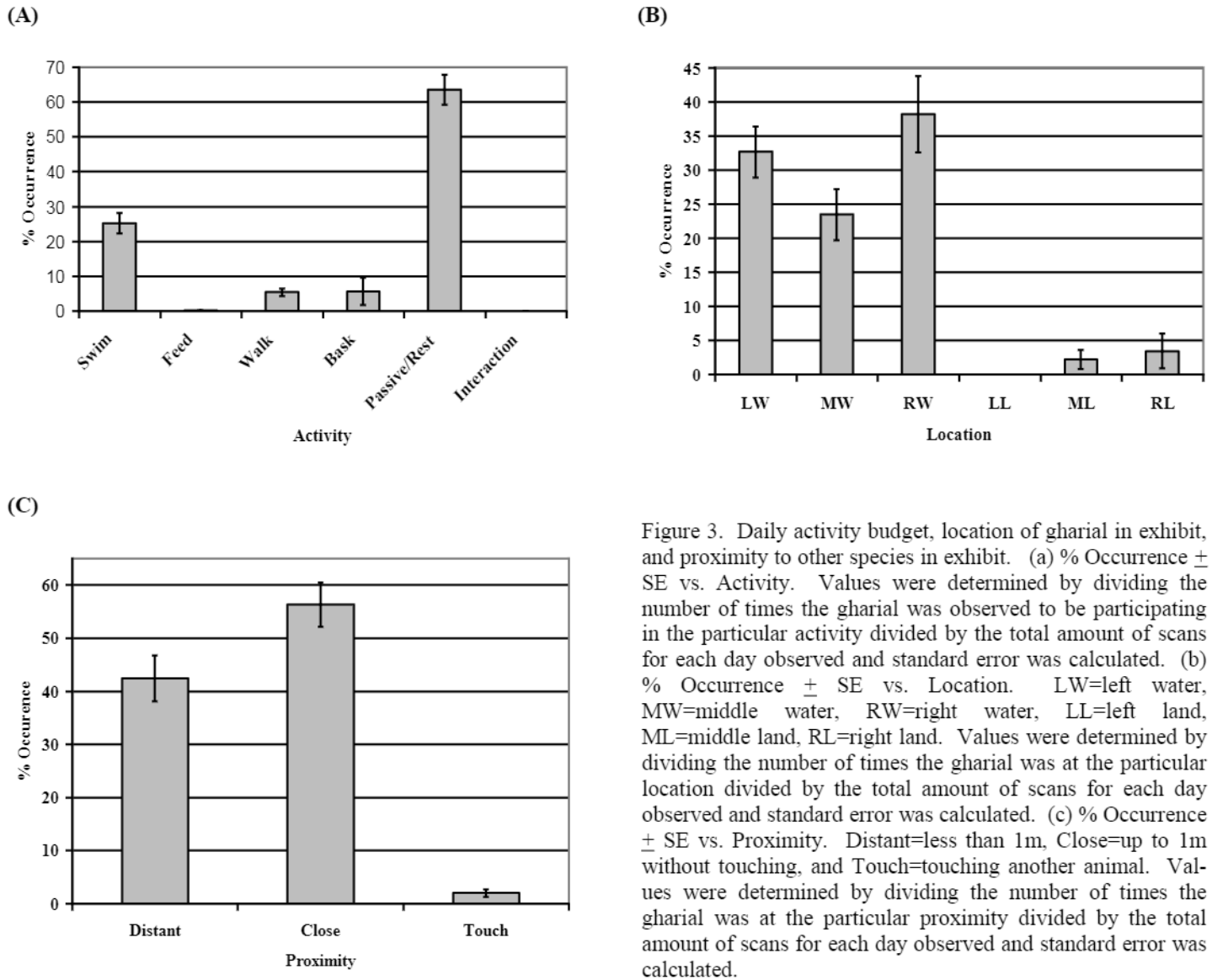


Figure 3. Daily activity budget, location of gharial in exhibit, and proximity to other species in exhibit. (a) % Occurrence \pm SE vs. Activity. Values were determined by dividing the number of times the gharial was observed to be participating in the particular activity divided by the total amount of scans for each day observed and standard error was calculated. (b) % Occurrence \pm SE vs. Location. LW=left water, MW=middle water, RW=right water, LL=left land, ML=middle land, RL=right land. Values were determined by dividing the number of times the gharial was at the particular location divided by the total amount of scans for each day observed and standard error was calculated. (c) % Occurrence \pm SE vs. Proximity. Distant=less than 1m, Close=up to 1m without touching, and Touch=touching another animal. Values were determined by dividing the number of times the gharial was at the particular proximity divided by the total amount of scans for each day observed and standard error was calculated.

A point of interest is that its activity differed on days when the public was present and when it was not (Fig. 4a). From the graph one can see that less time was spent at rest when there were people present, which was also the only time in which the gharial was basking. Due to large standard error values, no conclusions can be made about its swimming and walking behavior, and statistics were not feasible due to small sample size. Both days with public present and days without shows that the gharial spent the previously mentioned majority of time in water (Fig. 4b); based purely upon

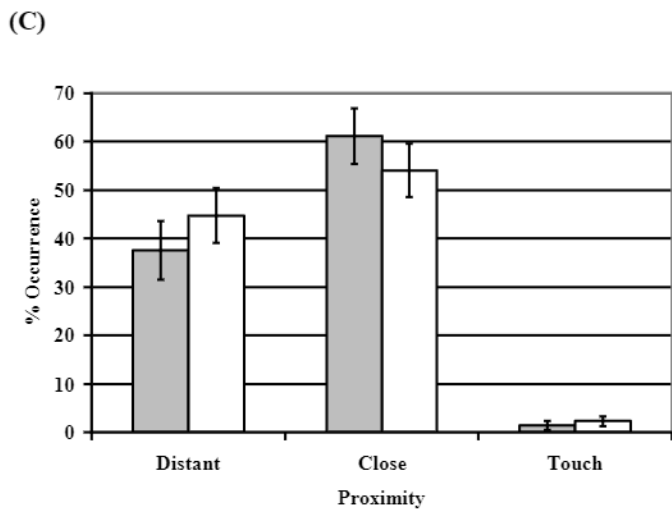
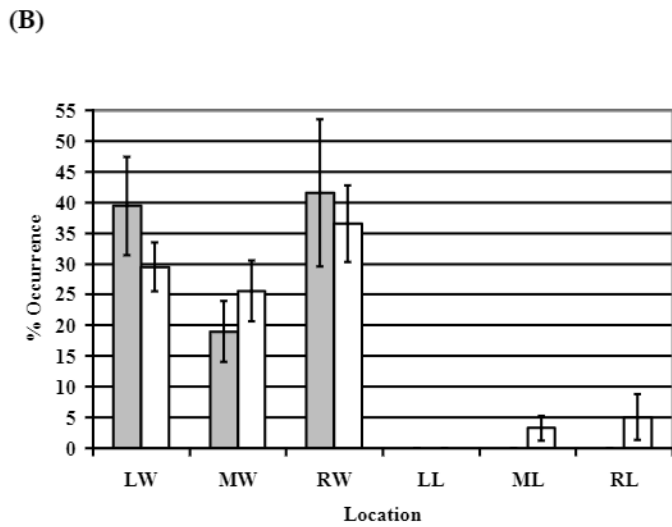
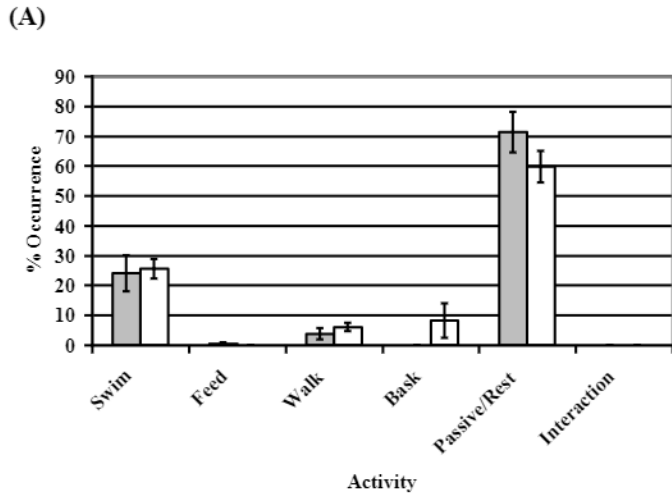


Figure 4. Activity budget, location of gharial in exhibit, and proximity to other species in exhibit on days with no public present (Filled bars) vs. days with public present (Open bars). (a) % Occurrence \pm SE vs. Activity. Values were determined by dividing the number of times the gharial was observed to be participating in the particular activity divided by the total amount of scans for each day observed and standard error was calculated. (b) % Occurrence \pm SE vs. Location. LW=left water, MW=middle water, RW=right water, LL=left land, ML=middle land, RL=right land. Values were determined by dividing the number of times the gharial was at the particular location divided by the total amount of scans for each day observed and standard error was calculated. (c) % Occurrence \pm SE vs. Proximity. Distant=less than 1m, Close=up to 1m without touching, and Touch=touching another animal. Values were determined by dividing the number of times the gharial was at the particular proximity divided by the total amount of scans for each day observed and standard error was calculated.

observation, the gharial was viewed basking on land more often when the public was present (in the afternoon only) than when it was not. When the public was present the gharial spent slightly more time distant, but also more time in contact with the other species, though no large difference was noted (Fig. 4c).

It was observed that the knifefish spent the majority of its time under the log, which was also under shadow, and the tinfoil barb frequently migrated to the opposite side of the exhibit that the gharial was on. On the days of observation when the zoo was open to the public, the gharial oriented itself towards the public 41% of the time.

The subject was also observed to have performed less stereotypic behaviors when the public was present. When initial observations were taken and no visitors were present, it was noticed that the gharial had a patterned swim route. It was passive for a period of time in the right corner of the water, and then swam along the front-bottom portion of the water. It would then rest in the corner that bordered the left and middle

water conditions explained previously, and then swim to where the bubbles emanated in the very left corner of the water and rest there. Afterwards it would return to the right side of the exhibit and begin again. Based on observation, this patterned swimming was seen less when the public was present.

DISCUSSION

The gharial has been stated as being the most timid of crocodylians (Brazaitis 2001). However this may not be the most accurate description. It may be the least aggressive, but not necessarily the most timid due to the fact that the gharial would often orient itself toward the public and continuously swim directly in front of the glass where the visitors stood to watch. One can see this visitor interaction by the results, in which the gharial spent less time resting in the afternoon when the public was present rather than in the morning when there is very little human interaction (Fig. 4a). In fact, very few instances about gharial attacks on humans are recorded in literature. According to minimal research on this topic, the gharials have all been either defending territory or eggs; the gharial has been known to mistakenly take small humans for prey by grabbing an extremity, but the person was then quickly released. There are no recorded deaths due to gharial attacks (Bustard & Singh 1981). This could either be due to lack of information from native people, lack of interaction between gharials and native people, or that the gharial is truly the least aggressive crocodylian. According to keepers and minimal experience in the exhibit during the study, the gharial at the Cleveland Metroparks Zoo is not prone to attacks and can even be hesitant to approach a new person. From the data and the results of this study, and by

the fact that stereotyped swimming was reduced, we can see that this particular gharial was stimulated by the presence of people (Fig. 4). The gharial often left what it was doing to swim in front of the glass in the exhibit.

One keeper related a story that in the morning when the first large group of people came up to the exhibit, the gharial, previously basking, opened one eye, turned its head toward the public and walked into the water and began swimming in front of the glass. The results of the days with public present versus not present are essentially the afternoon versus morning scans, respectively. The differences could be due to either time of day or presence of visitors. However, based upon the main keeper's and observer's observations of the gharial, the correlation strongly points towards the presence of people and not to time of day. There are also anecdotes from the keepers in which the gharial stayed active late at night, when the exhibit lights were already off, due to a large party. This would suggest that although it is the time of day in which the gharial is not normally active at the front of the exhibit, the presence of people changed this routine. These pure observational results must be studied further in a more scientific fashion in order to determine the complete significance of these observed behaviors.

The only basking that was seen was in the afternoon (Fig. 4a). This is difficult to interpret due to the artificial surroundings. During the winter, gharials are seen basking during all times of the day to maintain their higher body temperatures. In warm months, they are only seen basking in the early morning and retreat to water once early afternoon hits with the warm sun (Whitaker 1982). In a habitat in which artificial lighting and heat are emitted, it is difficult to determine the rea-

son why basking was seen in the afternoon due to the lack of thermometers in the exhibit itself. Therefore, the basking may only be seen once the gharial is more active and able to heave itself onto the land in order to keep itself warm for a portion of the day, but these results are inconclusive. Also, the gharial was never seen basking on the left side of the land. This is most likely due to two things: first, the small size of this portion of land would not provide enough room for the gharial to pull itself onto the land; second, this is also where the gharial is fed, and the keepers noticed that the gharial has only been seen in this section when it is fed.

The study began with the intent to determine what in its environment was causing the gharial to attack and kill, but not eat, the fish in its exhibit. During the study, the gharial only killed one tinfoil barb, and it was most likely due to the fact that it was not fed on its proper day since the keepers were waiting to feed it for a television crew that was coming four days after the usual feeding time to use the gharial for education purposes. The day before this was to happen a tinfoil barb was killed, and for the most part eaten. Therefore, no correlations were able to be drawn regarding the gharial's interspecific aggression. However, any studies on this species are valuable due to the lack of literature on the gharial.

The implications of the study may very well show a social nature of the gharial. They are known to be communal nesters (Rao & Singh 1993), meaning that females may live in social groups. Further research on their behavior in the wild is needed. Due to the dwin-

ding populations, this may not be a possibility, but as the captive-reared specimens are released into the wild it may allow us to discover aspects to their behavior not yet known. The aggression previously noted in this individual may be due to a lack of social stimulation, or even overstimulation due to the amount of other turtle and fish species in the exhibit. In the wild the gharial may choose its location based on water velocity and the relative amount of other animals and availability of a niche. The large volume of turtles in such a limited exhibit may be causing stress. A Callagur turtle was observed biting the tail of the gharial during an observation. Therefore, these constant stressors may be causing the gharial to react in an aggressive manner.

The future of the gharial in the wild is as variable as that of captivity. Although restocking programs are now in place in India, mainly the National Chambal Sanctuary (Hussain 1998), habitat destruction continues to occur throughout the gharial's native range. Commercial fishing and lack of knowledge of these relatively timid crocodylians have also added to the reduction of populations along the Brahmaputra River (Choudhury 1997). The sanctuaries in India, however, appear to be the only hope for breeding captive gharials as of now. Due to their rarity and negative public response, this species has been neglected in behavioral studies. In order to increase the population of gharials in the wild and those kept for education purposes in captivity, one must better understand its natural habitat and behavior, and this can only be done by further research on the world's least known crocodylian.

APPENDIX I

Ethogram for *Gavialis gangeticus*

Type of Behavior	Behavior	Description of Behavior
<i>Solitary</i>	Passive/Rest	Lack of movement in water, but may be roused due to environment
	Swim	Movement throughout water column
	Walk	Movement on land or on substrate at bottom of water
	Bask	Situated body towards light and heat source, passive on land
<i>Food related</i>	Feeding	Consumes food it is given by keeper
<i>Social</i>	Social interaction	Touching and orienting towards another animal, or another animal orienting towards gharial
<i>Aggressive (all occurrence)</i>	Dominance display	Tail and snout erect and out of water, while torso remains in water
	Snap	Quick closing of the jaws directed towards another animal
	Grunt	Loud noise produced from the throat
	Headslap	Head comes down quickly onto surface of water

Location	Abbreviation	Description (for clarification see figure 1)
<i>Left water</i>	LW	Far left of water portion of exhibit to left stairs
<i>Middle water</i>	MW	Left stairs to right stairs
<i>Right water</i>	RW	Right stairs to far right of water portion of exhibit
<i>Left land</i>	LL	Far left of exhibit to log
<i>Middle land</i>	ML	Log to tree
<i>Right land</i>	RL	Tree to far right of exhibit

Proximity	Description
<i>Distant</i>	Animal greater than 1 meter from gharial
<i>Close</i>	Animal less than 1 meter from gharial, but not touching
<i>Touch</i>	Animal has direct physical contact with gharial
<i>Public</i>	Gharial is orienting towards public

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