



Research Article

Open Access

Nest Attendance and Hatching Care in Wild Marsh Crocodile (*Crocodylus palustris*) in Kochchipathana Tank, Yala, Sri Lanka

Shashi Madhushanka^{1*}, Danushka S. Weerasekara², Manjula Perera¹, Kithsiri B. Ranawana³

¹Leopard Trails, Wilpattu Road, Galkadawala, Nochchiyagama, Anuradhapura

²Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka

³Department of Zoology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka

Abstract

This study investigates the behavior of wild marsh crocodiles (*Crocodylus palustris*) in Yala, Sri Lanka, focusing on nesting behavior and intruder dynamics using a trail camera. A burrow near Kochchipathana Tank was monitored over 72 days, documenting the frequency of four distinct behaviors: nest guarding (GR), burrow digging (DI), entry into the burrow (MO), and chasing intruders (CS). Guarding behavior (GR) was the most frequent, with 133,880 occurrences, while CS was the least observed. Behavioral changes before and after hatching revealed a significant decline in GR post-hatching, though statistical analysis using Chi-Square tests showed no significant difference in behavioral frequencies between the two stages. Monitoring nest intruders recorded 12 species, including predators like the gray mongoose (*Urva edwardsii*) and domestic animals such as cats (*Felis catus*) and dogs (*Canis familiaris*), highlighting potential anthropogenic pressures on the nesting site. These findings emphasize the critical role of nest guarding in reproductive success and point to the need for targeted conservation strategies to mitigate the impacts of human and predator interference. Future research should explore the long-term effects of environmental stressors and intruder interactions on reproductive success.

Received: 14 Oct 2024

Accepted: 19 July 2025

Keywords:

Behavior;
Guarding;
Hatchling;
Intruder;
Marsh crocodile

*Corresponding author:
shashimadhushanka2@gmail.com

 <https://orcid.org/0000-0003-4911-8512>

1. Introduction

The Marsh crocodile is a medium-sized crocodile species (4-5 m max) and is also known as the Mugger or Swamp crocodile (Da Silva & Lenin, 2010). The Mugger is mainly found in Iran, India, Nepal, Pakistan, Sri Lanka, and Bangladesh; however, it is probably extinct in Bhutan and Myanmar (Da Silva & Lenin, 2010). They are found in a number of freshwater habitat types such as lakes, rivers, and marshes. It is also found and adapted to reservoirs, irrigation canals, man-made ponds, coastal saltwater lagoons, and estuaries (Da Silva

& Lenin, 2010; Whitaker & Andrews, 2003). The *Crocodylus palustris* lays eggs during the dry period and makes a nest in a hole (Da Silva & Lenin, 2010). Females reach sexual maturity when they are about 1.8-2 m in length and the clutch size is about 25-30 eggs (Whitaker & Andrews, 2003). They make nests in a wide variety of habitats and females are known to guard the nest at the opening of, or inside their burrows (Da Silva & Lenin, 2010). The incubation period is relatively short, which is about 55-75 days (Whitaker, 1987). Similarly, to other crocodilians, *C. palustris*, including



This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License, which permits unrestricted use, distribution and reproduction in any medium provided the original author and source are credited.

yearlings, sub-adults, and adults dig burrows (Whitaker & Whitaker, 1984). Burrows are utilized as an effective refuge from hot daytime and play an important role in living in harsh environments enabling them to protect from extreme temperatures (<5°C and >38°C respectively) (Lang, 1987; Whitaker *et al.*, 2007; Da Silva & Lenin, 2010).

Numerous threats are known to affect this species in its natural habitats, including habitat destruction and fragmentation, downing in fishing nets, egg predation by people, and the use of crocodile parts for medicinal purposes (Groombridge, 1982). The world population of the mugger is small and isolated, estimated to be around 5,400 to 7,100 (Da Silva & Lenin, 2010). However, no clear data to suggest whether the overall wild population is increasing or decreasing (Da Silva & Lenin, 2010). In Sri Lanka, approximately 1,500 to 2,500 individuals are estimated to exist in the wild, most of which are concentrated in several national parks and also found in irrigation tanks and man-made reservoirs (Da Silva & Lenin, 2010). In some areas, it is threatened by rapid agricultural and industrial expansions (Whitaker & Whitaker, 1979). *Crocodylus palustris* is a relatively understudied species in Sri Lanka, particularly with regard to its nest attendance and hatching care, for which, to the best of our knowledge, no prior documentation exists. This study represents the first known investigation into the hatching care behaviors of wild mugger crocodiles in Sri Lanka.

2. Materials and Methods

2.1 Setting a Camera

The burrow near Kochchipatana Tank in Yala was initially identified in 2011 and believed to belong to a mugger crocodile. During several days of observation at the time, a female crocodile was seen with hatchlings nearby. Notably, the same burrow was revisited on 7th July 2017, where a female crocodile was once again observed guarding it, suggesting long-term or repeated use of the site for nesting. We set up a Bushnell Trophy Cam HD (model: 119676C) close to the mouth of the burrow, facing the mouth at knee level from July to 3rd of October. We made sure not to disturb the mother and her behavior. When the mother was away, we closely observed the burrow and which was 0.5 m wide and inclined at an angle and 3 meters deep. We also noticed that she had laid eggs close to the mouth of the burrow and we carefully dug the area. We found 14 eggs and did not disturb them, moving around and kept them in their original position. We continuously monitored the nest for 72 days using a trail camera, ensuring 24-hour coverage each day throughout the entire period.

2.2 Statistical Analysis

We used the R-Studio 4.3.2 version for statistical analysis and Excel 2016 for graphical representation.

This study analyzed a data set comprised of observational records of wild marsh crocodiles (*Crocodylus palustris*), focusing on four distinct behaviors: The observed behaviors associated with burrow use in crocodiles included nest guarding (GR), burrow digging (DI), entry into the burrow (MO), and chasing intruders (CS). guarding at the entrance involved individuals positioning themselves at or near the burrow opening in a vigilant posture, presumably to monitor for potential threats and protect the burrow. Digging the burrow was characterized by active excavation or maintenance using the limbs and snout, indicating nesting behavior or efforts to regulate the burrow's microenvironment. Moving into the burrow referred to individuals entering the burrow, likely for shelter, nesting, or thermoregulation. Chasing an intruder was observed when individuals aggressively pursued approaching animals or conspecifics, suggesting a territorial or protective response to perceived threats near the burrow. A total of 34 days of pre-hatching and 38 days of post-hatching observations were recorded over the course of the study. Chi-square tests were performed to evaluate differences in behavioral frequencies across the four behaviors and between the pre-hatching and post-hatching stages.

3. Results

3.1 Behavioral Frequency

Observations of a wild marsh crocodile at the Kochchipathana Tank nest were categorized into four distinct behaviors: guarding the entrance (GR), digging the burrow (DI), moving into the burrow (MO), and chasing intruders (CS). Figure 1 presents the total number of behavioral events recorded over the full 72-day study period, with GR being the most frequent behavior (133,880 occurrences), followed by DI (3,000), MO (1,200), and CS (430). These results indicate that the distribution of behaviors was highly uneven throughout the study period.

Guarding behavior (GR) clearly dominated the crocodile's behavioral repertoire, underscoring its critical role in nest protection and parental care during both pre-hatching and post-hatching phases. In contrast, chasing intruders (CS) was the least frequently observed behavior, occurring primarily in response to specific disturbances or the presence of potential threats. Moving into the burrow (MO) and digging (DI) were observed at intermediate frequencies, reflecting context-dependent activities related to burrow maintenance, thermoregulation, and nest care.

The pronounced differences in behavioral frequencies highlight the central importance of guarding behavior for the survival of hatchlings, while the lower frequencies of other behaviors suggest they serve specialized and situational roles within the broader behavioral repertoire.

(Figure 2).

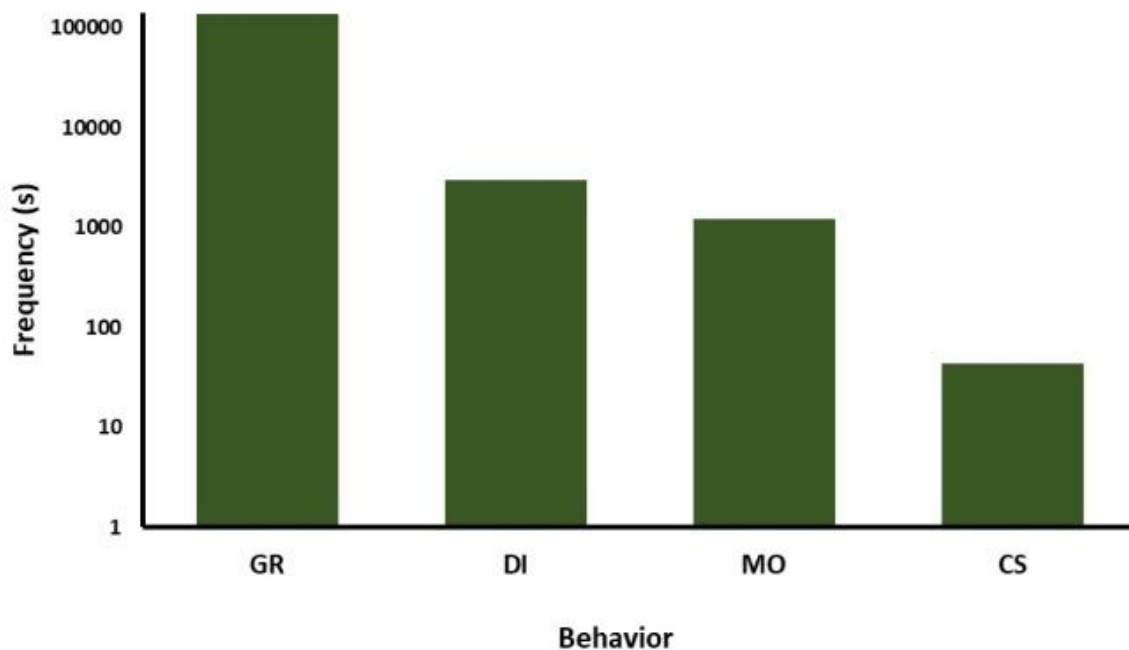


Figure 1. Total frequency of behaviors observed in a wild marsh crocodile (*Crocodylus palustris*) at the Kochchipatana Tank nest over the entire 72-day study period. Behaviors include guarding the entrance (GR), digging the burrow (DI), moving into the burrow (MO), and chasing an intruder (CS). The y-axis represents the cumulative number of occurrences for each behavior during the study period (72 days).

3.2 Behavioral Change Before and After Hatching

The analysis investigated behavioral differences in marsh crocodiles before and after hatching, focusing on the pre-hatching and post-hatching stages. A total of 61 observations were recorded, comprising 50 for pre-hatching behaviors and 11 for post-hatching behaviors. Behavioral analysis revealed a shift between the two stages. In the pre-hatching phase, "GR" was the most frequently observed behavior (34 occurrences), followed by "MO" (11), "CS" (4), and "DI" (1). Post-hatching, "GR" remained predominant but was observed only 11 times, indicating a significant decrease in this behavior after hatching (Figure 3).

A chi-squared test indicated there is no statistically significant difference among the observed behavior frequencies between the pre-hatching and post-hatching stages ($\chi^2 = 4.77$, $df = 3$, $p > 0.05$). A bar plot illustrated the frequency of behaviors, confirming the predominance of "GR" in both phases, although its frequency notably declined after hatching (Figure 3).

3.3 Intruder Dynamics

A total of 12 intruder species were recorded visiting the crocodile nest during the observation period (Table 1 and Figure 4). Of them, Land monitor (*Varanus bengalensis*), Gray mongoose (*Herpestes edwardsii*), Domestic dog (*Canis familiaris*), and Domestic cat (*Felis catus*), can pose some threats to the nest and hatchlings. These results suggest a diverse range of

predators and potential competitors frequenting the nest area, with the Grey Mongoose showing a notably higher frequency of intruders compared to other species. The presence of domestic animals such as dogs and cats highlights potential anthropogenic influences around the nest environment, which could pose additional risks to nesting crocodiles.

3.4 Intruder Dynamics

A total of 12 intruder species were recorded visiting the crocodile nest during the observation period (Table 1 and Figure 4). Of them, Land monitor (*Varanus bengalensis*), Gray mongoose (*Herpestes edwardsii*), Domestic dog (*Canis familiaris*), and Domestic cat (*Felis catus*), can pose some threats to the nest and hatchlings. These results suggest a diverse range of predators and potential competitors frequenting the nest area, with the Grey Mongoose showing a notably higher frequency of intruders compared to other species. The presence of domestic animals such as dogs and cats highlights potential anthropogenic influences around the nest environment, which could pose additional risks to nesting crocodiles.

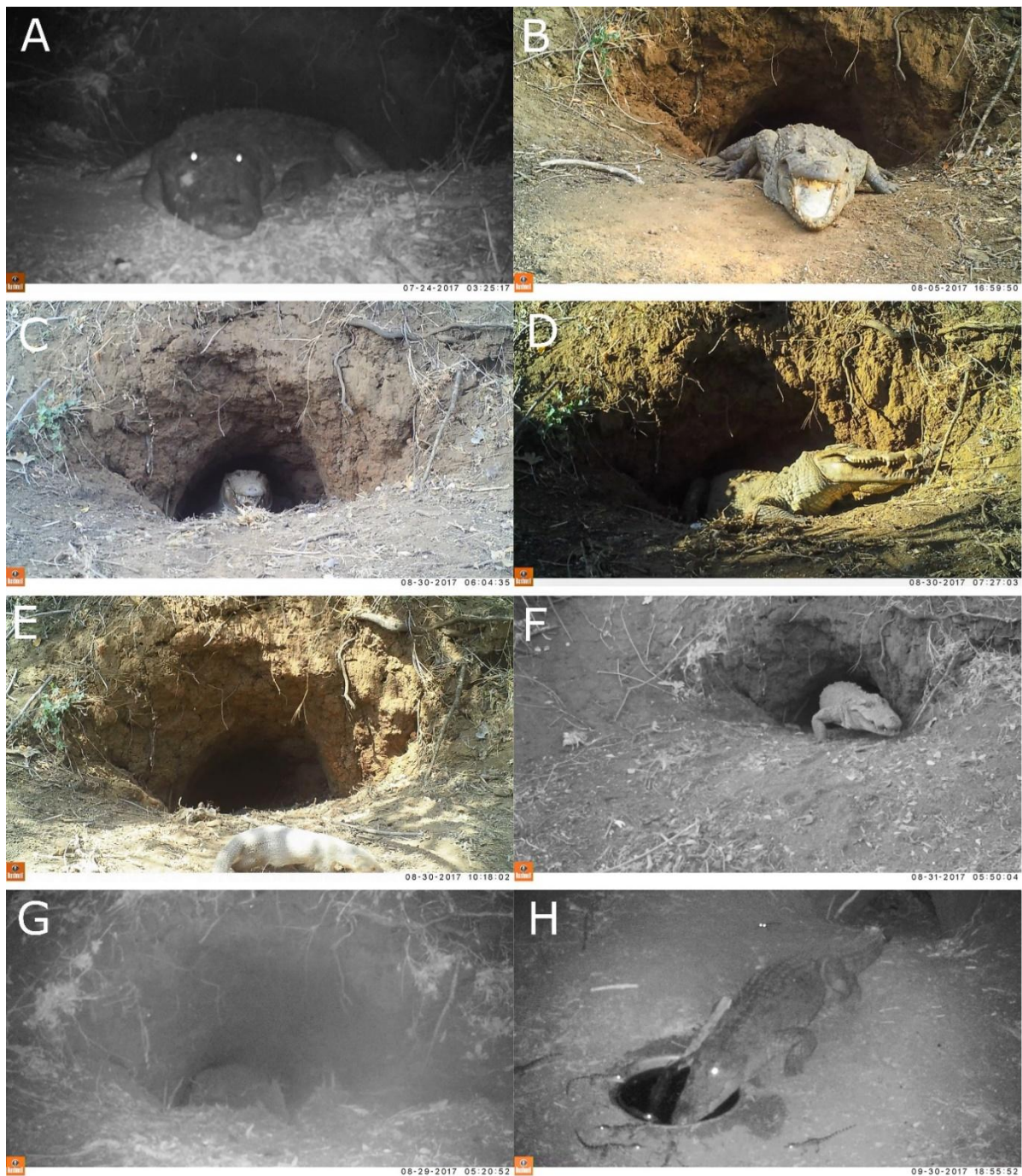


Figure 2. Photographs of mother at its nesting site (A) guarding the burrow entrance at night, (B) guarding the entrance during the day, (C) remaining on guard within the burrow, (D) retrieving a hatchling and returning it to the burrow, (E) presence of a gray mongoose near the nest, (F) repelling an intruder, (G) excavating the burrow, and (H) guarding a hatchling near a water source.

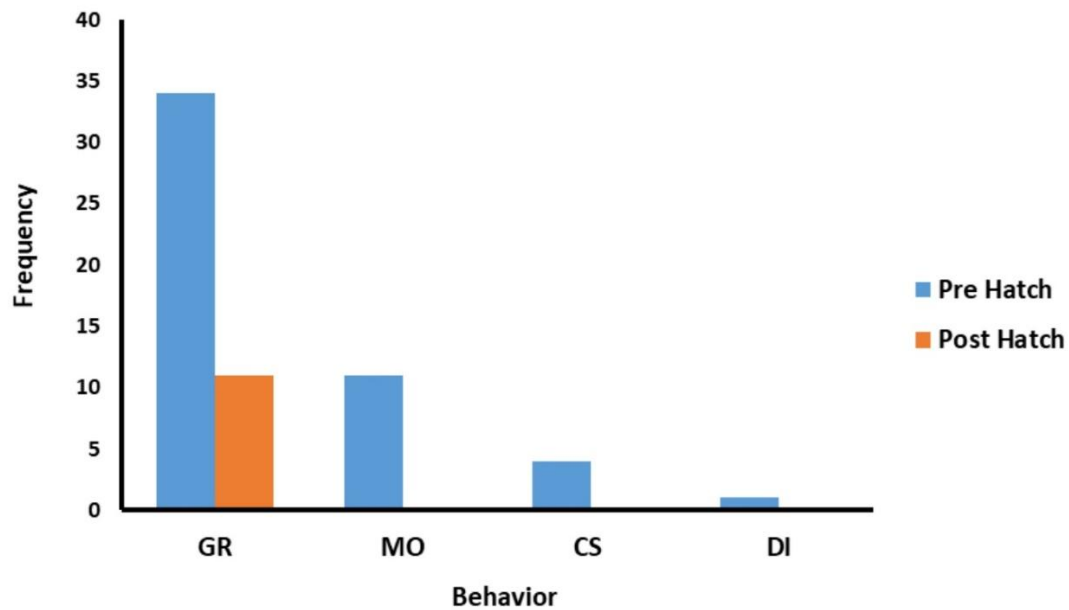


Figure 3. Daily frequency of behaviors exhibited by the marsh crocodile before and after hatching. The y-axis represents the average number of occurrences per observation day for each behavior: guarding the entrance (GR), digging the burrow (DI), moving into the burrow (MO), and chasing an intruder (CS). Pre-hatching and post-hatching phases are shown to illustrate changes in maternal behavior around the hatching period.

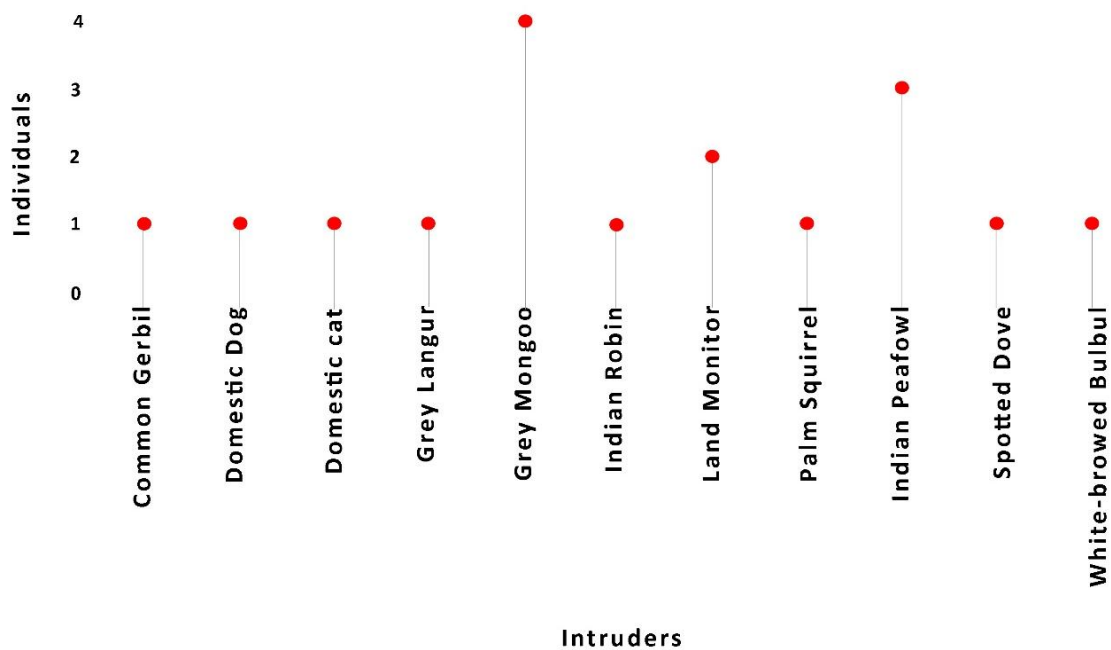


Figure 4. Intruder dynamics of crocodile nest pre-hatching and post-hatching phases.

Table 1. List of intruders recorded by camera traps at *Crocodylus palustris* nesting site

Common name	Family	Species
Land Monitor	Varanidae	<i>Varanus bengalensis</i>
Indian Peafowl	Phasianidae	<i>Pavo cristatus</i>
Indian Robin	Muscicapidae	<i>Saxicoloides fulicatus</i>
Spotted Dove	Columbidae	<i>Spilopelia chinensis</i>
White-browed Bulbul	Pycnonotidae	<i>Pycnonotus luteolus</i>
Gray Mongoose	Herpestidae	<i>Herpestes edwardsii</i>
Palm Squirrel	Sciuridae	<i>Funambulus palmarum</i>
Domestic Cat	Felidae	<i>Felis catus</i>
Domestic Dog	Canidae	<i>Canis familiaris</i>
Gray Langur	Cercopithecidae	<i>Semnopithecus entellus</i>
Common Gerbil	Cricetidae.	<i>Meriones unguiculatus</i>

4 Discussion

The analysis of behavioral frequencies in wild marsh crocodiles (*Crocodylus palustris*) revealed variations across distinct behaviors, with guarding behavior (GR) being the most frequently observed (133,880 occurrences). This substantial prevalence of GR underscores its importance as a protective strategy for both the nest and hatchlings. High frequencies of guarding have been documented in other crocodilian species, suggesting a universal adaptive strategy to mitigate predation risk (While *et al.*, 2009).

In contrast, digging (DI), movement (MO), and chasing intruder (CS) behaviors were observed significantly less often. The low occurrence of CS, in particular, aligns with previous studies indicating that mating activities in crocodiles are often infrequent and highly context-dependent (Garrick & Lang, 1977). The marked disparity in behavioral frequencies suggests that marsh crocodiles prioritize GR, reflecting an evolutionary adaptation to high predation pressures in their natural habitats (Murray *et al.*, 2020). Such findings prompt questions regarding the ecological factors driving this behavioral prioritization and how they may affect population dynamics.

The mother primarily guarded the nest near the entrance, particularly from around 6:00 p.m. until approximately 5:30 a.m. She typically retreated into the burrow between 5:00 a.m. and 6:30 a.m., possibly in response to human activity in the surrounding area. During daylight hours, she was rarely observed guarding from the entrance, instead remaining inside the burrow. The first hatchling was observed on 29 August 2017, when it attempted to leave the burrow and was gently retrieved by the mother using her mouth. On 4 September 2024, several hatchlings were seen near the burrow entrance. Notably, each time the mother entered the burrow headfirst, she would often engage in excavation behavior. Remarkably, the mother remained near the

burrow for over three months and was seldom seen leaving the nesting area.

The investigation of behavioral changes before and after hatching revealed a shift in behavior, with GR maintaining its predominance in both stages but exhibiting a notable decline post-hatching (34 occurrences pre-hatching vs. 11 occurrences post-hatching). This transition suggests that while parental care is critical during the pre-hatching phase to ensure nest protection, hatchlings may exhibit increased independence upon emergence (Charruau & Hénaut, 2012).

Future research could benefit from longitudinal studies tracking individual behavior over time to provide insights into how these changes affect survival and reproductive success. Such studies could also explore the potential impacts of environmental stressors on the expression of these behaviors (Balaguera-Reina *et al.*, 2015).

The observation of 12 different intruder species visiting the nesting site reveals a complex ecological interaction surrounding marsh crocodiles. The predominance of the Mongoose as a frequent intruder aligns with existing literature that identifies them as significant predators of crocodile eggs and hatchlings (Combrink *et al.*, 2016). This insight emphasizes the role of intruder species in shaping the nesting behavior and reproductive success of marsh crocodiles.

Furthermore, the presence of domestic animals, such as cats and dogs, at the nest sites indicates a concerning intersection of wildlife and urban environments. Domestic animals are known to pose significant threats to native wildlife through predation, habitat degradation, and competition for resources (Butler *et al.*, 2004). This anthropogenic influence on crocodile nesting sites could exacerbate predation risks and stress on nesting females,

ultimately affecting the population dynamics of marsh crocodiles (Mazzotti *et al.*, 2022).

Given the diverse range of intruders observed, it would be beneficial for future studies to assess the impacts of each intruder species on nest success rates and hatchling survival. Integrating camera trap data with ecological modeling could elucidate patterns of predation and inform conservation strategies aimed at mitigating risks associated with both native and domestic intruders.

The findings of this study highlight the critical role of guarding behavior in the survival of marsh crocodile populations and underscore the importance of protecting nesting sites from potential intruders. Effective conservation strategies should consider the ecological relationships surrounding nesting behaviors and intruder pressures. Implementing protective measures, such as habitat restoration and the establishment of buffer zones around nesting areas, could enhance reproductive success by minimizing human and predator interactions. Furthermore, public education initiatives targeting the owners of domestic animals could help raise awareness about the impacts of pet predation on local wildlife. Engaging communities in crocodile conservation efforts may foster coexistence and encourage responsible pet ownership practices.

5 Conclusions

This study offers valuable preliminary insights into the nesting behavior of wild marsh crocodiles, particularly emphasizing the importance of guarding behavior (GR) as a key protective strategy during the critical reproductive phase. Notably, behavioral shifts observed around the hatching period and interactions with intruding animals shed light on the complexity of parental investment and nest defense mechanisms in this species. However, as this study was based on observations from a single nest, the findings remain general and must be interpreted with caution. Behavioral variation is likely influenced by individual physiological states and environmental conditions, which can vary significantly across time and locations. Therefore, to draw robust conclusions, future studies should include multiple nests observed across different ecological settings and time periods. Such comprehensive research would deepen our understanding of intruder dynamics, maternal investment, and their implications for marsh crocodile ecology and conservation.

Acknowledgment

The authors extend their gratitude to Kulu Safari (Pvt) Ltd., Yala, Sri Lanka, for their invaluable support in data collection and the monitoring of the crocodile nest.

Declaration

The authors declare that they have no conflict of interest.

References

- Balaguera-Reina, S.A., Venegas-Anaya, M., Sanjurjo, O.I., Lessios, H.A. Densmore, L.D. (2015) "Reproductive ecology and hatchling growth rates of the American crocodile (*Crocodylus acutus*) on Coiba Island, Panama", *South American Journal of Herpetology*, **10** (1): 10–22.
- Butler, J.R.A., Du Toit, J.T. Bingham, J. (2004) "Free-ranging domestic dogs (*Canis familiaris*) as predators and prey in rural Zimbabwe: Threats of competition and disease to large wild carnivores", *Biological Conservation*, **115** (3), 369–378.
- Charruau, P. Hénaut, Y. (2012) "Nest attendance and hatchling care in wild American crocodiles (*Crocodylus acutus*) in Quintana Roo, Mexico", *Animal Biology*, **62** (1): 29–51.
- Combrink, X., Warner, J.K. & Downs, C.T. (2016) "Nest predation and maternal care in the Nile crocodile (*Crocodylus niloticus*) at Lake St Lucia, South Africa", *Behavioural Processes*, **133** (2016): 31–36.
- Da Silva, A. & Lenin, J. (2010) Mugger Crocodile *Crocodylus palustris*. In: *Crocodyles. Status Survey and Conservation Action Plan*. S.C. Anolis and C. Stevenson (eds), pp. 94-98, Crocodile Specialist Group: Darwin.
- Garrick, L.D. & Lang, J.W. (1977) "Social signals and behaviors of adult alligators and crocodiles", *Integrative and Comparative Biology*, **17** (1): 225–239.
- Groombridge, B. (1982) The IUCN Amphibia-Reptilia Red Data Book. IUCN: Gland.
- Lang, J.W. (1987) Crocodilian behaviour: implications for management in Wildlife Management: In: *Crocodyles and Alligators*, G.J.W. Webb, S.C. Manolis and P.J. Whitehead (eds), pp. 273-294. Surrey Beatty and Sons: Sydney.
- Mazzotti, F.J., Balaguera-Reina, S.A., Brandt, L.A., Briggs-González, V., Cherkiss, M., Farris, S. & Godahewa, A. (2022) "Natural and Anthropogenic Factors Influencing Nesting Ecology of the American Crocodile in Florida, United States", *Frontiers in Ecology and Evolution*, **10**: 1–14.
- Murray, C.M., Crother, B.I. & Doody, J.S. (2020) "The evolution of crocodilian nesting ecology and behavior", *Ecology and Evolution*, **10** (1): 131–149.
- While, G.M., Uller, T. & Wapstra, E. (2009) "Family conflict and the evolution of sociality in reptiles", *Behavioral Ecology*, **20** (2): 245–250.
- Whitaker, R. & Andrews, H. (2003) Crocodile conservation, Western Asia Region: an update. *Journal of the Bombay Natural History Society*, **100** (2&3): 432-445.
- Whitaker, R. & Whitaker, Z. (1979) Preliminary crocodile survey - Sri Lanka. *Journal of the Bombay Natural History Society*, **76** (1): 66- 85.
- Whitaker, R. & Whitaker, Z. (1984). Reproductive biology of Mugger. *Journal of the Bombay Natural History Society*, **81**(2): 119-127.

- Whitaker, R. (1987) The management of crocodilians in India. In: *Wildlife Management: Crocodiles and Alligators*, G.J.W. Webb, S.C. Manolis and P.J. Whitehead (eds), pp. 63-72. Surrey Beatty and Sons: Sydney.
- Whitaker, R., Barr, B., de Silva, A. & Ratnasiri, P. (2007) Observations on burrows dug by mugger crocodiles (*Crocodylus palustris*) in Bundala National Park, Sri Lanka. *Journal of the Bombay Natural History Society*, 104 (2): 19-24.