JOURNAL OF SUSTAINABLE NATURAL RESOURCES VOL. 2 NO. 1 (2021) 31-37

J-SuNR

Journal homepage: http://publisher.uthm.edu.my/ojs/index.php/jsunr
e-ISSN : 2716-7143

Journal of Sustainable Natural Resources

Agonistic Behavior of Captive Saltwater Crocodile, *Crocodylus Porosus* in Kota Tinggi, Johor

Mohd Faudzir Najmuddin[1], Nurhizatul Safikah Mohd Hauri[1], Hidayah Haris[1], Fatin Zahari[1], Nursyuhada Othman[1], Siti Hasmaliza Hassem[1], Muhammad Abu Bakar Abdul-Latiff [1,2*]

[1]Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia, KM1 Jalan Panchor, 84600, Muar, Johor, MALAYSIA

[2]Oasis Integrated Group (OIG), Institute for Integrated Engineering (I²E), Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, MALAYSIA

*Corresponding Author

DOI: https://doi.org/10.30880/jsunr.2021.02.01.005
Received 30 March 2021; Accepted 24 June 2021; Available online 28 June 2021

Abstract: Agonistic behavior in *Crocodylus porosus* is well known in the wild, but the available data regarding this behavior among the captive individuals especially in a farm setting is rather limited. Studying the aggressive behavior of *C. porosus* in captivity is important because the data obtained may contribute for conservation and the safety for handlers and visitors. Thus, this study focuses on *C. porosus* in captivity to describe systematically the agonistic behaviour of *C. porosus* in relation to feeding time, daytime or night and density per pool. This study was carried out for 35 days in two different ponds. The data was analysed using Pearson's chi-square analysis to see the relationship between categorical factors. The study shows that *C. porosus* was more aggressive during daylight, feeding time and non-feeding time in breeding enclosure (Pond C, stock density =0.0369 crocodiles/m^2) as compared to non-breeding pond (Pond B, stock density =0.3317 crocodiles/m^2) where it is only aggressive during the nighttime. Pond C shows the higher domination in the value of aggression in feeding and non-feeding time where it is related to its function as breeding ground. Chi-square analysis shows that there is no significant difference between ponds ($p=0.47$, $\chi^2= 2.541$, $df= 3$), thus, there is no relationship between categorical factors. The aggressive behaviour of *C. porosus* is important for the farm management to evaluate the risk in future for the translocation process and conservation of *C. porosus* generally.

Keywords: *Crocodylus porosus*, saltwater crocodile, agonistic behaviour, aggression, Teluk Sengat Crocodile Farm, Malaysia

1. Introduction

Crocodiles are well-known for its fierceness and territorial behavior. Hence, they are categorized as the apex predator [1]. Territorial behavior in animal world can defined as an expression of site-dependent dominance behaviors [2]. In crocodile world, the male crocodile will express their territorial behavior by defending their territorial from other males and also opportunist reptiles such as monitor lizard. Apart from being the largest species crocodile, saltwater crocodile can swim across ocean due to its ability to regulate salt in its body effectively compare to other crocodile species [3], [4]. Saltwater crocodiles, *C. porosus* ranged from India to Australia including Malaysia and well known for their highly territorial act especially during sub-adult and adult phase [2], [5]. Based on the previous data, the larger crocodiles often prevent smaller ones from accessing particular resources such as the basking sites, food, shelter and water [6]. Their territories are defended throughout the year, with various seasonal reproductive activities [2]. The

*Corresponding author: latiff@uthm.edu.my

young crocodiles were recorded to start their territorial behaviors at the age of 2.5 years old. The shallow open water areas appeared to be an important resource for competition, with dominant individuals clearly attempting to exclude others from it during periods of aggression (dusk and dawn). Messel et al. (1980) reported that the resident juvenile of *C. porosus* with total length of 90–240 cm long in the wild will start to chase the conspecifics away from the shallow water areas near the riverbank [7]. In Malaysia, *C. porosus* is one of the three crocodile species that can be found either in the wild or captive breeding [8].

Despite the detail description of *C. porosus* behaviour, information on the agonistic behavior of the captive adult crocodile in Malaysia are scarce in scientific report as compared to the other countries. Lack of study in Malaysia was mainly because of safety factors when study wanted to be done around adult crocodile. Previously available study on captive saltwater crocodile in Malaysia was in Tuaran Crocodile Farm, Sabah, which mainly focuses on the agonistic behavior and mating behavior of the crocodile [9]. Results from the study in Tuaran revealed that captive *C. porosus* in Tuaran Crocodile Farm displayed the most aggressive behaviour at daylight, specifically during feeding time with stock density related to aggression value. Nonetheless, other information on the behavior of this species such as provocation reaction, territorial, and daily seasonal activity are still limited. As compared to the study on wild *C. porosus,* the behavior is well-known to be aggressive, territorial and feared man-eater [2]. In contrast to the wild populations, Brien et al. (2013) mentioned that the saltwater crocodile in the farm has become less territorial and less aggressive starting from hatchling phase [1].

Thus, this study focuses more on the agonistic behavior of the captive adult saltwater crocodile in Teluk Sengat Crocodile Farm, Kota Tinggi, Johor. The specific objectives of this study are to evaluate the agonistic behavior of the adult *C. porosus* in captivity that related to the practice by the park management and eventually, provide additional data for the conservation of *C. porosus*. By using direct observation, the agonistic behavior of *C. porosus* will be recorded to see any differences between daylight and nighttime, and between feeding time and non-feeding time. We sought to explain the intensity of agonistic behavior of saltwater crocodiles and how they are affected by the time of day, and whether or not they are influenced by the feeding time.

2. Methodology

2.1 Study Site

This study was carried out in Teluk Sengat Crocodile Farm (1.5651066ºN, 104.0241387ºE) in Kota Tinggi, Johor (Fig. 1). There are more than 1,000 individuals live in the captivity. There are small size ponds measured approximately 150.743 m^2 (Fig. 2), two breeding ponds measured approximately 812.4779m^2 (Fig. 2), and 20 individual ponds measured approximately 30 m^2 big. Each pond has different number of crocodiles. However, only six breeding enclosure, 27 small enclosure and 37 individual enclosure were open to public. The other two breeding enclosure and ten small enclosures were restricted for the management purposes. This study was done simultaneously with feeding regime management study in another manuscript in the same volume.

Fig. 1 - Location of Teluk Sengat Crocodile Farm, Kota Tinggi, Johor

Fig. 2 - Non-breeding pond (Pond B) and breeding pond (Pond C) inhabited by *C. porosus* in Teluk Sengat Crocodile Farm

2.2 Intensive Observation

All occurrence sampling (*ad libitum)* was used to count the agonistic behavior of *C. porosus* (Altmann, 1974). The observation was conducted to compare agonistic behavior between two ponds condition which are daylight (9:00AM-6:00PM), nighttime (7:00PM-9:00PM), daylight feeding time, and daylight non-feeding time. The observation for agonistic behavior focused on two ponds, "pond B" and "pond C". Pond B has 50 individual crocodiles in 150.743m^2 pond and Pond C has 30 individuals in 812.4779m^2 pond. Stopwatch was used to record the duration of every interaction of individuals in the pond. The description of various postures, non-contact movement displayed by the crocodilians during agonistic interactions in this study followed the description by [1] in Table 1.

Table 1 - Description of various postures, non-contact movement displayed by the crocodilians during agonistic interactions, interaction studies [1]

	Abbreviation	Definition
Initiation		
Rapid advances	RA	Series of short rapid advance movements towards another individual while low in water.
Termination		
Slow flight	SF	Slow movement away from another individual in a low in water posture
Rapid flight	RF	Rapid movement away from another individual in a low in water posture

Posture		
Low in water	LIW	Immobile with only the top of the head and back above the water surface.
Inflated posture	IP	Immobile with upward extension of either the front two or all four limbs, with neck and back arched high and head and tail angled downward.
Head and tail raised	HTR	Immobile with head and tail raised out of water while back remains low. Head is usually parallel to the water but can also be angled upwards.
Head raised high	HRH	Immobile with upward extension of the front two limbs pushing the head and chest high out of the water on a ~ 45^0 angle while tail remains low.
Mouth agape	MA	Immobile with mouth opened wide (all postures)
Non–contact movement		
Light jaw clap	LJC	Rapid opening and closing of the jaws at the water surface, often repeated several times while low in the water or inflated.
Tail-wagging	TW	Undulation of the tail from side to side in either gentle sweeping motion or rapid twitching, often repeated several times (all posture).
Inflated tail sweep	ITS	In an inflated posture, the whole tail is swept side to side in a slow deliberate fashion as the individuals' approaches another. This becomes more rapid and the tail is trashed from side to side.
Vocalization	V	Vocalization observed and confirmed from body movement.
Contact movement		
Head push	HP	Head is pushed in to an opponent, usually with mouth closed while low in water or inflated.
Push down	PD	Chest and neck of individuals pushed down on the upper neck or back of an opponent while head us raised high.
Bite	B	Jaws closed shut on an opponent (all postures).
Side head-strike	SHS	Head is thrust sideways in to an opponent while the mouth is either open or closed (all postures).
Tail-wag side head strike	TWSHS	Tail wagging occurs prior to a side head strike, increasing the force of the impact (all postures).
Tail-wag bite	TWB	Tail-wagging occurs prior to a bite and it propels the individual in to an opponent with force while low in water.

2.3 Data Analysis

The data obtained from every event during the observation was analyzed according to the method proposed by [11]. The mean duration of recorded interaction was calculated to obtain the aggression value using the formula below [9], [11].

$$\text{Aggression (events/min)} = \frac{\text{Number of behaviour exhibited}}{\text{Number of individuals} \div 100} \div \text{Mean duration of interaction} \quad (1)$$

The number of individuals was divided by 100 (constant factor), for the conversion of the number of individuals into its standard value [11]. Then, the stock density was calculated to obtain the exact value of aggression. Stock density is the number of individuals present in a particular area [9]. Then, the aggression value in relation with stock density will be compared in each observed condition (daylight, night, feeding time, and non-feeding time). The calculation was calculated and visualized by using Microsoft Excel software.

3. Results

3.1 Ponds Description and Aggression Behaviour

The total sampling days were 35 days between July until August 2018. The total observation hours recorded were 32 hours, where 16 hours were separated for each pond with 251 total aggression behaviour recorded. The total hours allocated for the different type of observations were varied due to various limitations such as inconsistent schedule for feeding time and enclosure safety. The daily operation hours in Teluk Sengat Crocodile Farm were another limitation as it only operates from 8:00AM to 5:00PM, which making it is impossible to conduct a scheduled dawn and night observation every day. Furthermore, it was hard to observe after daytime as the crocodile farm only installed the lighting system in the cafe area and around the receptionist department but not in the cage area. Unpredictable weather such as rain also causes poor visibility, thus, contributing to the limitation during data collection.

Pond B accommodated up to 50 individuals while Pond C accommodated up to 30 individuals. For both ponds, the number of female *C. porosus* is more than the male. Based on the report provided by the management, the ratio of males to females *C. porosus* is 1: 4. The age of the *C. porosus* mostly ranged from 15 years old to 20 years old in Pond B and 20 years old to 25 years old in Pond C. Most of them were bred since juveniles, but only a few of them (mostly are male) were captured from Sungai Johor. The feeding time was observed once a week depending on the day, usually Monday, while the type of food given were usually chicken or tuna. The size of Pond B is 150.743 m^2 while the size of Pond C is 812.4779 m^2. The shape of Pond C is irregular shaped while Pond B is rectangularly shaped. Both ponds have different characteristics where Pond B was made up with cement and has a hut in the middle of the pond while Pond C was designed specifically for breeding purposes. As compared to the Pond C design, Pond B was built with half cement with sandy ground as well as few vegetation available and the pond cliff was completely cement. The average temperature for both Pond B and C is 29.15°C during daylight and 27.1°C during nighttime respectively. The stock density of Pond B (0.3317 crocodiles/m^2) was higher compared to Pond C (0.0369 crocodiles/m^2).

3.2 Aggression Related with Stock Density

Both ponds show a comparable sum of aggression behaviour per minute. Pond B (stock density = 0.3317 crocodiles/m^2) showed lower aggressive behaviour per minute compare to Pond C (stock density = 0.0369 crocodiles/m^2) in all condition except for nighttime. While Pond C exhibit higher aggression value per minute in all condition except for nighttime compared to Pond B (Fig. 3). Through observations, Figure 3 shows the highest level of agonistic interactions and it was displayed during the feeding time. However, the other area in the pond displays a lower level of aggression compared to feeding areas. In this study, feeding time stated the highest value of stock density related to aggression (4.7018 events/min observed in a density 0.3317 crocodiles/m^2 in Pond B, 9.7079 events/min observed in a density 0.0369 crocodiles/m^2 in Pond C) compared to non-feeding time (1.4533 events/min observed in a density 0.3317 crocodiles/m^2 in Pond B and 8.4650 events/min observed in a density 0.0369 crocodiles/m^2 in Pond C). The results from chi-square test shows that the p-value=0.47 where there is no significant evidence to conclude the observed distribution is different as the expected distribution (χ^2 = 2.54075; d.f.=3). We can conclude there is no difference in aggression behavior between categorical factor (nighttime, daytime, feeding and non-feeding time) as p-value is more than 0.05.

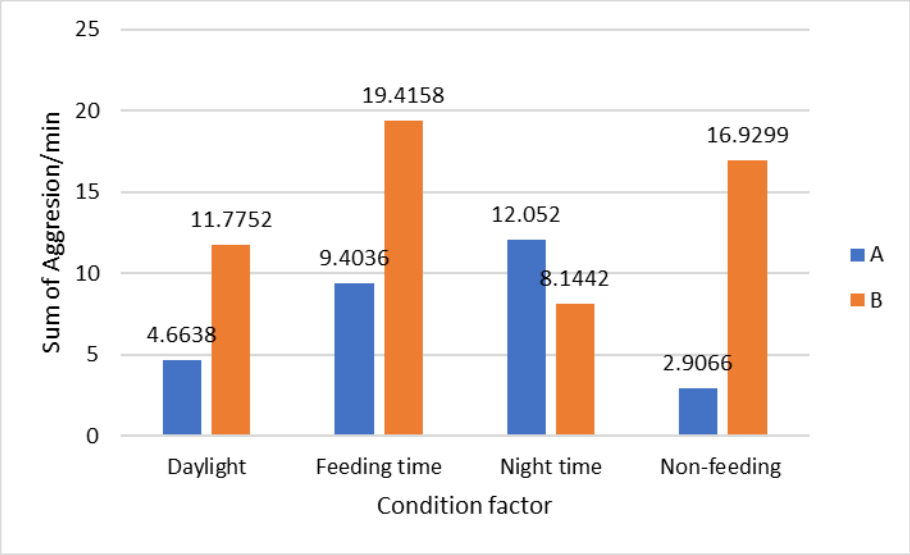

Fig. 3 - Comparison of aggression interaction between Pond B and Pond C

4. Discussion

This result shows consistent pattern with the previous study in Tuaran Crocodile Farm when comparing between the feeding and non-feeding time [9]. Based on the record, wild *C. porosus* is able to stay alive without food for more than 12 months [2]. So, the relationship between food limitation and aggressiveness in *C. porosus* is insignificant as 'starvation' is not the main reason for the individuals to react aggressively. Based on the observation, when the staff distributed the food, there would be a lot of individuals coming out from the water or move forward to the feeding areas, either to eat or unintentionally moved because it was disturbed when the others were swimming in the water area or being roughly pushed by the rushing crocodiles. There were also immobile female crocodiles in Pond C (taking care of theirs's nest), excited juvenile in Pond B and submissive crocodiles available in both ponds that contribute to the variable aggression value. Juvenile crocodiles in Pond B were very competitive as they rushed (RA) and jumped with MA about one meter in height when they arrived approximately 0.5 m from the fence towards feeding areas. Besides that, female *C. porosus* were very highly possessive and protective near their nests and when it being disturbed, where aggressive behavior would be initiated [1]. Submissive *C. porosus* commonly will either stay unmoved or will head raised high (HRH) to reflect that they surrendered and will never disturb others again. Besides, the individual which was disturbed would raise the head and tail (HTR) combined with mouth agape (MA) to intimidate the other individual. The fight included vocalization (V) that occurred alternatively during tail-wag side-head strike (TWSHS) and side head strike (SHS). Injuries were common when combative incident occurs [1].

Comparing between both ponds, recurrence of injury in Pond B was higher than Pond C. There were the events of the same submissive individual being attacked by the dominant crocodile for two consecutive days in each pond recorded. The injuries were mostly located at the snout, front legs, eye, or at the back of the body. Most of the agonistic interactions occurred near the feeding area (the highest aggressive level) but moving away from the feeding area, they only displayed the moderate level of aggression. Most of the interactions were initiated unintentionally (resulted from being rushed) and specifically for Pond C, the agnostic behavior occurred on the sandy area or near the shallow water 0.5m away from the ground. The movement of most of the crocodiles in the pond were slow and some of them observed crawled up against other individuals occasionally. The dominant crocodiles remain with the fierce characters in both ponds. Overall, submissive crocodiles will only steal the food among them and avoided the dominant ones. The interactions involved mostly initiated with RA, MA and V then finished with RF after they were able to grab the food from the opponents. However, the distance of crocodile's interaction from RA to RF between both ponds was different. The range of the interaction in Pond B was 0.7m while in Pond C was 1m. The frequency of the opposing crocodile chased the other individuals was low in both ponds. The aggression showed in Pond B was more related with the high stock density while in Pond C, it was related with the mating and breeding behavior [1]. The data recorded in this study may help in understanding the overall behavior of *C. porosus* in captivity. This may also help in decision making for translocation process of *C. porosus* in *ex-situ* conservation site.

5. Conclusion

This study described the agonistic behaviors of captive saltwater crocodile in Teluk Sengat Crocodile Farm and its relationship with stock density and enclosure function. The saltwater crocodile in non-breeding pond shows more tolerance toward each other compared to the breeding pond. Breeding pond (Pond C) shows the higher domination referring to the value of aggression in feeding and non-feeding time where it's related to its function for breeding ground compared to non-breeding pond.

Acknowledgement

The authors acknowledge Ministry of Higher Education Malaysia and Universiti Tun Hussein Onn Malaysia for providing the necessary funding, facilities, and assistance. This research was supported by Fundamental Research Grant Scheme FRGS/1/2018/WAB13/UTHM/03/2 provided by Ministry of Higher Education Malaysia and GPPS-UTHM-2019-H552 postgraduate grant by Universiti Tun Hussein Onn Malaysia (UTHM). We also acknowledge Teluk Sengat Crocodile Farm for their generous assistance and cooperation throughout this research and their kindness in sharing information as well as their openness to receive suggestions from our team.

References

[1] Brien, M. L., Webb, G. J., Lang, J. W., McGuinness, K. A., & Christian, K. A. (2013). Born to be bad agonistic behaviour in hatchling saltwater crocodiles *(Crocodylus porosus) Behaviour* 150 (7) 737-762.

[2] Lang, J. W. (1987). Crocodilian behaviour: implications for management. *Wildlife management: crocodiles and alligators* 273-294.

[3] Taplin, L. E. (1984). Homeostasis of plasma electrolytes, water and sodium pools in the estuarine crocodile, *Crocodylus porosus*, from fresh, saline and hypersaline waters *Oecologia* 63 (1) 63-70.

[4] Taplin, L. E., Grigg, G. C., & Beard, L. (1985). Salt gland function in freshwater crocodiles: evidence for a marine phase in eusuchian evolution'. In: G Grigg, Shine & H Ehmann (eds), *Biology of Australasian Frogs and Reptiles* Surrey Beatty & Sons, Chipping Norton 403–41.

[5] King, F. W., & Burke, R. L. (1989). Crocodilian, Tuaturan and Turtle species of the world. A taxonomic and geographic reference *Association of Systematics collections* Washington DC.

[6] Grigg, G., & Gans, C. (1993). Morphology and Physiology of the Crocodylia *Fauna of Australia Vol 2A Amphibia and Reptilia* Australian Government Publishing Service. Canberra 326-336.

[7] Messel, H., Vorlicek, G. C., Wells, A. G., Green, W. J., & Johnson, A. (1980). Surveys of the tidal river systems in the northern territory of Australia and their crocodile populations. Monograph 14: Tidal Waterways of Van Diemen Gulf. Ilamaryi River, Iwalg, Saltwater and Minimini Creeks and Coastal Arms on Cobourg Peninsula Resurveys of the Alligator Region Rivers.

[8] Nazli, M. F., & Hashim, N. R. (2009). Preliminary survey of *Crocodylus porosus* in Rembau Estuary, Peninsular Malaysia.

[9] Asmat, M. F. (2015). Agonistic Behaviour In Captive Adult saltwater crocodile. *Crocodylus porosus*. Universiti Malaysia Sabah: Degree's Report Project.

[10] Altmann, J. (1974). Observational study of behavior: sampling methods *Behaviour* 49 (3-4) 227-266.

[11] Morpurgo, B., Gvaryahu, G. & Robinzon, B. (1993). Aggressive behaviour in immature captive Nile crocodiles, *Crocodylus niloticus*, in relation to feeding *Physiology &behavior* 53 (6) 1157- 1161.