DISTRIBUTION, ABUNDANCE AND HABITAT CONSERVATION OF *CROCODYLUS POROSUS* IN REMBAU-LINGGI ESTUARY, PENINSULAR MALAYSIA

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Introduction

The Estuarine crocodile (*Crocodylus porosus*) is one of the 23 species belonging to family Crocodylidae and is the largest crocodilian species (Ross, 1989; Alderton, 1991). This species is found throughout the tropical regions of Asia and the Pacific ranging from western coast of India through mainland Southeast Asia to northern Australia (Alderton, 1991; Stuebing *et al*., 1994).

Estuarine crocodiles inhabit more than one habitat: freshwater, brackish tidal rivers, estuaries, lakes, swamps and coastal mangrove forest habitats (Webb *et al*., 1987). In its habitat, *Crocodylus porosus* is a charismatic megafauna that acts as the keystone species to maintain the structure and function of the habitat (Ross, 1998). The females produce large clutch of eggs and become the formidable defender of her nest (Whitaker and Whitaker, 1989). *Crocodylus porosus* also feeds on a wide range of prey from crustaceans, fish, amphibians, lizards, birds and mammals (Ross, 1989; Alderton, 1991).

According to the International Union for the Conservation of Nature Red List 2009, *C. porosus* is currently listed as 'least concern/lower risk' and this was based on its population assessment by Crocodile Specialist Group in 1996 (IUCN, 2009). *Crocodylus porosus* is also listed in Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora throughout most of its range except for Australia, Indonesia and Papua New Guinea which are included in Appendix II (CITES, 2009). This species is listed under of The Protection of Wildlife Act 1972 (Act 76) as a 'protected' species in Malaysia.

Several studies on *C. porosus* have been conducted on its population dynamics, habitat selection and behaviour in Borneo (Cox and Gombek, 1985; Stuebing and Mohd Sah, 1992; Stuebing *et al*., 1994). However, currently no reliable data on the distribution and abundance of *C. porosus* is available in Peninsular Malaysia.

Therefore, it is very important to study the ecology of *C. porosus* in order to fill the gap of information on its population. The information on the population of this species is essential for its long-term conservation especially in Peninsular Malaysia. This study which employed population survey method was therefore aimed to understand the

population ecology of *C. porosus* in a mangrove lined river, Rembau-Linggi Estuary, Peninsular Malaysia.

Objectives

1. To obtain data on the distribution and abundance of *C. porosus* in study area.
2. To identify the habitat threats of *C. porosus* in study area.

Materials and methods

Study area

This study was conducted in Rembau-Linggi Estuary, Peninsular Malaysia. Rembau-Linggi Estuary consists of two major rivers, which are Rembau River and Linggi River (Negeri Sembilan-Malacca border) that flow into Straits of Malacca. Tidal influence forms the brackish water when the saline water from the Straits of Malacca mixes with the freshwater during high tides. The vegetation of this study area is dominated by mangroves genera such as Sonneratia, Rhizophora and Avicennia with extensive mangrove mudflats. Land use types around the study area varied; however, it is mainly dominated by oil palm and rubber plantation and human settlements.

Survey design

The crocodile survey was conducted along a total of 26.3 km of three transect lines that divided the three the river sections as follows (Fig. 2):

1. Transect 1 (11.4 km): Survey along the upstream area of Rembau River to river confluence.
2. Transect 2 (6.4 km): Survey along the upstream area of Linggi River to river confluence.
3. Transect 3 (8.5 km): Survey along the downstream area of Linggi River.

Spotlight survey

Crocodiles were surveyed from a 14 feet fibre boat equipped with 40 hp engines along the transect lines. The surveys started around 12.30 a.m., provided that there was no rain 2-3 hours prior to survey. We also made sure that the appropriate weather coincided with low tides as more crocodiles are visible with an increase in the amount of exposed mudflats (Messel *et al*., 1981). The mudflats and river waters surface were shone with a spotlight.

Once the crocodiles were spotted, they were approached as closely as possible to estimate their total length. Total length was estimated as the length from the nostril to the tail of the crocodiles. Based on the total length estimation, they were classified into ten size classes as shown in Table 1 (sensu Bayliss, 1987). They were recorded as ‘eyeshine only’ (EO) if they cannot be approached or have their total length estimated. The coordinates of the location where the crocodiles were observed were recorded using the Global Positioning System (GPS).

Table 1: Size classes of *C. porosus* (sensu Bayliss, 1987).

Class	Size class (ft)	Size class (m)
1	1-2 (H)	0.3-0.6
2	2-3	0.6-0.9
3	3-4	0.9-1.2
4	4-5	1.2-1.5
5	5-6	1.5-1.8
6	6-7	1.8-2.1
7	7-8	2.1-2.4
8	8-9	2.4-2.7
9	9-10	2.7-3.0
10	>10	>3.0

H=Hatchlings

Interviews

Several villagers and personnel from relevant departments will be interviewed to find out information on hunting, selling, killing, habitat destruction, pollution and crocodile attacks.

Direct observation

The habitat of *C. porosus* will be directly observed along the study period to ascertain the type of threats.

Land use analysis in GIS

The recent land use map of the study area will be obtained from the Ministry of Agriculture and digitized in ArcGIS 9.2. The land use types of the study area will be analyzed from the digitized land use map.

Results and discussion

Distribution of Crocodylus porosus

In order to obtain high precision of mean of *C. porosus*, the spotlight surveys were replicated twice for each transect (n=2). The spotlight surveys showed that a total mean of 60 individuals were distributed along a total distance of 26.3 km, of which 10 individuals were found in the Rembau River and 25 individuals in both upstream and downstream area of Linggi River, respectively.

From the results, 16 (26.7%) were found to be Class 1 individuals which are hatchlings, followed by 7.5 (12.5%) Class 2, 3 (5%) were classified as Class 3, Class 4 and Class 5 respectively with a total of 2.5 (4.2%) in both Class 6 and Class 8. Only 1.5 (2.5%) were found to be Class 10 individuals and 1 (1.7%) of Class 7 individuals forming the lowest

distribution. The total mean of EO recorded was 19.5 (32.5%) observations which might be varied of different size classes.

Distribution of *C. porosus* for each transects along the river for the ten size classes is shown in Figure 1. In Rembau River, no observation of *C. porosus* was found to be Class 4, Class 6, Class 7 and Class 9 with the number of EO (4.5 observations) was the highest. The total mean of *C. porosus* showed that both Class 1 hatchlings (12 individuals) and Class 2 (4 individuals) were highest in the upstream area of Linggi River. However, no observation of individuals in Class 6, Class 7, Class 8 and Class 10 in this area. For the downstream area of Linggi River, the number of EO (9.5) was the highest while the total mean of *C. porosus* for all size classes was comparable except for Class 9 because no crocodile was found to be in this size class.

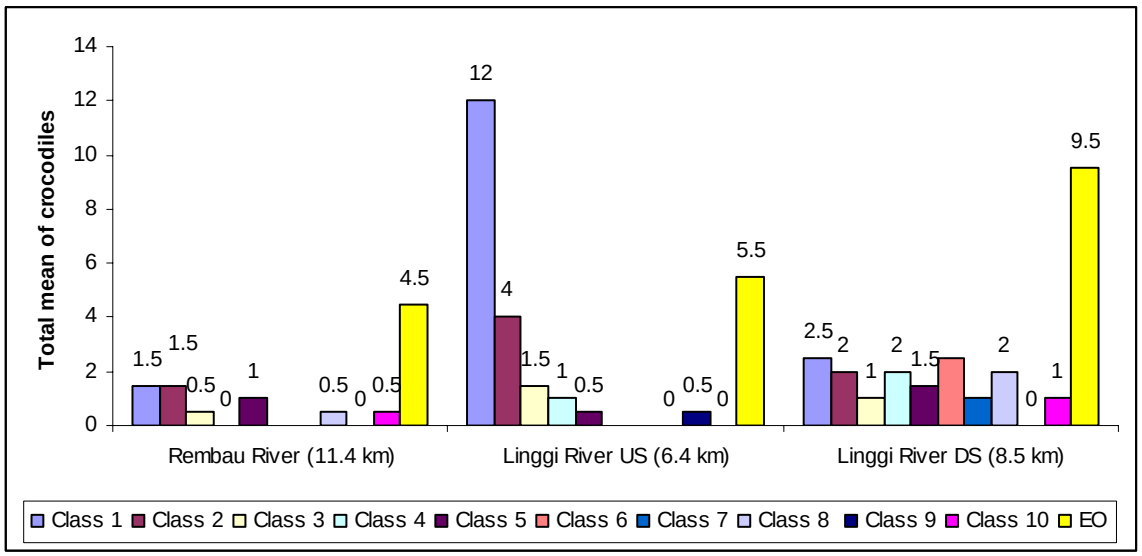

Figure 1: The distribution of *C.porosus* by size classes and EO for each river section. US= upstream and DS= downstream

It appears that the Class 1 hatchlings showed no preferences whether for Rembau River, upstream and downstream area of Linggi River. Interestingly, the highest mean of Class 1 were found in the upstream area of Linggi River although this area was highly disturbed by the river widening project. All the mangrove vegetations on both sides of the riverbank which provide the habitats for estuarine crocodiles were destroyed during the project. Moreover, hatchlings are threatened by many threats such as predators (e.g. monitor lizards, human poaching and pollution).

Male estuarine crocodiles get sexually mature at around 3.2m and females at around 2.2m (Groombridge, 1987). Therefore all crocodiles from that size onwards were considered being adults. However, only very few adults were observed during the spotlight surveys. This might be caused by the high degree of wariness where the older and larger crocodiles are usually more wary and difficult to detect during the spotlight survey (Webb and Messel, 1979). The high number of EO recorded in each river sections was

not clumped but observation was confounded by the difficulty to approach the crocodiles and to estimate their size.

Significance of finding

Estuarine crocodiles still inhabit the Rembau-Linggi Estuary although with small population remains. Since the information on the distribution and abundance of this species remain uncertainty, this finding is a cornerstone for an extensively crocodile population monitoring programmes. Information on the population of *C. porosus* obtained through this study will likely be significantly valuable for the conservation and management of this species especially in Peninsular Malaysia.

References

Alderton, D., 1991. Crocodiles and alligators of the world. Blanford Publishing, New York.

Bayliss, P., 1987. Survey methods and monitoring within crocodilian management programmes. In: Webb, G.J.W., S.C. Manolis and P.J. Whitehead, (Eds.). Wildlife management: crocodiles and alligators. Surrey Beatty and Sons Pty. Ltd., Chipping Norton, Australia, pp: 157-175.

CITES, 2009. The CITES species. Convention on International Trade in Endangered Species of Wild Fauna and Flora. Available from: http://www.cites.org/eng/app/appendices.shtml.

Cox, J., and F. Gombek, 1985. A preliminary survey of the crocodile resource in Sarawak, East Malaysia. World Wildlife Fund Malaysia. IUCN/WWF Project No. MAL 74/85.

Groombridge, B., 1987. The distribution and status of world crocodilians. In: Webb, G.J.W., S.C. Manolis and P.J. Whitehead, (Eds.). Wildlife management: crocodiles and alligators. Surrey Beatty and Sons Pty. Ltd., Chipping Norton, Australia, pp: 157-175.

IUCN, 2009. Crocodile Specialist Group 1996. *Crocodylus porosus*. In: IUCN, 2009, IUCN Red List of Threatened Species. Ver. 2009.1. Available from: http://www.iucnredlist.org.

Messel, H., G.C. Vorlicek, W.J. Green and I.C. Onley, 1981. Surveys of the tidal river systems in the Northern Territory of Australia and their crocodile populations. Monograph No. 1. Pergamon Press, Sydney.

Ross, C.A., 1989. Crocodiles and alligators. Facts on file, New York.

Ross, J.P., 1998. Crocodiles: Status survey and conservation action plan, 2nd Edn., IUCN/SSC Crocodile Specialist Group, Gland, Switzerland.

Stuebing, R.B. and S.A. Mohd Sah, 1992. Distribution, population structure and some aspects of the ecology of the estuarine crocodile (*Crocodylus porosus* Schneider) in the Kilas River, Sabah. In: Crocodiles, Proc. of the 11th Working Meeting of the Crocodile Specialist Group, 2: 149-162. IUCN, Gland, Switzerland.

Stuebing, R.B., G. Ismail and L.H. Ching, 1994. The distribution and abundance of the Indo-Pacific crocodile *Crocodylus porosus* Schneider in the Klias River, Sabah, East Malaysia. Biol. Conservat., 69: 1-7.

Webb, G.J. and H. Messel, 1979. Wariness in *Crocodylus porosus*. Aust. Wild. Res., 6: 227-34.

Webb, G.J., S.C. Manolis and P.J. Whitehead, 1987. Wildlife management: Crocodiles and alligators. Surrey Beatty and Sons Pty. Ltd., Chipping Norton, Australia.

Whitaker, R. and Z. Whitaker, 1989. Status and conservation of the Asian crocodilians. In Crocodiles: their ecology, management, and conservation. IUCN/SSC Crocodile Specialist Group. Phil Hall, Int. Union for Conservat. of Nature and Natural Res. pp: 297-302.