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Distribution of two species of Asian horseshoe crabs at west coast of Sarawak's Waters, East Malaysia ☆

A.R. Noor Jawahir*, M. Samsur, M.L. Shabdin, A.R. Khairul Adha

Department of Aquatic Science, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

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ABSTRACT

Conservation of horseshoe crabs worldwide has become challenging as the number of horseshoe crabs were decreased due to human activities. Therefore, this research was designed to assess the habitat of horseshoe crabs by determining their distribution at nine different locations in west coast of Sarawak's waters. A line transect method was used to determine species distribution where Pasir Putih Village had the highest density of *T. gigas* caught with of 1.72 individuals per hectare. Based on sediment analysis, *T. gigas* was found mainly in sandy beach of Pasir Putih Village, Pandan Beach, Sibul Laut Village, and Gerigat Beach with total organic matter and the sediment size ranging from 0.39% to 10.9% and 125 μm to 250 μm , respectively. Meanwhile, *C. rotundicauda* was mostly collected from mangrove area (high content silt-clay) with sediment size less than 63 μm and total organic matter ranging from 0.35% to 27.91%. The findings of this research indicated that the distribution of *T. gigas* and *C. rotundicauda* in different preferred habitat in west coast of Sarawak's waters were influenced by the *in-situ* physico-chemical parameters, type of sediment, lunar cycle and spawning season.

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Introduction

The habitat of horseshoe crabs are known to be at three different areas, which are at the coastal bay, intertidal mud or sand flat, and deeper water (Emily, 2011). Spawning activities of horseshoe crabs normally occurred in intertidal zone (Brockmann and Smith, 2009) during a full and new moon nights (Zaleha et al., 2012). Common natural habitat for *C. rotundicauda* is muddy and brackish areas (Robert et al., 2014). Meanwhile, *T. gigas* can be found in sandy to muddy areas (Tan et al., 2012). The spawning activity of horseshoe crabs was influenced by several environmental factors in habitat such as salinity, temperature, pH, dissolved oxygen (DO) level of water and sediment characteristics (Smith et al., 1991; Nelson et al., 2015).

To date, the distribution of horseshoe crabs in Sarawak is still unknown since most of the studies of horseshoe crab in Malaysia are in Peninsular Malaysia and Sabah (Sekiguchi and Shuster, 2009; Tan et al., 2012; Zaleha et al., 2012; Robert et al., 2014; Faridah et al., 2015). Besides that, human activities such as active consumption by local people, commercial purpose, habitat

destruction and natural causes (beach erosion) had caused concern which can contributed to extinction of horseshoe crab in west part of Sarawak waters. In addition, no conservation effort and no protection done by local government agencies to conserve this precious horseshoe crabs in Sarawak waters.

Therefore, this study is essential to determine the status of horseshoe crab in different habitats. The aim of this survey was to provide a baseline data of the two species of Asian horseshoe crab's distribution obtained from nine sites of the west coast of Sarawak's waters including their preferred habitat and related *in-situ* environmental factors such as particle size, total organic matter (TOM) and physico-chemical parameters.

Materials and methods

Sampling sites

Single sampling was conducted along the west coast of Sarawak waters which consists of nine sampling sites (Fig. 1). The survey was done from October 2013 to May 2014 either on the full moon or new moon days (Zaleha et al., 2012). Each sampling site was described in Table 1. The sampling sites were chosen on sandy beaches and mangrove areas. The distance of A (Kuching district), B (Samarahan district) and C (Kabong district) areas were approximately 87.5 km, 25 km and 87.5 km, respectively.

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* Corresponding author.

E-mail address: noorjawahir@gmail.com (A.R. Noor Jawahir).

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Table 1

District, name of locations, lunar cycle with sampling date, GPS coordinate and habitat description of nine sampling sites in western part of Sarawak waters.

District	Name of locations	Lunar cycle/sampling date	GPS coordinate	Habitat description
Kuching	Pasir Putih Village, Muara Tebas	N.M (03/03/14)	1°39'49.0"N, 110°28'30.0"E	Sandy beach with replanting mangrove trees
	Pandan Beach, Lundu	N.M (02/05/14)	1°45'51.7"N, 109°51'53.5"E	Open sandy beach
	Sibu Laut Village, Telaga Air	N.M (05/10/13)	1°41'18.2"N, 110°12'08.9"E	Sandy area; near estuary; covered with mangrove ecosystem
Samarahan	Asajaya Laut	F.M (23/10/13)	1°35'55.9"N, 110°36'19.4"E	Mangrove area, near estuary
	Jemukan	F.M (16/12/13)	1°33'53.9"N, 110°36'0.98"E	Mangrove area, near estuary
	Sadong Jaya	N.M (04/03/14)	1°30'37.8"N, 110°44'24.3"E	Mangrove area, near estuary
Betong	Gerigat Beach, Kabong	N.M (29/04/14)	2°02'27.7"N, 111°11'30.5"E	Open sandy beach
	Maludam	F.M (25/08/13)	1°39'50.7"N, 111°01'15.5"E	Open muddy beach, near estuary
	Beladin	N.M (29/04/14)	1°40'55.2"N, 111°04'26.2"E	Open muddy beach, near estuary

*N.M indicated new moon and F.M indicated full moon.

Sampling design

The modified line transect method was used to study the horseshoe crabs distribution, physico-chemical parameters and sediment size analysis at the intertidal area during low tide (Shin et al., 2009). The covered sampling area was estimated during low tide and the horseshoe crabs in that area were collected and counted. Estimated covered area for each sampling sites are 50 ha for Pasir Putih Village, 35 ha for Sibu Laut Village, 25 ha for Gerigat Beach and 1 ha for Pandan Beach, Asajaya Laut, Jemukan, Sadong Jaya, Beladin and Maludam, respectively. Three perpendicular line transects were set up equally apart at intertidal area from lower tidal level for water quality intake and sediment collection. The reasons for different size of each sampling area were due to the diversification of exposed intertidal area of sampling sites which depend on the tidal range, topographical, and geological conditions.

Sampling technique

The horseshoe crab specimens were collected by two different methods such as visual search technique and by using monofilament gill net (Tan et al., 2012; Faridah et al., 2015). These methods were carried out with the aid of local fishermen according to weather condition, dry or monsoon season and topography. For visual search technique, the horseshoe crab specimens were collected during high tide by hired fishermen during sampling period. The horseshoe crab specimens were detected with the presence of air bubbles and also through poking method with stick. A monofilament gill net of size 20.0 × 1.5 m net size; 5.08 cm mesh size was used during sampling. The net was set up by fisherman at intertidal area (depth of 1–2 m), approximately 100–500 m offshore on the day before sampling was made. The net was checked on next day during low tide. Both techniques were applied at Pasir Putih Village and Sibu Laut Village. Visual search technique also applied at Gerigat Beach and Sadong Jaya while net was applied at Maludam, Jemukan and Pandan Beach. The density of horseshoe crabs was calculated as total of horseshoe crabs caught divided by covered area. The species and sexes of horseshoe crabs were determined based on guidelines provided by Sekiguchi and Nakamura (1979).

Physico-chemical parameters and sediment samples

Four *in-situ* physico-chemical namely pH, temperature (°C), DO (mg L⁻¹) and salinity (ppm) were measured at depth of 15 cm with using pH meter (Lutron CD4303), digital thermometer (Traceable), DO meter (Lutron DO5510) and refractometer (ATAGO MillAlpha), respectively. The readings and sediment samples were taken triplicate in each transect line which was set up equally according the length of transect line. Sediment samples then transferred to the Ecotoxicology Laboratory at Universiti Malaysia Sarawak for particle size and total organic matter analyses.

Laboratory analyses

Sediment analysis

Particle size analysis (PSA) and total organic matter (TOM). The method for PSA was based on Bale and Kenny (2005). The sediment size was determined by using dry and wet sieving technique in order to differentiate the mixture of sand, silt, and clay. The types of sediment were classified and sorted based on Wentworth (1922) method. TOM was analyzed according to method adapted from Lenore et al. (1999). The sediment sample was oven-dried overnight at 60 °C and followed by combustion in MUFLA Felisa furnace at 475 °C for 4 h. The percentage of TOM was determined by using formula from Greiser and Faubel (1988).

Data analysis

No statistical analysis was done since the sampling done only once for each sites. All data related with density, physico-chemical parameters and sediment (PSA and TOM) were compared.

Results and discussion

Distribution of T. gigas and C. rotundicauda from nine sampling sites based on in-situ physico-chemical parameters, type of sediments and lunar cycle

The species and sex composition of spawning horseshoe crabs that were obtained from nine sampling sites is illustrated in Table 2. Difference of horseshoe crabs density based on species

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