Global Ecology and Conservation 15 (2018) e00422

Contents lists available at ScienceDirect

Global Ecology and Conservation

journal homepage: http://www.elsevier.com/locate/gecco

Original Research Article

Carcinoscorpius rotundicauda (Latreille, 1802) population status and spawning behaviour at Pendas coast, Peninsular Malaysia

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ARTICLE INFO

Article history:
Received 4 April 2018
Received in revised form 15 July 2018
Accepted 27 July 2018

Keywords:
Mangrove horseshoe crab
Spawning ecology
Seasonal impact
Local topography
Johor strait
Malaysia

ABSTRACT

The present study evaluates impacts from seasonal monsoons and lunar phases on the spawning activity of the mangrove horseshoe crab, *Carcinoscorpius rotundicauda* at Pendas (Sites 1–3) in State Johor, Peninsular Malaysia. The biological (no. of crabs and nests/eggs) observations indicated that Pendas is an active spawning ground for *C. rotundicauda* throughout the year. Higher egg yield was observed for Southwest monsoon (2918 eggs in 55 nests), followed by Northeast (2331 eggs in 48 nests) and Inter-monsoon (1253 eggs in 20 nests) periods. In all seasons, the full moon conditions favoured more number of eggs than to the new moon. Besides the availability of adult crabs in all three sampling sites, the spawning took place only at Site-1 due to its location (mini sandbar) being sheltered away from the impact of Johor Strait waters, underground (domestic) discharge point and pioneer mangroves like *Sonneratia* and *Avicennia* spp. nearby. In contrast, Sites 2 and 3 are open to the seawater current and its surface sediment is covered by broken seashells/pebbles and/or dense *A. alba* pneumatophore roots. Among the environmental (water quality and sediment) parameters tested, except sand, silt and clay, the rest (e.g. temperature, pH, salinity, total organic carbon, etc.) didn't show any strong correlation with the spawning behaviour of *C. rotundicauda*. The ongoing physical infrastructure developments on housing and property constructions in the vicinity are likely to pose a threat to the spawning ground of *C. rotundicauda* and thus requires a serious attention for its conservation and management.

1. Introduction

Horseshoe crabs with the same morphological features since 450 million years are believed to have survived four mass extinctions (Størmer, 1952; Shuster, 2001; Walls et al., 2002; Diedrich, 2011; Kin and Błazejowski, 2014; Nossa et al., 2014;

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https://doi.org/10.1016/j.gecco.2018.e00422

Smith et al., 2017). However, in recent years they were facing a serious threat in the form of overexploitation for biomedical research and edible purposes, including their habitat loss due to altered shoreline conditions (John et al., 2011; Gauvry, 2015; Nelson et al., 2015, 2016a; Yennawar, 2015; Chee et al., 2017; Kwan et al., 2017). Also, the horseshoe crabs are harvested regularly for fish bait and fishmeal preparations, especially in Asia (Cartwright-Taylor et al., 2011; Faridah et al., 2015). On the other hand, prolonged periods of its embryogenesis (32–40 days) and animal's maturity (10–14 years) are making them more susceptible to the environmental changes (Nelson et al., 2016b). Overall, anthropogenic activities have been a prime cause for its population decline all over the world (Behera et al., 2015; Smith et al., 2017; Noor-Jawahir et al., 2017).

Besides the renewed scientific attention for understanding the impact of local environmental conditions on the horseshoe crab's population and spawning (Botton et al., 1988; James-Pirri et al., 2005; Mattei et al., 2010; Wada et al., 2010; Brockmann and Johnson, 2011; Zaleha et al., 2012; Sahu and Dey, 2013; Cheng et al., 2015; Landi et al., 2015; Smith and Robinson, 2015; Tan et al., 2016), there was not much published literature on *Carcinoscorpius rotundicauda* which is known as a mangrove horseshoe crab (Lee and Morton, 2005, 2016; Cartwright-Taylor et al., 2009, 2011; Hu et al., 2010; Cartwright-Taylor and Hsu, 2012; Kwan et al., 2016; Noor-Jawahir et al., 2017). This is perhaps due to practical difficulties in the mangrove environment that experiences a regular tidal inundation to catch these crabs as well as finding their nests. *Carcinoscorpius rotundicauda* is native to India, Indonesia, Malaysia, Philippines, Singapore and Thailand (IUCN, 2017). Unlike the other two Asian horseshoe crab species - *Tachypleus gigas* and *T. tridentatus* which lay their eggs in sandy beaches, *C. rotundicauda* deposit them in (mangrove) muddy sand areas (Brockmann and Smith, 2009; Nelson et al., 2015), where its imprints on the ground are almost difficult to findout (pers. obs.).

In Malaysia, few researchers have worked on *C. rotundicauda* (Srijaya et al., 2010; Yap et al., 2011; Adibah et al., 2012, 2015; John et al., 2012; Robert et al., 2014; Noor-Jawahir et al., 2017), but none observed its spawning population and nesting activity on long-term basis. In addition, *C. rotundicauda* is most common in the mangroves of Singapore (Tan et al., 2016) whereas its status in Johor - the southernmost state of Peninsular Malaysia opposite to Singapore, remains unclear. Therefore, the present study was exclusively focused on investigating the current status of *C. rotundicauda* at Pendas village in Johor. The objectives are to inform the spawning activity of *C. rotundicauda* in relation to seasonal monsoons (Southwest (SW), Northeast (NE), and Inter-monsoon (IM)), lunar (full and new moon) phases, and identify the factors that most influential for its spawning locally.

2. Materials and methods

2.1. Study area

Pendas is a fishermen village located near Tanjung Kupang in State Johor, P. Malaysia (Fig. 1). Johor Strait is a pathway between the Malacca Strait and the South China Sea that separates P. Malaysia from Singapore. The horseshoe crabs were thought to consist of various populations that share common ancestry, but Adibah et al. (2015) found distinct *C. rotundicauda* groups between east and west coasts of P. Malaysia due to the land barrier effect. However, the work conducted by Adibah et al. (*op. cit.*) lack samples from Johor. After noticing the availability of *C. rotundicauda* in Johor from published literature of Srijaya et al. (2010) and Yap et al. (2011), a pilot study was conducted to identify the best location(s) for current sampling. With the advice of the local fishermen, Pendas village from where they regularly get the horseshoe crabs as bycatch was chosen. Local people do not prefer *C. rotundicauda* for edible purpose due to lethal poisoning effect (Robert et al., 2014), but collect them if there is any outside demand for fishmeal preparation or research purposes (pers. comm.).

2.2. Sampling sites and data collection

The sampling was conducted for 13 months from January 2016 to January 2017 covering both full moon and new moon conditions at Sites 1–3 (Fig. 1). However, the period that supporting biological observations i.e., male, female or amplexus including nests and eggs of *C. rotundicauda* varied among the sites (Table 1). While nesting activity was observed throughout in Site-1, there were no nests or eggs except the occurrence of adult crabs from August 2016 onward, at Sites 2 and 3. The mangroves represented by a combination of *Avicennia alba* and *Sonneratia alba* were found at Site-1, whereas Site-2 has the pure stands of *A. alba* and Site-3 a mixture of *A. alba* and *Rhizophora apiculata* (Table 1). Also, the ongoing housing construction projects in the vicinity of Pendas are evident (Fig. 1).

To record the no. of spawning (male, female and in amplexus) crabs at each sampling site, a gill net (200 m length $\times$ 3 m height with a mesh size of 12.7 cm) was deployed during the high tide (ca. 3–5 m away from intertidal mudflat as per the depth) and retrieved in subsequent low tide while the water is receding (not to wait until complete low tide and mudflat exposure). This strategy has benefited to avoid the conditions of a stranded net on the ground as well as monkeys predation on the trapped *C. rotundicauda* crabs. All crabs were gently removed from the net, counted and released back into the water. Once the tide is completely receded, the surface sediment in the intertidal area was gently excavated (using a hand shovel) at several places to find as many nests/eggs of *C. rotundicauda* as possible. After measuring the depth of each nest from sediment surface (using a ruler), the freshly deposited eggs in spherical shape and greenish yellow colour were carefully transferred into a 2 mm sieve and rinsed with the nearby seawater to remove sediment and dirt attached. Once the egg count is recorded, the eggs were carefully replaced into the same pit and gently covered by the sediment. To avoid recounting of the same nest in our next visit, a 4 mm plastic straw that coded with the date of observation was left inside the pit. In addition, the