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Ex-situ conservation of the critically endangered swamp forest crab *Parathelphusa reticulata* Ng, 1990 (Decapoda: Brachyura: Gecarcinucidae): observations on its reproduction and biology in captivity

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Abstract. The critically endangered swamp forest crab *Parathelphusa reticulata* is endemic to Singapore and known only from certain parts of Nee Soon Swamp Forest (NSSF) and some of its peripheral streams. As part of ongoing ex-situ conservation efforts to ensure the survival of this threatened species, wild-caught individuals were reared in captivity to determine its captive breeding, husbandry requirements, and reproductive biology. The conditions required for these wild-caught animals to successfully spawn and brood in captivity, as well as for their first-generation offspring (F1) to be reared to maturity, were determined over a period of more than three years. Second-generation offspring (F2) were produced by F1 individuals that mated in captivity, which is reported here for the first time. Data on the captive conditions, clutch size, and growth of newly-born crablets are detailed. A self-sustaining captive population of this highly-threatened species has been established and will play an important role in ensuring its future survival, representing the first successful ex-situ conservation effort for a freshwater crab found primarily in freshwater swamp forest.

Key words. decapod crustacean, threatened, husbandry, Singapore

INTRODUCTION

A wide variety of endemic fauna, including freshwater crabs, can be found in tropical freshwater ecosystems (Balian et al., 2007). A significant portion of this fauna, however, is threatened by a multitude of anthropogenic activities such as habitat alteration and urbanisation (Dudgeon et al., 2006; Reid et al., 2019). Cumberlidge et al. (2009) had already showed that one-sixth of all primary freshwater crab species (about 1,280 known species) had an elevated risk of extinction. More importantly, Cumberlidge's assessment highlighted that approximately a third of the countries harbouring freshwater crabs have threatened species with semi-terrestrial habits and restricted distibution ranges, which are in need of conservation efforts. However, very few species are benefiting from any active conservation actions (Cumberlidge, 2016; Yeo et al., 2016) and it is likely that the proportion of freshwater crabs with extinction risk is higher than presently recognised (Cumberlidge, 2016).

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Singapore's physical environment has undergone much transformation and most of its natural freshwater habitats such as streams and freshwater swamps have been lost or modified over the years (Yeo et al., 2010). Despite this, there are six extant freshwater crab species in Singapore, three of which are endemic—namely the Johnson's freshwater crab *Irmengardia johnsoni* Ng & Yang, 1985, Singapore freshwater crab *Johora singaporensis* Ng, 1986, and swamp forest crab *Parathelphusa reticulata* Ng, 1990 (see Ng, 1997). *Irmengardia johnsoni* is listed in the International Union for Conservation of Nature (IUCN) Red List as Vulnerable (Esser & Cumberlidge, 2008a) while *Johora singaporensis* and *Parathelphusa reticulata* are Critically Endangered (Esser & Cumberlidge, 2008b; Esser et al., 2008).

There is an urgent need to protect and conserve Singapore's native biodiversity, especially species that are endemic, rare, or threatened. Two threatened freshwater crab species (*J. singaporensis* and *P. reticulata*) have been included under the Species Recovery Programme by the Singapore National Parks Board (NParks) (NParks, 2017). Conservation efforts started first with *J. singaporensis* (Ng et al., 2015; Yeo et al., 2016; NParks, 2017). To achieve the aim of ensuring their long term persistance in the wild, a multi-pronged conservation approach (which included long-term monitoring, research, translocation, and captive breeding) was taken for both species. As these freshwater crabs occur in small numbers with limited distribution and do not disperse well (Yeo et al., 2008; Ng et al., 2015; Tay et al., 2018), captive

Table 1. Size range and number of *P. reticulata* collected for the founder population

Species	**Size (mm)**	
	Females	**Males**
P. reticulata	(N = 8) 29.20–36.15	(N = 4) 29.39–37.61

Fig. 1. Captive breeding facility in the Singapore Botanic Gardens. Photograph: Daniel J. J. Ng.

breeding is an integral part of the holistic conservation strategy to conserve them. Husbandry protocols, followed by captive breeding protocols, were developed. After their successful breeding in captivity, the end goal was to establish new translocated populations through the release of captive-bred individuals.

Following the earlier husbandry successes for *J. singaporensis* (see Tan, 2018), a similar approach was extended to *P. reticulata.* This species is nationally endangered (Davison et al., 2008), and is present only in certain parts of Nee Soon Swamp Forest (NSSF) (Ng, 1990, 1995, 1997; Ng & Wee, 1994; Davison et al., 2008; Tan et al., 2010; Lim et al., 2011; Yeo et al., 2011; Ng et al., 2015; Hwang & Mendoza, 2015; Cai et al., 2016) and some of its peripheral streams (Tan & Low, 2017; Yau et al., 2020). *Parathelphusa reticulata* was previously thought to be an unusual variant of the more common and widespread congener *Parathelphusa maculata* De Man, 1879, but was subsequently recognised as a separate species (Ng, 1990). As a swamp forest specialist, *P. reticulata* is usually found in slow-flowing shallow water with low pH and low dissolved oxygen (Ng, 1990; Chua et al., 2015; Ho et al., 2016). In captivity, it is observed to be more aggressive than its congener *P. maculata* (see Ng, 1990). Being a secretive animal and often hiding underneath thick leaf litter, it is infrequently observed in the wild and little is known about its reproductive biology (Ng, 1990).

In this paper, we document the captive husbandry protocols involved in rearing *P. reticulata* as well as the first successful captive breeding of the species. Ex-situ observation of its spawning, incubation, and maternal care were recorded. In addition, the growth of the F1 individuals was also documented. The knowledge gained on the biology and life history of the species contributes to and enhances the limited information available and informs specific conservation actions in ensuring its survival. To our knowledge, this study represents the first ex-situ conservation effort for a freshwater crab found primarily in freshwater swamp forest.

MATERIAL AND METHODS

Ex-situ species recovery for *P. reticulata* began in December 2018, when 12 adult individuals were collected from NSSF, Central Catchment Nature Reserve, Singapore to form the founder captive population (F0) (Table 1). To minimise stress on the animals, individuals were transported in opaque plastic buckets with water (in-situ water parameters — Temperature: 25.8 °C, pH: 5.7, Total dissolved solids: 30 ppm, Dissolved oxygen: 55%) and submerged leaf litter from the collection site and were immediately brought back to the captive breeding facility.

Captive breeding facility

The facility occupies a room (6.5 m × 5.5 m) at the Singapore Botanic Gardens (Fig 1). About 40% of the space was reserved to house *P. reticulata*. Air temperature in the room was kept at ~25°C while room humidity was kept below 60%. Aquarium tanks of various sizes were placed on multiple 4-tiered metal racks. All *P. reticulata* individuals were kept in reconstituted water (made by adding dechlorinator to tap water to remove chlorine and chloramine and subsequently filtering it through mixed bed resin to reduce the water hardness) with efforts made to replicate in-situ water parameters. While the captive conditions are not identical to the environmental conditions in the wild, the crabs generally are able to survive and thrive in these conditions. Water parameters used for keeping *P. reticulata* are listed in Table 2. A photoperiod of 12:12 was maintained with room lighting.

Detailed captive conditions for adult crabs (carapace width >25 mm)

Each adult crab was kept individually in a covered aquarium (measuring 60 cm × 30 cm × 35 cm, L × W × H) with 10 L of reconstituted water (see Fig. 2a). Each aquarium had a water filter and a terrestrial habitat in the form of large rocks. Dead leaves were introduced to serve as shelter. A thin layer of artificial aquarium substrate (Borneo Wild Shrimp Soil) was placed, and beneficial bacteria (Mosura BT-9) were added in at recommended doses. Crabs were fed ad libitum with frozen blood worms and other commercially available food for crustaceans (Hikari Crab Cuisine). A 50% water change was conducted weekly.

Detailed captive conditions for crablets (carapace width <10 mm)

Each crablet was kept individually in a plastic circular container (measuring 11 cm × 6 cm, D × H) containing 300 mL of reconstituted water (see Fig. 2b). A small dead leaf was placed inside to serve as a shelter. A 50% water change was conducted thrice weekly. Crablets were fed ad libitum with commercially available food for crustaceans (Hikari Shrimp Cuisine & Mosura Graze Active).

Detailed captive conditions for juvenile crabs (carapace width 10–25 mm)

Each juvenile crab was kept individually in a plastic rectangular container (measuring 17 cm × 12 cm × 5 cm, L × W × H) containing 500 mL of reconstituted water (see Fig. 2c). A 100% water change was conducted thrice weekly. Crabs were fed ad libitum with frozen blood worms and other commercially available food for crustaceans (Hikari Crab Cuisine). A small dead leaf was placed inside to serve as a shelter.

Table 2. Water parameters used to maintain *P. reticulata* in the facility

Water parameters	Range
Temperature (°C)	25–27
pH	5–7
Total dissolved solute (ppm)	40–70
Salinity (ppm)	0–1
Dissolved oxygen (%)	70–90
Ammonia (ppm)	0
Nitrite (ppm)	0
Nitrate (ppm)	<10

Set-up for ex-situ mating

To pair the individuals, a F1 male crab and a F1 female crab were taken out from their respective aquariums and placed together in a plastic tank (measuring 29 cm × 18 cm × 18 cm, L × W × H; see Fig. 2d). Individuals used for pairing were at least 25 mm in carapace width (CW) and the size difference between individuals was kept within 5 mm. All individuals used for mating had all appendages fully intact and were only used during their intermoult period. Individuals were paired not more than twice a week. 1000 mL of reconstituted water was used for the pairing setup. At least 10 food pellets (Hikari Crab Cuisine) were introduced into the setup to prevent them from starving. Several dead leaves were placed inside to serve as shelter. After pairing the animals for a maximum of 24 hours, they were separated and returned back to their respective aquariums. The animals were not paired beyond 24 hours due to concern over intraspecific aggression.

Spawning and maternal care

After succcessful pairing was observed, females were returned to their respective aquariums and kept isolated until they became ovigerous. Regular observations were made on the female crabs' behaviour (e.g., emerging out of water) as well as signs of eggs and crablets (to determine incubation duration). Upon observing a female crab being gravid, black opaque plastic boards were placed around the aquarium to block out the room light from disturbing the individual. Once the crablets were fully developed and free roaming, they were carefully removed and their population count was determined.

Growth, moulting, and survival

48 individuals were monitored for over a period of 52 weeks for survival. For all individuals, CW was measured with a digital calliper (to the nearest 0.01 mm) every four weeks. To track the growth of F1 crablets from birth, 20 crablets that survived for 52 weeks were randomly selected and their CW tracked every four weeks. To ascertain a moulting event, the presence of the moult or a crab with an unhardened carapace was used. The intermoult period was determined by using the number of days between moulting events.

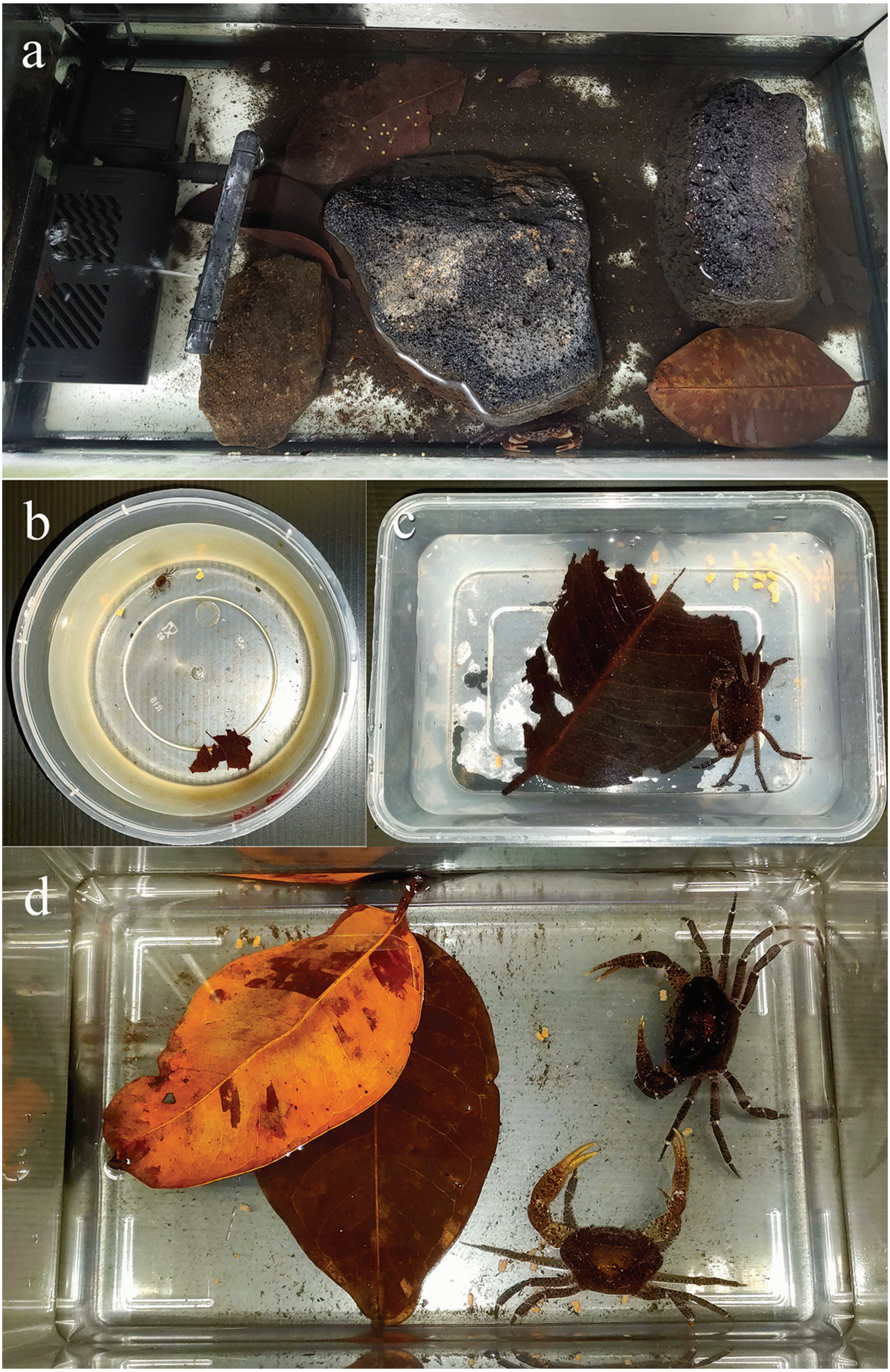

Fig. 2. Top view of captive conditions of a, adult crab (CW: 30 mm); b, crablet (CW: 4 mm); c, juvenile crab (CW: 15 mm); d, Setup for pairing individuals. Photographs: Dian Alisha Binte Misba.

Table 3. Chronological sequences of major events in the study

Date	Event
December 2018	Founder (F0) population brought back from the wild and kept in facility
June–July 2019	Three females (F0) turned gravid
July–August 2019	F1 progeny produced. A brood of approximately 300 crablets were successfully raised in captivity
December 2021–January 2022	Three females (F1) turned gravid
January–February 2022	F2 progeny produced. A brood of approximately 180 crablets were successfully raised in captivity

RESULTS

Captive breeding

After the wild F0 *P. reticulata* were brought into captivity, two F0 females became gravid within four months. Within six months, five F0 females (62.5%) became gravid as a result of a previous copulation in the wild and eventually three F0 females successfully brooded their eggs and produced the F1 progeny in July 2019 to August 2019 (Table 3). It took approximately 30 months for the F1 generation to mature and produce the F2 generation (Table 3). CW of female crabs that successfully brooded ranged between 28.4–38.4 mm (mean CW = 33.8 mm).

Courtship and mating

In most instances (112 of 116 observations), pairing did not result in mating. In few occasions where the male crab was observed to mate with the female crab, the mating pair placed themselves in a sternum-sternum position, with the male positioned below the female.

Observation of spawning and maternal care

Among the F1 individuals, the success rate of egg production following observed copulation was 100% while the success rate of crablet production from following egg production was 60%. It took between two to four months for eggs to be first observed after copulation. The ovigerous females emerged out of water and stayed at the terrestrial portion of the tank only. During this period, the eggs were carried by the females under the expanded pleonal flap and kept in place by pleopods. The females exhibited maternal care of their yolky eggs and were not observed to feed while out of water (Fig. 3a). The gravid females would periodically return to water (presumably for hydration or osmoregulation). The gravid females returned back to the aquatic environment after two weeks and were observed to be feeding while guarding their eggs. Ovigerous females were occasionally seen to ventilate and clean their egg clutches. Among all F0 and F1 females that turned ovigerous, about 70% lost their entire egg clutches within a few days of being observed to be ovigerous (due to unknown reasons). For some ovigerous females, egg cannibalism was suspected as their incubation chambers (area under the expanded pleonal flap where the eggs are stored) progressively became smaller over time. On some occasions, detached eggs were observed to be lying around the aquatic portion of the aquarium, suggesting that the ovigerous females had aborted their egg clutches.

Incubation period of the egg clutch was typically between 32–36 days. After the eggs hatched, crablets would remain beneath the pleonal flap of the brooding female crab (Fig. 3b) and they dispersed several weeks later (exact duration was not determined). The brooding females were observed to remain in the water and to continue feeding throughout the period while guarding the crablets. The presence of a yolk reserve in the newly hatched crablets was seen. The number of crablets per female ranged between 9–133 (102 ± 19). No cannibalism by the brooding females was observed.

Growth, moulting and survival

At birth, the crablets were ~3 mm when they first hatched (Fig. 4). For the first few weeks, they relied on their yolk reserve for nutrients and were observed feeding 2–3 weeks later. Their first moult usually took place approximately one month after they were born. After their first moult, small individuals (CW <15 mm) grew rapidly (Fig. 4) and moulted very regularly (with as little as 14 days between moults). However, as individuals grew bigger, growth slowed down and moulting frequency greatly decreased. The intermoult period of adults could be up to four months. Crabs were observed not feeding a few days before moulting as well as after moulting. They would only resume feeding after consuming their moult. Individuals with missing appendages would sometimes regenerate their limbs upon moulting. However, moulting could also result in loss of limbs or even mortality. Occasionally, individuals were observed to have failed to moult and died in the process. Survival of the F1 progeny in captivity was relatively high (60%) at the end of 52 weeks.

DISCUSSION

For *P. reticulata*, successfully carrying out captive husbandry to the F2 generation demonstrates that the species can be reared and bred in captivity. This represents the first successful captive breeding and the first completion of this species' full life cycle in captivity. Captive breeding can perform a significant role in the recovery of threatened species and has been highly successful in ensuring the future survival of some species such as the California condor (*Gymnogyps californianus*) and Arabian oryx (*Oryx leucoryx*) (see Maunder & Byers, 2005). While captive breeding can potentially yield positive conservation outcomes, it should also complement existing in-situ conservation efforts (IUCN/

Fig. 3. Female *Parathelphusa reticulata*. a, female *Parathelphusa reticulata* with orange yolky eggs on land; b, female *Parathelphusa reticulata* carrying her crablets in water. Photographs: Daniel J. J. Ng.

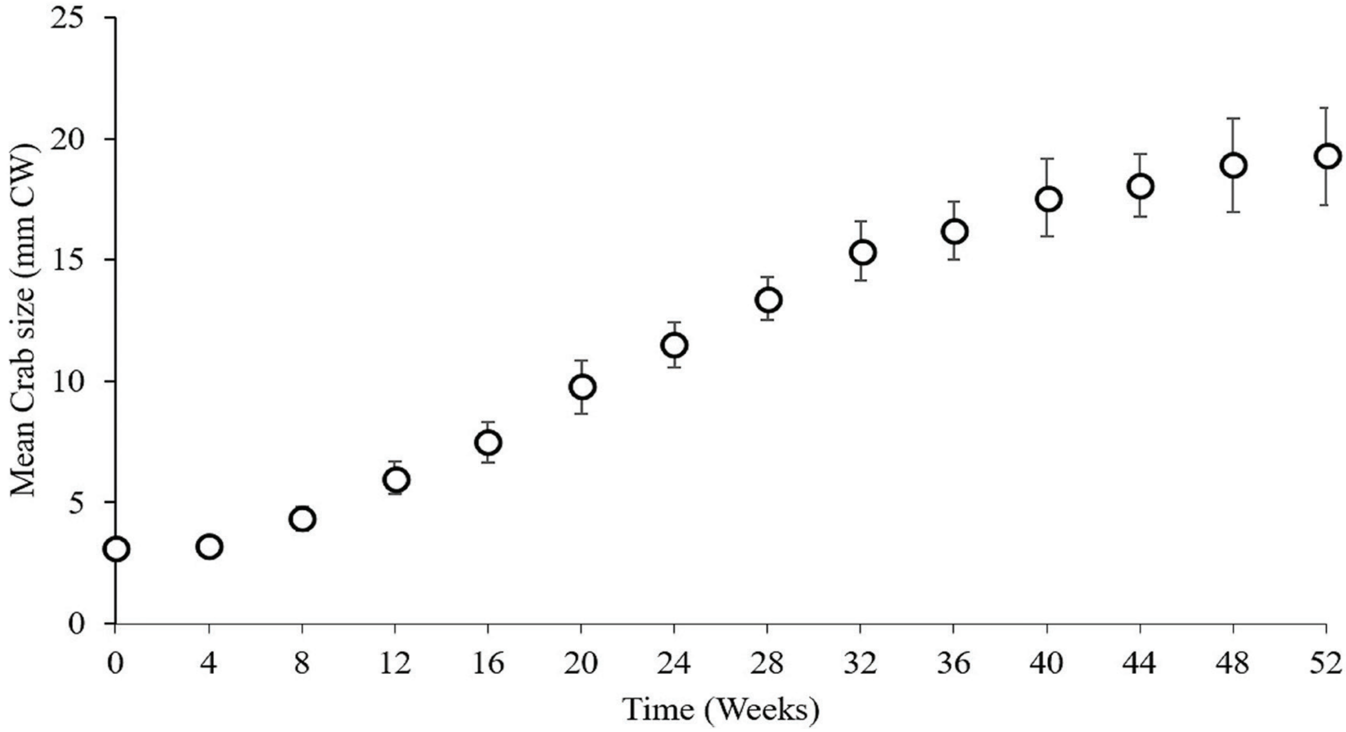

Fig. 4. Growth of captive *Parathelphusa reticulata* (F1 generation) over 52 weeks (N = 20). Vertical bars indicate standard deviations.

SSC, 2014). Although a self-sustaining captive population can act as an assurance population, the eventual objective of the present captive breeding programme is to serve as a source for boosting wild numbers as well as establishing new populations in the wild through the release of captive bred individuals.

Given that NSSF is the only remaining natural freshwater swamp forest in Singapore and *P. reticulata* is largely restricted to this habitat, suitable streams for translocation are limited in Singapore and this makes establishment of new populations challenging. To overcome this, streams that replicate the swamp forest can potentially be created. Although this species is associated with freshwater swamp, its habitat requirement is probably not so stenotopic as it has been observed in nearby streams with conditions that are atypical of its primary habitat (Yau et al., 2020; personal observation). This suggests that other parts of the Central Catchment Nature Reserve (where the species is not currently present) may have potential for translocation. These streams are currently being identified and evaluated for their translocation suitability. To improve the suitability of these identified streams for the translocation of this species, habitat enhancement or modification can be explored.

During the mating trials, there were a few observations of mating, with the male positioned below the female, similar to a few other freshwater crab species such as *J. singaporensis* (see Chua et al., 2014) and *Kingsleya attenboroughi* (see Nascimento et al., 2020). The observed mating differs from some other species such as *Candidiopotamon rathbuni* de Man, 1914 [Potamidae] and *Dilocarcinus pagei* Stimpson, 1861 [Trichodactylidae] where the female is positioned below the male (Liu & Li, 2000; Senkman et al., 2015). We speculate that this may be a limiting factor in the reproduction of *P. reticulata*. This is because the superior position of the male crab is believed to assist in sperm transfer to the female crab via gravity (Jivoff et al., 2007). More studies and observations will need to be made to extrapolate more information. The low observation rate of copulation could be the result of missing some copulation events between individuals when it took place during the night.

Based on our observations, female *P. reticulata* spawns out of water and exhibits post-hatching maternal care. This is similar to some freshwater crab species such as *C. rathbunae* de Man, 1914 [Potamidae], *D. pagei* Stimpson, 1861 [Trichodactylidae], *Trichodactylus borellianus* Nobili, 1896 [Trichodactylidae], and *Zilchiopsis collastinensis* (Pretzmann, 1968) [Trichodactylidae] (see Liu & Li, 2000; Senkman et al., 2015). While Liu and Li (2000) speculated that spawning out of water could be a strategy to reduce egg damage due to fast-flowing water, this is not likely the case for *P. reticulata* as their natural habitat in the swamp forest tends to possess very slow water flow. This spawning behaviour could be a mechanism to avoid osmotic shock which may affect egg development. Producing eggs out of water would avoid excessive water intake from the hyperosmotic medium which may prevent egg damage (Senkman et al., 2015). The post-hatching maternal care where the mother crab protects her brood is believed to raise the survival rate of the crablets (Ng, 1988) and ranged from a week to over one month (Liu & Li, 2000; Senkman et al., 2015; Fadlaoui et al., 2022). However, in this study, we were unable to determine the exact duration of the extended care for the species as in most instances the crablets were manually separated from the brooding female before they dispersed naturally.

Similar to other primary freshwater crabs with direct development (Ng, 1988; Mansur & Hebling, 2002; Wehrtmann et al., 2010), *P. reticulata* produced relatively few but large eggs (averaging about 100 per clutch). It is not surprising for female primary freshwater crabs to have small egg clutches as the energy cost to produce each large egg is much higher. This is in contrast with marine crab species and some secondary freshwater crab species that live as adults on land or in freshwater habitats but spawn at/near the sea, where their eggs are much smaller but their clutch size can be in the millions (Guillory et al., 1996).

Newly-born *P. reticulata* crablets were ~3 mm in size. This is similar to other primary freshwater crabs from other families such as *D. pagei* Stimpson, 1861 [Trichodactylidae] (see Sant'Anna et al., 2015), *Poppiana dentata* (Randall, 1840) [Trichodactylidae] (see Singh et al., 2021), and *Potamon fluviatile lanfrancoi* Capolongo and Cilia, 1990 [Potamidae] (see Wehrtmann et al., 2010). The *P. reticulata* crablets grew rapidly in size at this stage. However, as they grew in size, their growth increment decreased while their intermoult period increased with size. This mirrors some primary freshwater crabs such as *P. dentata* (Randall, 1840) [Trichodactylidae] (see Singh et al., 2021), *Potamon fluviatile* (Herbst, 1785) [Potamidae] (see Micheli et al., 1990), and *Travancoriana schirnerae* Bott, 1969 [Gecarcinucidae] (see Sudha Devi & Smija, 2015). The intermoult pattern of *P. reticulata* is similar to most decapod crustaceans where they exhibit an increase in intermoult period with size as the longer period allows for gathering of adequate resources required for the next size increment during moulting and allows for brooding of offspring by females (Hartnoll, 1982).

Similar to other freshwater crabs (Rodríguez, 1982, 1992; Ng, 1988; Cumberlidge, 1999; Dai, 1999), *P. reticulata* were observed to stop feeding a few days prior to moulting and after moulting, and would only consume their old exoskeleton within a few days after moulting. After a crab has moulted, it is unable to forage and feed until its new and soft exoskeleton has hardened (Warner, 1977; Greenaway, 1985). Consuming the exoskeleton is consistent with other freshwater crabs as an adaptation to regain calcium that is still present in the moult (Greenaway, 1985; Ng, 1988). Given that its natural habitat in the freshwater swamp and the soft, acid-water forest streams in the Central Catchment Nature Reserve contain very low amounts of dissolved calcium, this behaviour may be particularly important for their survival.

We experienced several challenges during the study. One was the high % loss of egg clutches by ovigerous females. This could be attributed to their sensitive nature to any external disturbance during this stage. During the early stages of egg incubation, these female crabs were highly susceptible to external stimuli (e.g., shining light directly at the animal during observation can stress them enough to cause escape into the aquatic environment) and they would often prematurely release their eggs a few days later. This was reported in another study where ovigerous females prematurely released their developing eggs into the water environment when disturbed (Senkman et al., 2015). To reduce the incidence of egg loss, care will need to be taken to ensure disturbance is kept minimal when observations are conducted. Another was the low incidence of successful copulation observed. In most cases, the males did not display any interest in mating with the females. Additionally, in some cases, the females displayed intraspecific aggression and injured the males during the process.

As this species is only found in Singapore, it is part of our natural heritage that is exclusively Singaporean. Though not as well known as *J. singaporensis*, *P. reticulata* has also been featured in the media (Tan, 2018). In fact, *P. reticulata* was featured in a special series on crabs by the Singapore Philatelic Agency in 1992 (Ng, 1992). From the evolutionary point of view, conserving this species is important as it is placed in its own clade and is quite distinct from many sister species, as was shown by a recent phylogenetic study (Klaus et al., 2013).

Threats and conservation outlook

The threats faced by *P. reticulata* include habitat loss/deterioration (Ng & Wee, 1994; Ng, 1995; Davison et al., 2008; Hwang & Mendoza, 2015), invasive alien species (Ho et al., 2016; Cai et al., 2018), climate change (Cumberlidge et al., 2009; Cai et al., 2016), and possibly poaching (Cai et al., 2016). As this species is largely restricted to NSSF (the last remaining primary freshwater swamp in Singapore), the continued preservation of this habitat is of utmost importance for the survival of this species. Given that many threatened native aquatic flora and fauna in Singapore are found exclusively at this site, there were early pushes to safeguard it from development (Ng & Lim, 1992; Lim et al., 2011). Currently managed by NParks, NSSF is legally protected and has remained largely intact (Clews et al., 2018; Davison et al., 2018). The threat posed by invasive species appears to be relatively minor as these exotic species are largely restricted to the outskirts of NSSF due to abiotic and biotic resistance (Cai et al., 2018). However, there is still a possibility that certain species (e.g., red-claw crayfish, *Cherax quadricarinatus* (von Martens, 1868) can spread into the swamp, adversely impacting the native species there (Yeo et al., 2010; Ho et al., 2016; Cai et al., 2018). Hence, long-term monitoring will be crucial to ensure that appropriate measures can be taken before this happens. Climate change-associated effects (e.g., increased temperature and variation in precipitation) can result in changes to hydrology, impacting the species (Cumberlidge et al., 2009; Cai et al., 2016). To mitigate this climate change risk, an integrated eco-hydrological model has been developed for NSSF and possible management strategies have been proposed for mitigation (Sun et al., 2018). Given that it is an endemic species and has some ornamental value, there may be poaching pressures for the aquarium trade. To prevent this, regular patrolling and enforcement are in place to stop such illegal activity (Cai et al., 2018).

With the development of the captive husbandry protocols and the successful captive breeding of *P. reticulata*, an assurance population in captivity has been established. This plays a complementary role in its conservation as new individuals produced from the facility can be used to boost existing wild populations as well as to establish new populations outside its existing distribution through translocation without the risk of depleting the wild population. Coupled with in-situ conservation measures (e.g., continued habitat protection, patrolling, and enforcement) and long-term monitoring of the existing population, it is unlikely that ex-situ captive breeding will become a necessity for the long term survival of this species. Given that various in-situ and ex-situ conservation measures have been implemented, the future outlook of *P. reticulata* looks more optimistic. A similar multipronged management strategy that involves husbandry and captive breeding in combination with translocation and long-term monitoring can be applied for the conservation management of other freshwater crab species under threat.

In conclusion, this study highlights ongoing ex-situ conservation efforts for *P. reticulata* and represents the first successful captive rearing and breeding of the species to the F2 generation. It is also the first reported ex-situ conservation of a freshwater swamp crab. While there are still many unknowns regarding its reproductive biology, insights from this study serves as a baseline for more research. Future research can explore its reproductive and mating behaviour to improve its reproductive success in captivity. Studies can also be conducted to determine their population genetics and to increase its distribution in the wild. A comprehensive knowledge of its reproductive strategies will contribute to a better understanding of its ecology, and will be important for the long-term conservation of this threatened species.

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