Impact of *Thalamita crenata* (Decapoda; Portunidae) predation on *Holothuria scabra* juvenile survival in sea farming pens

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Abstract

We evaluate the impact of predation by the crab *Thalamita crenata* on *Holothuria scabra* juvenile survival in a sea farming site in Madagascar where crab predation pressure is high. Three experiments were carried out: the first was conducted to estimate the survival of sea cucumber juveniles of different body masses when placed in open enclosures; the second compared the survival of juveniles placed in opened and closed enclosures; and the third evaluated the survival of juveniles when placed in the presence of crabs in closed enclosures. *Holothuria scabra* juveniles were of a body mass between 1 and 80 g. The results showed that predation by *T. crenata* is a key parameter to take into account when farming *H. scabra*. The seeding of juveniles at sea should be performed with large individuals weighing at least 30 g to avoid predation.

Introduction

Predation is one of the most important factors affecting the success or failure of sea cucumber farming. In the natural environment, newly released juveniles are attacked and eaten by different species of fish (Hamel et al, 2001; Pitt and Duy 2004), crabs (Pitt and Duy 2004) and shrimps (Pitt and Duy 2004). In Solomon Islands, during experiments with juveniles released in mangrove and seagrass habitats, the mortality of juvenile *Holothuria scabra* was mainly due to predation by fish in the families Balistidae, Labridae, Lethrinidae and Nemipteridae (Dance et al. 2003). Predation may lead to the disappearance of an entire stock of sea cucumbers in a very short period of time (Mercier et al. 2000a). The crab *Thalamita crenata* was found to be the most redoubtable predator of sea cucumbers in the Toliara region of Madagascar. Aside from the control of biotic parameters, the choice of adequate sites for building sea pens is one of the key parameters for ensuring the success of sea cucumber farming. In 2007, abnormal mortalities of juvenile *H. scabra* in sea pens were recorded by Lavitra et al. (2009) in Madagascar, while adults were unaffected. Only a few sea cucumber juveniles were found dead in the pens during the observation, and *Thalamita crenata* (Portunidae) were observed in abundance near and inside the pens. During several observations, Lavitra et al. (2009) found these crabs eating the newly transferred juveniles of *H. scabra*. Experiments in outdoor ponds showed that the crabs did not eat *H. scabra* when the sea cucumbers were fed daily. On the other hand, five crabs were enough to kill and eat 20 sea cucumber juveniles weighing, on average, 17 g within five days, and 10 juveniles of an average body mass of 54 g within 10 days when they were kept in external ponds without any food (Lavitra et al. 2009).

Some success in reducing predation of juvenile sea cucumbers released into the sea has been obtained with the use of cages to exclude large predators (Dance et al. 2003; Purcell 2004; Rougier et al. 2013). On the other hand, in experiments carried out in a sea cucumber farming site where there was a very low density of crabs, Lavitra et al. (2015) demonstrated that the use of covered sea pens is not necessary and that juveniles less than 5 g can be released in these sites with average survival rate between 78% and 84% after three months. Similar experiments made by Hair et al. (2016) in Papua New Guinea gave similar results and, contrary to expectations, short-term cage protection did not lead to higher survival rates.

The aim of the present work is to estimate the impact of predation by the crab *Thalamita crenata* on juvenile sea cucumber survival at a sea farming site in Madagascar where crab predation pressure is high.

Methods

Three types of experiments were carried out in the enclosures of the Belaza site located 20 km south of Toliara, Madagascar.

Experiment no. 1. The purpose of this experiment was to evaluate the survival rate of sea cucumbers of different body masses (i.e. wet body masses) when placed in open enclosures. The experiment lasted two months (June to July 2017) and used eight enclosures, each measuring 2 m². The walls of the enclosures were made of plastic netting that was embedded no less than 30 cm into the sea bed, and all enclosures were open at the top. Five to twenty sea cucumbers were placed in each enclosure, with their masses varying from one enclosure to another:

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- 20 sea cucumbers weighing 5–15 g (initial biomass of 100 g/m²),

- 20 sea cucumbers weighing 15–30 g (initial biomass of 225 g/m²),

- 15 sea cucumbers weighing 30–60 g (initial biomass of 338 g/m²),

- 20 sea cucumbers weighing 60–100 g (initial biomass of 600 g/m²),

- 10 sea cucumbers weighing 100–150 g (initial biomass of 625 g/m),

- 10 sea cucumbers weighing 150–200 g (initial biomass of 875 g/m²),

- 5 sea cucumbers weighing 200–250 g (initial biomass of 563 g/m²), and

- 5 sea cucumbers weighing 250–300 g (initial biomass of 688 g/m²).

The number and condition of sea cucumbers were checked once a week. Sea pens were excavated to record all individuals, even those buried in the substrate. The number of wounded holothurians was recorded: The number of individuals with one or more ulcerations from a skin ulceration disease (SKUD) (Fig. 1A) and the number of individuals with a cut due to a crab attack were recorded (Fig. 1B).

Experiment no. 2. The purpose of this experiment was to compare the survival rate of juveniles placed in two different types of enclosures: 1) enclosures open at the top, and 2) enclosures closed by a net placed on top (Fig. 2). The disappearance of juvenile sea cucumbers in open enclosures is considered to be due to: a) crab attacks (mainly *T. crenata*), b) diseases (mainly SKUDs), and c) escapes (some individuals swell with water, thereby acquiring an overall density nearly equivalent to seawater, and are carried above the enclosures by currents). The disappearance of juvenile sea cucumbers in closed enclosures is considered to be due solely to diseases. The experiment lasted three months (June to August 2017), and used four enclosures that measured 2 m². Two open enclosures each contained seven individuals weighing 5–15 g, seven weighing 15–30 g, and seven weighing 30–50 g (two replicates). Two other enclosures that were closed on top each contained seven individuals weighing 5–15 g, seven weighing 15–30 g, and seven weighing 30–50 g (two replicates).

In order to check the tracking of the various calibres (i.e. body mass category), a red mark – specific to body mass – was drawn on each juvenile (Fig. 3). The red mark – which did not affect the health or behaviour of sea cucumbers – was water resistant for two weeks, and was refreshed once a week so that it was easily visible. Juveniles in sea pens were checked once a week.
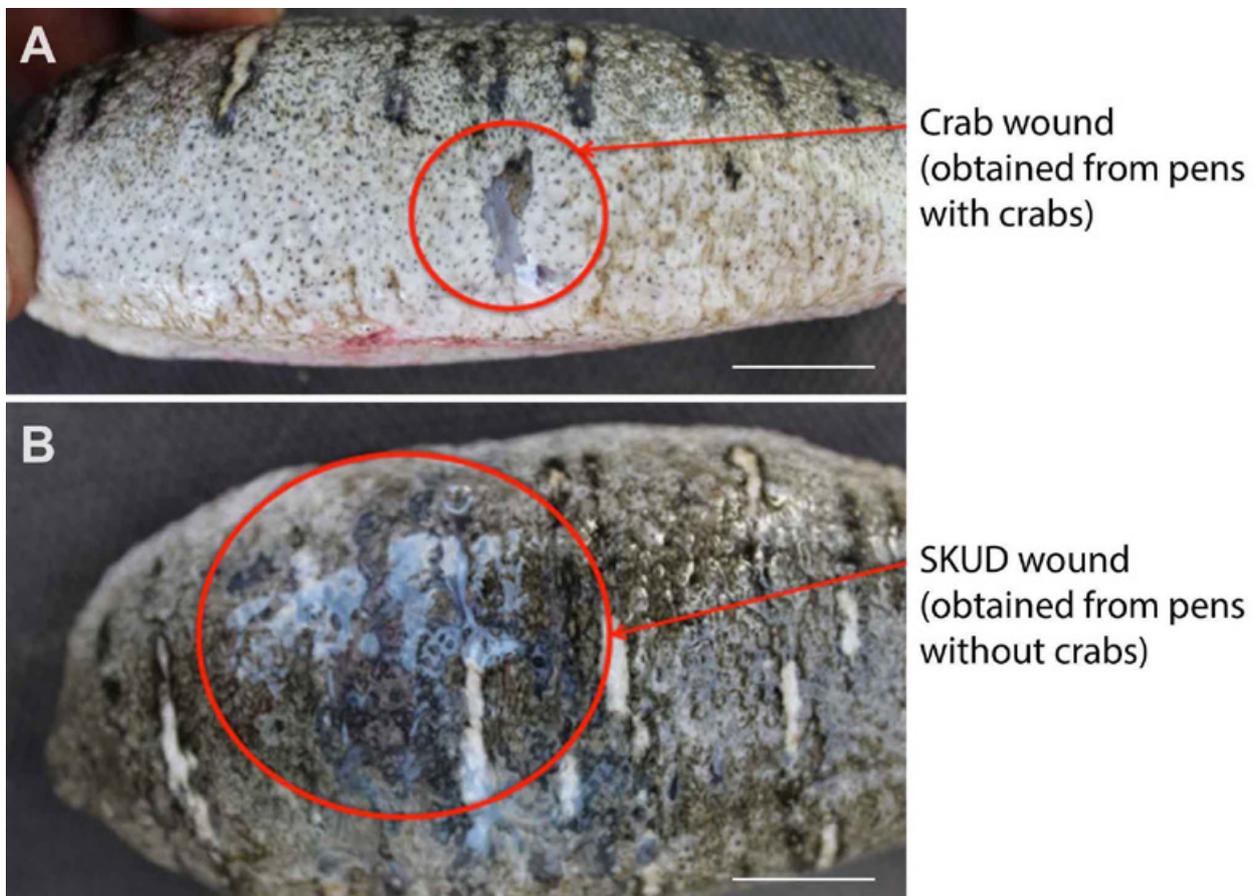

Figure 1. A) Wound due to an attack by *Thalamita crenata*, and B) ulcerations caused by a skin ulceration disease (SKUD).

Experiment no. 3. The purpose of this experiment was to estimate the survival rate of juveniles (of varying body masses) when they were released in the presence of crabs in closed enclosures. The experiment lasted about three weeks (in May 2017) and used 10 enclosures, each 2 m², with the tops closed. Twenty juveniles were placed in each enclosure, their body masses varying from one enclosure to another. Three enclosures had 20 juveniles weighing 5–15 g, another

three enclosures had 20 juveniles weighing 15–30 g, and yet another three enclosures had 20 juveniles weighing 30–50 g, and one enclosure had 20 juveniles weighing 50–80 g. Two crabs (*T. crenata*) measuring 5 cm (i.e. width at the cephalo-thorax) were introduced into each enclosure.

At each low tide (every 12 hours), sea pen covers were removed to count the number of juveniles (i.e. two observations each 24 hours). Like adults, juveniles of this size bury into the substrate; therefore, we had to sift through the sand to determine the number of actual juveniles present, and to check whether the two crabs were still there.

Results

Experiment no. 1. Figure 4 illustrates the percentage of individuals who survived in the pens after two months. We note that survival is positively correlated with body mass, and the survival rate varies from 43% to 100%, according to body mass categories ranging from 15–30 g to 250–300 g. Traces of crab attacks were visible only on individuals weighing less than 100 g, while traces of ulcerations due to SKUDs were visible in all weight ranges except on individuals weighing more than 250 g.

Figure 2. Open and closed sea cucumber enclosures.

Figure 3. A-C: Red marks, specific to size and body mass category (A:5–15 g, B:15–30 g, C:30–50 g), were drawn on juvenile sea cucumbers. D: Resistance of neutral red staining after one week.
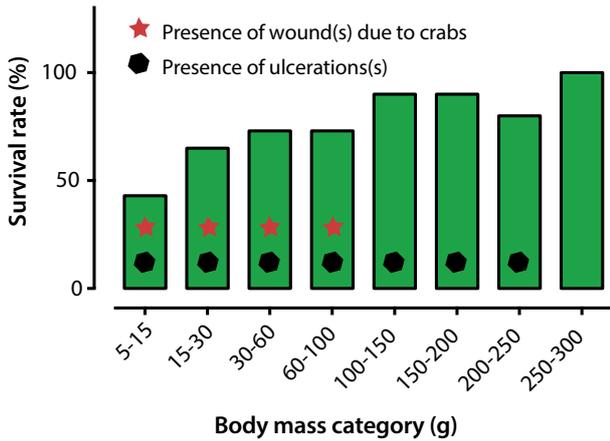
Figure 4. Survival of sea cucumbers of different masses when placed in open enclosures after two months (experiment no. 1). Additional observations of SKUD ulcerations and crab wounds are also presented.

Experiment no 2. At the end of the experiment, the survival rate of juveniles was higher when the enclosure was closed. When comparing open enclosures and closed enclosures, survival rates were 7% and 50%, respectively, for juveniles weighing 5–15 g (Fig. 5 A), 71% and 86%, and the survival rate for those weighing 15–30 g (Fig. 5 B) was 86%, and for juveniles weighing 30–50 g (Fig. 5 C) the rate was 93%.

Experiment no. 3. When juveniles were placed in the presence of crabs in closed enclosures, the survival rate was higher, at the end of the experiment, when juveniles had a higher mass. After 13 days, survival rates were 5% for the body mass category 5–15 g (Fig. 6 A), 35% for the category 15–30 g (Fig. 6 B), 48% for the category 30–50 g (Fig. 6 C) and 60% for the category 50–80 g (Fig. 6 D). The number of injured individuals was significantly higher for the first body mass category (5–15 g).
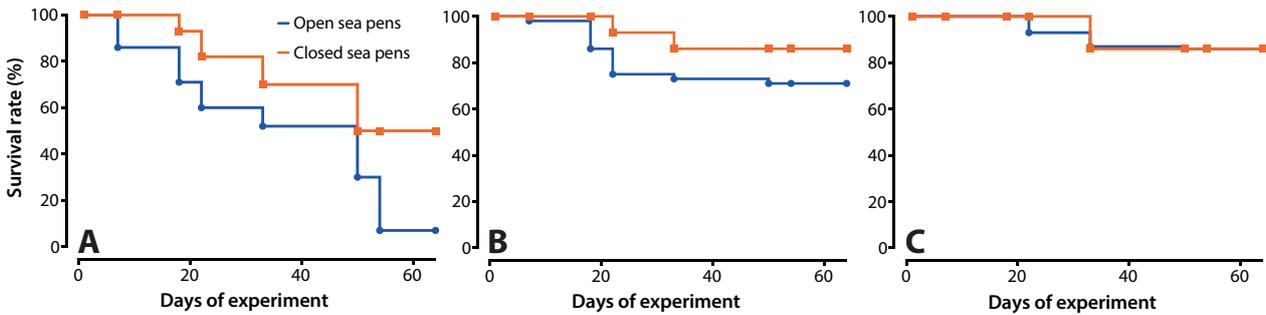

Figure 5. Survival rate of juveniles observed between open enclosures and closed enclosures, with juvenile body masses of A) 5–15 g, B) 15–30 g and C) 30–50 g.
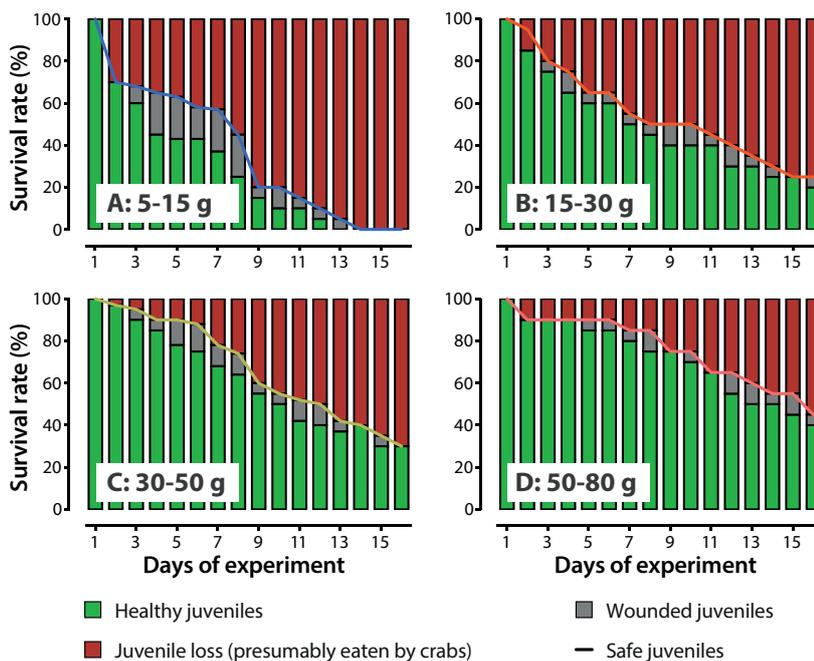

Figure 6. Survival rates of juveniles when placed in the presence of crabs in closed enclosures. Juvenile body masses were A) of 5–15 g, B) 15–30 g, C) 30–50 g and D) 50–80 g. Proportions of healthy (green), injured (grey) and missing (red) individuals are shown.

Figure 7 illustrates the linear projections of the survival rate for the four body mass categories of juveniles investigated during the experiment. The predicted death of all sea cucumber juveniles, due to the predation by *T. crenata* (density: 2 ind./m²), occurred after 14, 21, 22 and 31 days for the body mass categories 5–15 g, 15–30 g, 30–50 g, 50–80 g, respectively.
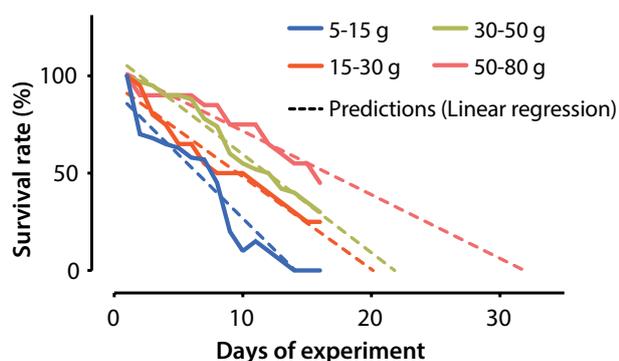

Figure 7. Linear projections of the survival rates of the four weight categories of juveniles based on the results of experiment no. 3.

Discussion

In his review of sea cucumber predators, Francour (2007) reported 76 different species, but none of these included *Thalamita crenata*. Crustaceans represent 22% of all such predators. In the southwest of Madagascar, *T. crenata* is the most significant predator of juvenile *Holothuria scabra*. *Thalamita crenata* is the mangrove swimming crab also called the crenate swimming crab or spiny rock crab. It is a swimming crab species distributed throughout marine and brackish waters of the Indo-West Pacific region. It is widely eaten in many countries. The gut content of a Kenyan *Thalamita* revealed that it is a generalist predator, its diet being mainly composed of bivalves and slow-moving crustaceans (Cannicci et al 1996).

Regarding *H. scabra* aquaculture, the experiments carried out clearly indicate that the size or mass at which juveniles are released into the sea considerably influences the survival rate of individuals and, *a fortiori*, the economic success of the activity. Our results show that the later the juveniles are released into the sea, the greater their survival rate is (experiment no. 1). Based on our results, the best option would be to release them when they reach a mass of approximately 100 g. Indeed, a survival rate of 90% was observed for this size category during our two-month experiment. The loss of juveniles is significantly higher when they are placed in the sea before they reach 30 g; in experiment no. 2, the survival rate reached a maximum of 65% after two months. A good compromise would be to release them when they reach a size of approximately 30 g. Reaching 30 g, however, requires them to be reared in a nursery pond for at least four months (after a hatchery development of three months). This, therefore, requires significant cost to build earthen ponds that will have

an optimal density of 10–20 ind./m² (Lavitra et al. 2010). When juveniles reach 100 g, mortality is due to both SKUDs and crab attacks, while individuals over 100 g seem to be less affected by crab predation.

Our study also shows that the use of closed enclosures is useful when farming takes place in an area where *T. crenata* is present (experiment no. 2). The use of these closed pens is certainly essential if juveniles are released into the sea at a mass less than 15 g because the technique ensures that 43% of these juveniles will survive after two months. If juveniles are released at a mass greater than 30 g, the use of closed pens becomes less necessary because closed pens only ensure the survival of 7% of juveniles. In practice, in farms such as those in Madagascar where enclosures may be larger than 1 ha, it is impossible to keep all enclosures closed. It is, therefore, preferable to release larger juveniles (in terms of mass) and, if this proves difficult, to have small closed enclosures for recently released juveniles.

The third and final experiment confirms that *T. crenata* is a serious predator of sea cucumber juveniles and can affect the profitability of *H. scabra* farming. With a density of 1 crab/m2, all sea cucumber juveniles weighing less than 15 g are likely to be eaten within two weeks. The impact of this crab is also significant on juveniles over 50 g, and a linear projection suggests that in one month, these individuals could completely be wiped out due to predation by *T. crenata*. It is, however, important to note that all experiments were performed during the cold season (May–August 2018) and that a seasonal effect on global sea cucumber survival is not to be excluded. As observed in previous studies in the southwest of Madagascar, SKUDs are more present during the cold season (Lavitra et al. 2009; Eeckhaut et al. 2019).

In conclusion, predation by *T. crenata* is a parameter to take into account when developing *H. scabra* farming activities. The seeding of juveniles at sea should be done with large individuals weighing at least 30 g to avoid predation. This, however, requires an additional investment in the development of earthen ponds that accommodate juveniles before leaving hatcheries.

Acknowledgment

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