Zoosymposia 7: 177–183 (2012)
www.mapress.com/zoosymposia/

ISSN 1178-9905 (print edition)
ZOOSYMPOSIA
ISSN 1178-9913 (online edition)

Characterization of a population of the Harlequin crab, *Lissocarcinus orbicularis* Dana, 1852, an obligate symbiont of holothuroids, in Toliara bay (Madagascar)*

GUILLAUME CAULIER[1,5], ERIC PARMENTIER[2], GILLES LEPOINT[3], FLEUR VAN NEDERVELDE[4], IGOR EECKHAUT[1]

[1] *University of Mons—UMONS, Research Institute for Biosciences, Biology of Marine Organisms and Biomimetics, Mons, Belgium*
[2] *University of Liège, MARE centre, Functional Morphology, Liège, Belgium*
[3] *University of Liège, MARE centre, Oceanology, Liège, Belgium*
[4] *University of Bruxelles, Laboratory of Systems Ecology and Resource Management, Bruxelles, Belgium*
[5] *Corresponding author, E-mail: guillaume.caulier@umons.ac.be*

**In*: Kroh, A. & Reich, M. (Eds.) Echinoderm Research 2010: Proceedings of the Seventh European Conference on Echinoderms, Göttingen, Germany, 2–9 October 2010. *Zoosymposia*, 7, xii+316 pp.

Abstract

Harlequin crabs, *Lissocarcinus orbicularis*, are commensals found on the integument and in the buccal/cloacal cavity of several species of holothuroids. The population of these crabs was investigated on holothuroids of the barrier reef of Toliara (South-West of Madagascar) from 2002 to 2008. Seventeen holothuroid species were observed and eight were crab hosts. There is generally one adult crab or a heterosexual pair per infested holothuroid but up to ten juveniles were recorded on a *Thelenota ananas*. Carapace length of the observed *L. orbicularis* was from 0.3 to 1.4 cm from the tip of the rostrum to the end of the cephalothorax, with a mean length of 0.85 cm. *L. orbicularis* is characterized by a weak sexual dimorphism (females are bigger than males) and the presence of pereiopods morphologically adapted to fixation on the host integument. Gravid females were observed at each month of the survey indicating that the crab reproduces all the year. Considering our results and personal observations, we also discuss the monogamy mating system of the Harlequin crab.

Key words: Indian Ocean, Holothuroidea, symbiotic crabs, reproduction

Introduction

Three families of brachyuran crabs are closely associated with various species of echinoderms: the Eumedonidae, Portunidae and Pinnotheridae (Ng & Jeng 1999). About ten percent of Portunidae have developed a relatively strong association with other organisms (Vannini & Innocenti 2000), amongst them is the genus *Lissocarcinus*. Of nine species of *Lissocarcinus*, three are known to be facultative symbionts of anthozoans (*L. laevis* Miers, 1886), echinoids (*L. arkati* Kemp, 1923) and madreporans (*L. polybioides* Adams & White, 1949) (Spiridonov 1990). The Harlequin crabs, *L. orbicularis* Dana, 1852, are obligate symbionts found exclusively on the integument (Fig. 1) or in the buccal and cloacal cavities of several species of holothuroids (Bauchau 1966; Spiridonov 1990). These crabs do not cause any negative effects on their hosts and they are considered as commensals (Vannini & Innocenti

Accepted by A. Kroh & M. Reich: 8 Nov. 2012; published 12 Dec. 2012

FIGURE 1. The Harlequin crab, *Lissocarcinus orbicularis* Dana, 1852 on its host.

2000). This common symbiosis has been reported on the coasts of East and South of Africa, Tanzania, Seychelles, Sri Lanka, Japan, Australia, Fiji, Hawaii (Vannini & Innocenti 2000) and Madagascar (Crosnier 1962).

To date, only morphological and taxomomic studies were performed on adults of Harlequin crabs. Edmondson (1954) and Ng & Jeng (1999) describe the Harlequin crab (Figs. 1–2) as having a subcircular carapace with a dorsal surface strongly convex medially, a preorbital tooth reduced and anterolateral margin strongly arcuate without well-defined teeth. This portunid shows a distinctive and specific color pattern with spots on the carapace and banded pereiopods (Figs. 1–2). Like a lot of commensal crustaceans, *L.orbicularis* shows morphological adaptations derived from its associate lifestyle (Mariappan *et al.* 2000). For example, the hook-shaped pereiopods are morphologically adapted to fix to the host integument. The crab often stands still on the host integument where it temporarily deforms the body of the host in creating a slight depression where it stands. Its chelipeds are smooth so that *L.orbicularis* can strongly attach without harming the holothuroids.

Despite this symbiosis being very common throughout the Indo-West Pacific Oceans, very little is known about how the relationship works and whether benefits to both species are equal or unequal. This study aims at giving some characteristics about a population of Harlequin crabs that has been surveyed in the bay of Toliara (South-West of Madagascar) during a 6-year period.

Material and methods

From 2002 to 2008, SCUBA dives were performed around the reef of Toliara and in the lagoon that separates the reef from the coast (Fig. 3). Various species of holothuroids were observed *in situ* and the presence or absence of *L. orbicularis* was recorded. From December 2006 to March 2008, all

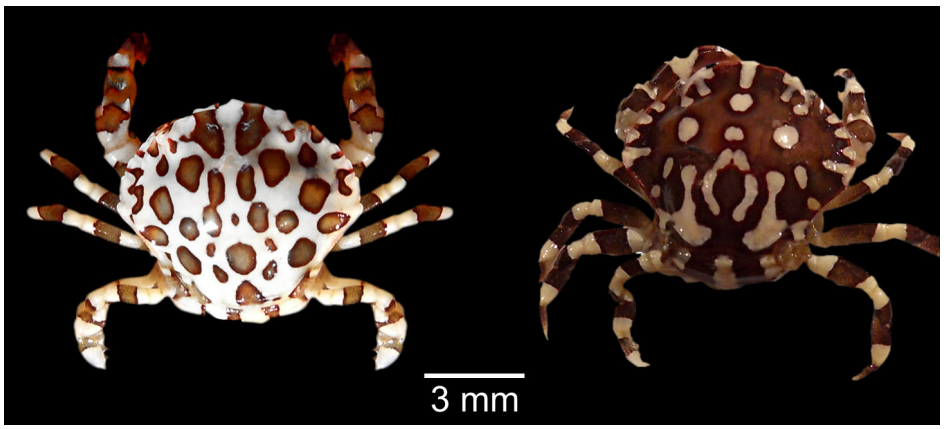

FIGURE 2. External morphology of the Harlequin crab viewed from above.

TABLE 1. Characteristics of the holothuroid infestation by Harlequin crabs in Toliara bay.

Holothuroid species	Observed	Infested	Most common habitat
Holothuria atra (Jaeger, 1833)	36	3	Reef flat close to external slope under dead corals
Holothuria scabra (Jaeger, 1833)	125	11	Sea grass beds
Holothuria lessoni (Massin, 2009)	12	6	Sea grass beds
Bohadschia argus (Jaeger, 1833)	15	13	Lagoon, on patch reefs
Holothuria fuscogilva (Cherbonnier, 1980)	16	6	End of the external slope (30 m depth)
Holothuria edulis (Lesson, 1830)	34	0	Mainly external slope (2–10 m)
Holothuria leucospilota (Brandt, 1835)	13	0	Reef flat close to external slope under dead corals
Holothuria arenicola (Semper, 1968)	8	0	Reef flat close to internal slope, buried
Holothuria hilla (Lesson, 1830)	15	0	Reef flat close to external slope between dead corals
Bohadschia subrubra (Quoy & Gaimard, 1834)	6	4	Lagoon, on patch reefs
Bohadschia vitiensis (Semper, 1968)	3	2	Lagoon, on patch reefs
Thelenota ananas (Jaeger, 1833)	5	5	End of the external slope (30 m depth)
Pearsonothuria graeffei (Semper, 1968)	21	0	Mainly external slope (2–10 m)
Actinopyga echinites (Jaeger, 1833)	6	0	Reef flat close to external slope between dead corals
Actinopyga mauritiana (Quoy & Gaimard, 1834)	7	0	Reef flat close to external slope between dead corals
Synapta maculata (Eschscholtz, 1829)	12	0	Reef flat close to internal slope, in sea grass beds
Stichopus chloronotus (Brandt, 1835)	12	0	Reef flat close to external slope between dead corals
Total	346	50	

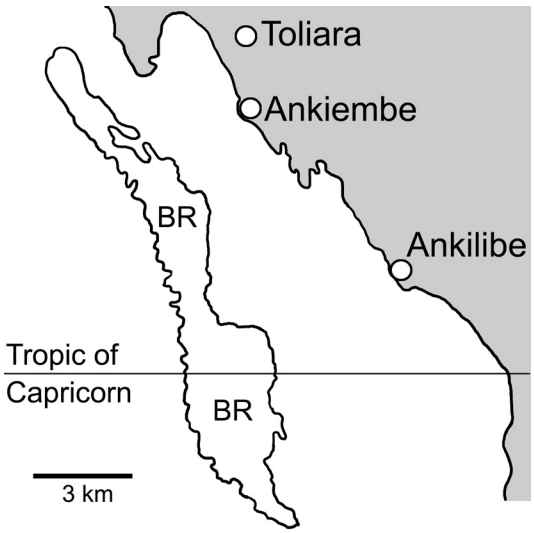

FIGURE 3. Map of the SW of Madagascar corresponding to the sampling area (adapted from Vaïtilingon *et al.* 2003). (BR = barrier reef).

crabs observed on *Holothuria scabra* and *Holothuria lessoni* were collected with their hosts, by fishermen from the villages of Ankilibe and Ankiembe (Fig. 3). Once back from their daily collect, holothuroids were checked and the crabs counted by fishermen, removed from their hosts and fixed in ethanol. Once in the laboratory, we recorded their sex, carapace length and the presence of gravid females. For the length, measurements were taken from the tip of the rostrum to the posterior end of the carapace.

Results

Seventeen holothuroid species were observed and eight were infested (Table 1). Considering all holothuroid individuals, the prevalence of the infestation is 14% and considering only the host species,

TABLE 2. Characteristics of the population of Harlequin crabs in the bay of Toliara.

	Male		**Female**			**Sex ratio**
	n	X length (cm) ± SD	n	X length (cm) ± SD	Gravid (%)	
December 06	78	5.3 ± 1.3	112	7.7 ± 1.6	32	1.4
February 07	24	6.9 ± 1	40	8.4 ± 1.1	45	1.7
March 07	34	7.5 ± 1.8	62	9 ± 1.4	44	1.8
April 07	45	7.9 ± 1.7	50	9.7 ± 1.5	64	1.1
July 07	33	6.4 ± 1.4	50	8.7 ± 1.7	39	1.5
August 07	74	6.9 ± 1.5	69	9.2 ± 1.5	62	0.9
October 07	50	6.3 ± 1.4	67	7.7 ± 1.4	36	1.3
November 07	64	6.8 ± 1.7	101	8.6 ± 1.9	46	1.6
December 07	84	6.3 ± 1.1	112	7.5 ± 1.7	35	1.3
January 08	44	6.6 ± 1.7	62	7.1 ± 4.6	35	1.4
February 08	47	5.8 ± 1.3	47	7 ± 1.4	32	1.0
March 08	58	6.5 ± 1.5	58	7.8 ± 1.8	36	1.0

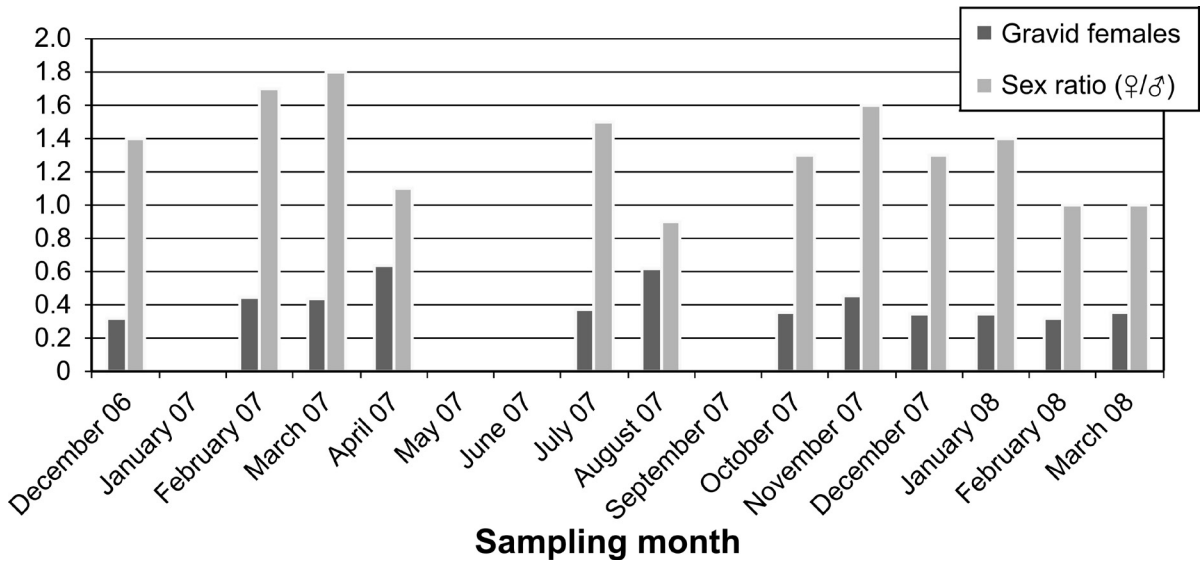

FIGURE 4. Changes in the sex ratio (female/male) and the proportion of gravid females of the Harlequin crabs measured in the Toliara population.

the prevalence increases to 23%. Harlequin crabs prefer to associate with holothuroids found in sea grass beds, at the end of the external slope, on patchy reefs in the lagoon or those on reef flat close to the external slope under dead corals (Table 1). They were not observed on holothuroids buried in substrates, never on some species on the external slope (*Holothuria edulis, Pearsonothuria graeffei*) nor on species living between dead corals of the reef flat (*Holothuria hilla, Holothuria leucospilota*). They prefer to shelter on big holothuroids and the most infested species are of the genera *Thelenota, Bohadschia* and *Holothuria*. They were not found on the two surveyed species of *Actinopyga* nor on the only collected species of *Synapta* and *Stichopus* (Table 1).

There was generally only one crab on each host sea cucumber but there were also heterosexual couples in 30% of the cases. A maximum of ten individuals were recorded on a *Thelenota ananas*, the biggest species found during the survey. In the case of multi-infested holothuroids, a heterosexual pair of adults was always with juveniles. The size of the observed *L. orbicularis* was between 0.3 and 1.4 cm with a mean C.L. (Carapace Length) of 0.85 cm. Females, with a mean length of 0.9 cm (data from all months combined), were significantly bigger than males, which measure 0.7 cm on average. Harlequin crabs had also different color patterns, usually matching with the body wall color of the host species of sea cucumber on which they were found. They varied from white-spotted, red-brown individuals to dark-spotted white crabs. Most of the times, crab color patterns match to the one of their host.

During the survey, 1882 crabs were observed with 24 to 112 crabs per month. Males, females, juveniles and gravid females were observed throughout the year. The months where the biggest females were observed were April and August (Table 2). These months also correspond to the time when the sex ratio (frequency of females / frequency of males) is at its minimum (close to 1.0) and the percentage of gravid females at its maximum. In 8 of the 12 surveyed months, the sex ratio was more than 1.4; in 3 months it was between 1 and 1.2; it was less than 1 only in August. The sex ratio is thus skewed towards female dominance most of the time of the year (Fig. 4; Table 2). Proportions of gravid females varied from 28% to 64% (Fig. 4; Table 2). Gravid females incubate about five hundred eggs.

Discussion

From these observations and from literature, Harlequin crabs do not infest holothuroids that are buried in sediments. It also seems that they do not infest all the holothuroid species that live in habitats which, at first sight, do not show any constraining parameters excluding their presence. For example, they are found on some species located on the external slope of the reefs, but not on *P. graeffei* which is a very common holothuroid in Toliara. The distribution of Harlequin crabs that are found on some holothuroid species, but not others, probably do not rely exclusively on the host habitat, but perhaps also on the toxicity of the holothuroids. Indeed, it is well known that holothuroids produce and release saponins in their environment (Van Dyck *et al.* 2009, 2011; Caulier *et al.* 2011). These noxious compounds are deleterious for most organisms and are considered to play a role in chemical defense of holothuroids against predators and fooling organisms (Kalinin *et al.* 1996a; Kalinin *et al.* 1996b; Caulier *et al.* 2011). Other parameters that could explain why some holothuroids are hosts while others are not are the size of the host or the texture of the integument.

Usually, adult *L. orbicularis* present strong territorial behaviors towards other adults of the same sex. They fight each other until there remains one adult, one heterosexual couple, or a heterosexual pair with juveniles (personal observation). As showed by Britayev & Zamishlak (1996) with symbiotic scale worms associated with sea cucumbers, the number of symbionts is correlated with host size. Females are bigger than males, but sexual dimorphism is low and both sexes present the same morphological adaptations to hold onto the host integument. Because gravid females were observed at each period of the year, we think that the crab reproduces all year round. There are, however, more gravid females in the population in April and August where the sex ratio is also close to 1:1. That could indicate a higher mortality of females at these periods probably due to the fact that females could die after laying their eggs.

Based on the theory developed by Baeza & Thiel (2007), breeding ecology of symbiotic crustaceans depends on host characteristics (relative size, morphological complexity, abundance) and predation risk in the environment. All of these environmental factors generate two main behaviors that they call host guarding and host switching with five mating system categories (from monogamy to polygynandry). Considering the low complexity and frequency of host holothurians and the high predation pressure existing on the coral reef of Toliara (personal observation), this model predicts host monopolization. Indeed, high rate of predators coupled with the fact that hosts are not frequent increases the costs of roaming around hosts to switch on another one. Then, the mating system of the Harlequin crab should be characterized by monogamy, based on host guarding (which is, in this case, supported by the fact that crabs profit from the chemical defenses provided by their hosts to deter their predators). Monogamy mating system also explains the fact that (i) adults are found easily in heterosexual pairs with a high prevalence, (ii) no more than two heterosexual adults occur on the same host, (iii) Harlequin crabs present strong territorial behaviors towards other adults of the same sex, (iv) males are smaller than females to make food more available for female and offspring production. However, we hypothesize that a low host switch of males could occur, which would explain the breeding asynchrony and the sex ratio because when males move from a host to another, they are subjected to a higher predation rate (females thus often remains in the population with which males reproduce). Further investigations considering the determination of the Harlequin crab mating system should be realized by monitoring potential switch of males and females from a host to another.

Acknowledgments

This work is a contribution of the Centre Inter-universitaire de Biologie Marine (CIBIM). It was supported by a FRIA grant (to G.C and F.V.N). Special thanks to J. Delroisse, M. Demeuldre, J. Derock, T. Lavitra, N. Lienard, S. Roosa, E. Wattier and M. Wautier for their valuable help.

References

Baeza, J.A. & Thiel, M. (2007) The mating system of symbiotic crustaceans: a conceptual model based on optimality and ecological constraints. *In*: Duffy, J.E. & Thiel, M. (Eds.), *Ecology and Evolution of Social Behavior: Crustaceans as Model Systems*. Oxford University Press, Oxford, pp. 249–267.

Bauchau, A. (1966) La Vie des crabes. *Encyclopédie biologique*, 66, 1–138.

Britayev, T.A. & Zamishlak, E.A. (1996) Association of the commensal scaleworm *Gastrolepidia glavigera* (Polychaeta: Polynoïdae) with Holothurians near the coast of south Vietnam. *Ophelia*, 45(3), 175–190.

Crosnier, A. (1962) Crustaces decapodes: Portunidae. *Faune de Madagascar*, 16, 1–154.

Caulier, G., Van Dyck, S., Gerbaux, P., Eeckhaut, I. & Flammang, P. (2011) Review of saponin diversity in sea cucumbers belonging to the family Holothuriidae. *SPC Beche-de-mer information bulletin*, 31, 48–54.

Edmondson, C.H. (1954) Hawaian Portunidae. *Occasional papers of the Bernice P. Bishop Museum*, 21(12), 217–274.

Kalinin, V.I., Anisimov, M.M., Prokofieva, N.G., Avilov, S.A., Afiyatullov, S.H. & Stonik, V.A. (1996a) Biological activities and biological role of triterpene glycosides from holothuroids (Echinodermata). *In*: Jangoux, M. & Lawrence, J. M. (Eds.), *Echinoderm studies 5*. A.A. Balkema, Rotterdam, pp. 139–181.

Kalinin, V.I., Prokofieva, N.G., Likhatskaya, G.N., Schentsova, E.B., Agafonova, I.G., Avilov, S.A. & Drozdova, O.A. (1996b) Hemolytic activities of triterpene glycosides from the holothurian order Dendrochirotida: some trends in the evolution of this group of toxins. *Toxicon*, 34, 475–483.

Mariappan, P., Balasundaram, C. & Schmitz, B. (2000) Decapod crustacean chelipeds: an overview. *Journal of Biosciences*, 25(3), 301–313.

Ng, P.K.L. & Jeng, M.S. (1999) The brachyuran crabs (Crustacea: Decapoda: Eumedonidae and Portunidae) symbiotic with echinoderms in Taiwan. *Zoological Studies*, 38(3), 268–274.

Spiridonov, V.A. (1999) Results of the Rumphius Biohistorical Expedition to Ambon (1990). Part. 8. Swimming crabs of Ambon (Crustacea: Decapoda: Portunidae). *Zoologische Mededelingen*, 73(4), 63–97.

Vaïtilingon, D., Rasolofonirina, R. & Jangoux, M. (2003) Feeding preferences, seasonal gut repletion indices, and diel feeding patterns of the sea urchin *Tripneustes gratilla* (Echinodermata: Echinoidea) on a coastal habitat off Toliara (Madagascar). *Marine Biology*, 143, 451–458.

Vannini, M. & Innocenti, G. (2000) Research on the coast of Somalia. Portunidae (Crustacea Brachyura). *Tropical Zoology*, 13, 251–298.

Van Dyck, S., Gerbaux, P. & Flammang, P. (2009). Elucidation of molecular diversity and body distribution of saponins in the sea cucumber *Holothuria forskali* (Echinodermata) by mass spectrometry. *Comparative Biochemistry and Physiology (B: Biochemistry & Molecular Biology)*, 152(2), 124–134.

Van Dyck, S., Caulier, G., Todesco, M., Gerbaux, P., Fournier, I., Wisztorski, M. & Flammang, P. (2011) The triterpene glycosides of *Holothuria forskali*: usefulness and efficiency as a chemical defense mechanism against predatory fish. *Journal of Experimental Biology*, 214, 1347–1356.