دراسة تجريبية على ستة أنواع من السرطانات المرتبطة بالشعاب المرجانية المحتملة الافتراض على كبسولات بيض بطنقديات آكلة المرجان نوع: دروبيل كورنس

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المستخلص. يتغذى الحلزون البطنقدي *دروبيل كورنس* (*Drupella cornus*)، والذي ينتمي لعائلة الميوريسيدي (Fmily : Muricidae) بشكل خاص على المستعمرات المرجانية، ويسبب تزايد أعدادها إلى وفيات أعداد كبيرة من المستعمرات المرجانية. حيث تضع إناث *دروبيل كورنس* كبسولات بيضها على طبقات تحتية صلبة متاحة م على مدار العام؛ وتبلغ ذروة إطلاقها للكبسولات خلال الأشهر من مايو إلى يوليو ومن أكتوبر إلى يناير على ساحل جدة بالبحر الأحمر. و تهدف هذه الدراسة إلى التعرف على إمكانية افتراض كبسولات بيض *دروبيل كورنس* من قبل ست سرطانات بحرية تعيش بداخل المستعمرات المرجانية تحت ظروف المختبر ولمدة ٤٨ ساعة. وأظهرت النتائج تباين في معدلات افتراض السرطانات على كبسولات بيض *دروبيل كورنس*؛ حيث سُجلت أعلى نسبة افتراض على كبسولات البيض ٩٠% من إجمالي الكبسولات التي خضعت لاختبار السرطان سيكلوديو سنيديوس (*Cyclodius nitidus*) والذي تغذى بشراهة على كبسولات بيض *دروبيل كورنس*، مقارنة بمعدل افتراض منخفضة جداً بنسبة ٥% من إجمالي كبسولات البيض التي خضعت لاختبار السرطان *تراپيزيا ديجيتاليس* (*Trapezia digitalis*). كما أظهرت النتائج أن السرطان *تراپيزيا بيدانتاتا* (*Trapezia bidentata*) قد سبب إعطاب ٣٠% من إجمالي كبسولات البيض دون فتحها والتغذية عليها. في حين لم يُلاحظ دلائل افتراض أو اثر هجوم على كبسولات بيض *دروبيل كورنس* من قبل السرطانات الأخرى الثلاث *تراپيزيا سيمودوس* (*Trapezia cymodoce*) ، سيمو ميلانوداكتيلوس (*Cymo melanodactylus*) و *سيوليومير اسبيسيوسا* (*Pseudoliomera speciosa*). استخلصت النتائج أن السرطان سيكلوديو سنيديوس يعتبر مفترس مهم على كبسولات بيض *دروبيل كورنس*؛ وهذا ما قد يجعله وسيلة مكافحة بيولوجية للحد من تزايد أعداد بطنقديات آكلة المرجان *دروبيل كورنس*.

الكلمات الدالة: افتراض كبسولات البيض، السرطانات المرتبطة بالشعاب المرجانية، شرم أبحر، جدة

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shown to cause a great impact on several snail populations (Martel *et al.* 1986; Rawlings 1990, 1994; Dumont *et al.* 2008), which also can control population of the corallivorous gastropod *Drupella cornus* by using associated crab *Cyclodiusnitidus*.

Further research is needed on predation on egg capsules of *Drupella* in the laboratory and the field with a wide range of predators and their susceptibility to different spawning substrates throughout this stage.

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Discussion

Our results indicated that the coral associated crab *Cyclodius nitidus* is voracious predator on egg capsules of *Drupella cornus* with approximately consumption rate of 5 capsules a day per crab when alternative prey were not provided. While low consumption rate was observed in *Trapezia digitalis* 0.5 capsule a day per crab. Squeezed but not opened egg capsules were observed in the case of crab *Trapezia bidentata* with a rate of 1.5 capsules a day per crab leading to mortality of eggs inside them.

Stella *et al.* (2011) identified 869 invertebrate species found to be associated with scleractinian corals including 636 arthropods, of these 310 species were decapod crustaceans, constituting 35% of the total number of invertebrate species that utilize corals.

Trapezid crabs are obligated symbiont mainly with *Pocillopora* corals and feeding on coral tissues (Knudsen 1967, Stimson 1990, Rinkevich *et al.* 1991, Castro *et al.* 2004). The genus *Trapezia* are well documented defenders of their pocilloporid coral hosts against coral predators such as the Crown of Thorns seastar *Acanthaster planci* and corallivorous snail *Drupella* sp. (Pearson and Endean 1969; Glynn 1976, 1987; Mckee *et al.* 2014, Al-Sofyani, Personal Communication), but they have never been recorded as egg capsules predators.

The crabs *Cyclodius nitidus* and *Pseudoliomera speciosa* are still unknown if they are obligated or facultative symbiont with coral and usually found on *Stylophora* using coral as habitat, whereas *Cymo*

melanodactylus is obligated symbiont usually found on *Acropora* and feeding on coral tissues (Edwards & Emberton 1980, Stella *et al.* 2011).

Predation by crabs on egg capsules have also been observed worldwide. Brenchley (1982) observed that 52% of egg capsules of mud snail *Ilyanassa obsoleta* were consumed by crab *Carcinus maenas* and hermit crab *Pagurus longicarpus* and snail *Littorina littorea* during the first 10 days of caging experiments. Rawlings (1989) found that 32% of egg capsules of snail *Nucella marginata* were consumed by intertidal predators such as shore crab *Hemigrapsus* spp. and isopod *Idotea wosnesenskii*. Also, predation has been observed on egg capsules of the snail *Odontocymbiolamagellanica* by echinoderms: the green sea urchin *Arbacia dufresnii* and the starfish *Cosmas terias lurida* on recently laid capsules and on those near the end of development (Bigatti *et al.* 2010). Fukumori *et al.* (2013) described drilling predation on the reinforced egg capsule of neritid snail *Nerita japonica* by muricid snail *Reishia clavigera* on a high intertidal rocky shore in central Japan.

To conclude, only the crab *Cyclodius nitidus* can be considered as an egg capsule predator. The attacks on egg capsules of *Drupella cornus* while in laboratory were observed near the end of the experiment and at a very low rate by *Trapezia digitalis*. *Trapezia digitalis* has shown almost little predation even in the absence of alternative prey, so, it could not be considered as a predator. It is also observed that the only one opened egg capsule was opened through exit pore not by the drilling of *Trapezia digitalis* crab. However, high predation rates on egg masses have been

initial egg capsules were eaten by the crab. We observed that the wall of 50 % of initial capsules were eaten too (Fig. 5). In one case of crab *Cyclodius nitidus* after 48 hours; 2 egg capsules were intact because they were in a crevice and not accessible to the crab.

In the case of *Trapezia bidentata*, the crabs squeezed egg capsules but couldn't open the capsules during the experiment. Mean of one egg capsule (± 1.41 , $N=2$) comprise 10% of the initial egg capsules were attacked by the crab and removed from the substrate during the 24 hours. After 48 hours, mean of 3 egg capsules (± 1.41 , $N=2$) comprise 30% of the initial egg capsules were observed with signs of attacks on the capsule wall and some embryos inside capsules were damaged (Fig. 6).

In the case of *Trapezia digitalis*, evidence of predation on the egg capsules of *D. cornus* was observed after 48 hours of exposure at low level with mean of 0.5 egg capsule (± 0.71 , $N=2$) 5% of the initial egg capsules and consumed very little amount of the eggs content. Signs of attacks were also observed on 0.5 egg capsule (± 0.71 , $N=2$) which form 5% of the initial capsules by the crab after 48 hours (Fig. 6).

Fig. (5): Broken egg capsule of *Drupella cornus* by predation of *Cyclodius nitidus*. Arrows show predation marks.

Fig. (6): a, Bore in egg capsule of *Drupella cornus* by *Trapezia digitalis*, arrow show opened exit pore. b, egg capsule of *D. cornus* attacked by *T. bidentata*. Scale bar = 1 mm.

A single individual of each crab species was placed in appropriate size of a plastic container (1 liter capacity) with 10 intact egg capsules of *D. cornus* attach to their corresponding substrate. Two replicates were performed for each species. Containers were covered by nylon net with mesh size of 2 mm and then immersed in the circular fiber glass tanks (300 liters), and provided with a continuous flow of fresh seawater (salinity 40.3 ‰, at temperature 28°C under a natural light cycle) (Fig. 3). The experimental crabs were starved for 24 hours prior to exposure to egg capsules. This experiment was conducted for two days (48 hours). The number of eaten and damaged capsules were counted after 24 and 48 hours from the starting time of the experiment.

Fig. (3): Experimental design of predation on egg capsules. a, Plastic containers with experimental crabs and egg capsules of *Drupellacornus*. b, containers immersed in seawater tanks (300 liters).

Results

The evidence of predation on egg capsules of *D. cornus* was clearly observed in the case of coral associated crab *Cyclodius nitidus*. A low level of predation has been observed with *Trapezia digitalis*. Signs of attacks were observed on egg capsules of *D. cornus* by *T. bidentata* but without any evidence of predation. There was no evidence of predation or signs of attacks on egg capsules of *D. cornus* exposed to three experimental crab predators, *Trapezia cymodoce*, *Cymomelanodactylus* and *Pseudoliomerus peciosa*.

Fig. (4): Mean of intact egg capsules of *Drupellacornus* after 24 and 48 hours exposure to *Trapezia bidentata*, *Trapezia digitalis* and *Cyclodius nitidus*

In the case of *Cyclodius nitidus* after 24 hours; mean of 4.5 egg capsules (± 0.71 , $N=2$) which comprise 45% of the initial egg capsules were observed with evidence of predation, opened and entirely empty of their eggs content, whereas mean of 0.5 egg capsules (± 0.71 , $N=2$) which comprise 5% of initial egg capsules were squeezed but not opened. After 48 hours, mean of 9 egg capsules (± 1.41 , $N=2$) comprise 90% of the

Fig. (1): Map of coral collection site at Ubhor Creek, Jeddah

The targeted predator crab species *Trapezia cymodoce* (carapace width mean 2.4 cm), *T. bidentata* (CW= 2.3 cm) and *T. digitalis* (CW=1.2 cm) were collected from coral colonies of *Pocilloporaverrucosa* and *Pocillopora damicornis*. Crabs of *Cyclodius nitidus* (CW=2.9 cm), and *Pseudoliomera speciosa* (CW=3.1 cm) from the coral *Stylophora pistillata*. The crab *Cymo melanodactylus* (CW=0.9 cm) was collected from *Acropora* spp. (Fig. 2).

Fig. (2): crabs used in predation experiment on egg capsules of *Drupella cornus*. a, *Trapezia cymodoce*; b, *Trapezia bidentata*; c, *Cymomelanodactylus*; d, *Trapezia digitalis*; e, *Cyclodius nitidus* and f, *Pseudoliomera speciosa*. Scale bar = 1 cm.

temperature (Spight 1977; Pechenik 1986), predation (Pechenik 1979; Perron 1981; Rawlings 1990, 1994; Dumont et al. 2008; Kano *et al.*, 2010; Roche *et al.* 2011; Fukumori 2013), bacterial attack (Lord 1986; Benkendorff *et al.* 2001), and wave action (Perron 1981).

Drupella are muricid gastropod, found on coral reefs in the tropical and subtropical shallow waters of the Indo-Pacific region. They are obligate corallivorous and thus exclusively prey on living coral tissues. Over the last three decades many reports were conducted on the population outbreak of *Drupella* from several reef areas in the tropical Indo-West Pacific region including the Red Sea. These reports pointed to the population outbreak of *Drupella* and its significant role of coral mortality (Moyer *et al.* 1982; Fujioka *et al.* 1983; Boucher 1986; Turner 1994; Black and Johnson 1994; Cumming 1999; Al-Moghrabi 1997; Shafir et al. 2008; Cumming 2008; Cumming 2009; Morton *et al.* 2009; Hoeksema *et al.* 2013 and Scott *et al.* 2017).

Females of *Drupella* enclose their eggs in capsules and usually attach the capsules to available hard substrata on rock and dead coral boulders (Turner 1992, 1994; Sam 2017; Baomar, 2016), over the year with peaks during May-July and October-January on Jeddah coast, Red Sea (Baomar, 2016). Embryonic development of *Drupella cornus* in the capsules takes 27-37 days at 21°C and 20-29 days at 25°C (Turner 1992).

Mortality due to predation at early life of *Drupella* has not been studied yet. Turner (1994) referred to his personal observation of empty egg capsules of *D. cornus* with the exit pores still intact and small drill holes in the

side or top of each capsule in the wild. He observed variable numbers of egg capsules of *D. cornus* in the gut contents of some fishes such as *Plectorhinchus chaetodontoides* (Harlequin sweetlips), *P. flavomaculatus* (gold spotted sweetlips), *Thalassomalutescens* (green moon wrasse) and *Sufflamen chrysopterus* (black triggerfish).

This study is designed to investigate experimentally the predation potential of six species of coral associated crabs on the egg capsules of the muricid *D. cornus*.

Materials and Methods

To collect the experimental predators, coral colonies of *Stylophora pistillata*, *Pocillopora verrucosa*, *P. damicornis* and *Acropora* sp. (i.e the most preferable coral species by the targeted crabs) were collected from Ubhor Creek entrance (Fig. 1) and transferred in plastic boxes filled with seawater to 300 liters circular fiberglass tanks established at the marine station (Faculty of Marine Science, Southern Ubhor, Jeddah). Six species of associated coral crabs were sorted from the collected coral colonies.

Experimental study of six coral associated crab species predation potential on egg capsules of Corallivorous Gastropod *Drupella cornus*

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Abstract: The muricid *Drupella cornus* feed exclusively on coral colonies and their population outbreaks cause significant coral mortality. Females of *D. cornus* are laying egg capsules on available hard substrata over the year and with peaks during May-July and October-January in the Jeddah coast, Red Sea. This study was designed to investigate the predation potential of six coral associated species of crabs on the egg capsules of *D. cornus*. Egg capsules of *D. cornus* were provided to the six coral associated crab species in experimental exclusion under laboratory conditions for 48 hours to determine their predation potential. The predation rates on egg capsules varied according to the crab species. Highest predation rate was recorded for *Cyclodius nitidus* where 90% (± 14.14 , n=2) of provided egg capsules were consumed within 48 hrs. In comparison, only 5% (± 7.1 , n=2) of the provided egg capsules were consumed by the species *Trapezia digitalis*. In the case of *Trapezia bidentata*, damaged capsules were noticed, with mean of 30% (± 14.14 , n=2) of the total number of provided capsules, but none of the damaged capsules was eaten. Regarding the three other crab species, *Trapezia cymodoce*, *Cymo melanodactylus* and *Pseudoliomera speciosa*, there was no evidence or signs of predation or even attacks on the egg capsules of *D. cornus*. The results indicated that the crab species *C. nitidus* possesses high predation potential on the egg capsules of *D. cornus*, therefore the species could be good control labelagent against *D. cornus* outbreak.

Key words: Egg Capsules predation, coral associated crabs, Ubhor Creek, Jeddah

Introduction

The encapsulation of fertilized eggs is a common phenomenon among many marine invertebrate groups, especially in gastropod mollusks. The egg capsules protect eggs from

environmental stresses, such as osmotic changes (Pechenik 1982, 1983; Hawkins and Hutchinson 1988), desiccation (Spight 1977; Pechenik 1978), exposure to ultraviolet light (Rawlings 1996; Przeslawski *et al.* 2004; Przeslawski 2005; Wraith *et al.* 2006),