Predation by the gastropod *Tonna perdix* (Gastropoda: Tonnoidea) on the holothurian *Actinopyga echinites* (Echinodermata: Holothuroidea) on a reef of Réunion

Philippe Bourjon[1] and Sébastien Vasquez[1]*

Introduction

Although holothurians are sometimes considered to have few predators, 76 specialist or opportunist predator species have been identified, with the most significant groups being sea stars, finfish and crustaceans (Francour 1997). A recent summary paper (Purcell et al. in press) adds yet more information based on recent observations of commercially important sea cucumber species. Holothurians have developed seven methods of defence against these predators, with each species of sea cucumber using one or more of the following tactics: 1) possessing a thick tegument and spicules; 2) possessing a toxic tegument and organs; 3) swelling and hardening the body; 4) eviscerating or autotomising (including the expulsion of the Cuvierian tubules); 5) swimming; 6) having nocturnal behaviour; and 7) having cryptic or burrowing behaviour (Francour 1997). *Actinopyga echinites* (Jaegger, 1833) uses the first four types of defence as well as the seventh. The fourth defence is, however, limited to a few observed cases of evisceration (Conand 1989), and this species possesses a rudimentary Cuvierian organ whose tubules, incapable of extension and becoming sticky, are never expelled (VandenSpiegel and Jangoux 1993). In addition, it does not swim and its activity is diurnal.

The prosobranch gastropod *Tonna perdix* (Linnaeus, 1758), which is a widespread species in the Indo-Pacific region, is a specialist predator on holothurians (Francour 1997; Morton 1991; Vos 2013). Its shell can reach 227 mm.[2] It has a highly extendable proboscis, into which lead two canals supplying a place close to the mouth with secretions containing sulphuric acid produced by two large salivary glands (Bolis et al. 1984). The percentage of sulphuric acid in the secretions is from 3 to 5 %, enough to paralyse the prey (Vos 2013). Like some sea star species, *T. perdix* seems to have immunity against the chemical defences – called saponins and known collectively as holothurin – used by sea cucumbers (Caulier et al. 2011). From experiments conducted, *T. perdix*, however, seems to be selective in its choice of prey (Morton 1991), preferring to attack species in which the content and nature of these chemical substances are less repellent than its own (Bondoc et al. 2013). Kropp (1982) observed that *Holothuria atra* is not a preferred prey of *T. perdix* in an experimental setting, and Van Dick et al. (2010) noted that *H. atra* only contains sulfated saponins, similar to *A. echinites* (Bondoc et al. 2013). It is, therefore, probable that the sulfated saponins have a stronger deterrent effect than non-sulfated saponins on this gastropod. In addition, Van Dick et al. (2010) observed a higher concentration of these substances in the Cuvierian tubes than in the tegument of *A. echinites*. Such a concentration within an apparently non-operational defence mechanism seems anomalous. The authors suggest that this means of defence has evolved in these species from an aggressive defence strategy based on the tubules sticking to the attacker in a defence strategy based on toxicity (Hamel and Mercier 1999). Some species of the genera *Actinopyga*, *Bohadschia* and *Holothuria* actually show their Cuvierian tubes without expelling them and then retract them. While most of the sulfated saponins found in the Cuvierian tubes are highly soluble in water and disperse rapidly in the environment, the mere exposing of the Cuvierian tubes can, therefore, be enough to obtain the desired repellent effect (Van Dick et al. 2010).

Predatory behaviour by Tonnidae on holothurians has infrequently been observed in the wild and has only been studied in experimental situations in aquaria (Kropp 1982; Morton 1991; Toscano et al. 1992; Heron Island Research Station 2009). Predation by *T. perdix* on *A. echinites* had never been observed in the wild until the observation recorded on 3 February 2015 on the fringing reef of Saint-Pierre, Réunion (21°07'S and 55°32'E). The observation[3] lasted from 20:45 to 21:15. When the observer came across the event, the gastropod was beginning to attack the holothurian (Fig. 1), which had already swollen itself up with water and pushed its podia out as far as they would go. Several fruitless attempts by the predator to suck the holothurian into its proboscis by grasping its sides were observed (Fig. 2). The

1 Réseau d'observateurs volontaires "Les Sentinelles du Récif", Réserve Naturelle Marine de La Réunion (GIP-RNMR) ["Sentinels of the Reef", network of volunteer observers: Réunion Marine Park]
2 See http://www.gastropods.com/9/Shell_1499.shtml
3 https://www.youtube.com/watch?v=mFftCx6BnUM
* Author for correspondence: seizhavel@wanadoo.fr

holothurian was released three times. The gastropod seemed to be trying to move the prey using the end of its proboscis, particularly by trying to turn the prey onto its back, probably so as to be able to grasp it more easily by its anterior end. During the first attempt, four-fifths of the holothurian's body was enveloped by the proboscis; the proboscis was then retracted, with only one end of the prey still being held. It showed no sign of injury. A second attempt produced the same result, but after that, the posterior third of the holothurian was contracted, while the rest of the body remained swollen (Fig. 3). The separation zone between these two parts of the body was very clear, with the difference in diameter being 3 cm. The fact that the majority of the podia on the contracted part were retracted suggests that the prey was paralysed by the sulfuric acid in the gastropod's secretions. The fact that the predator had resumed its manoeuvre from this contracted part on the third attempt (Fig. 4) would tend to confirm this, and to suggest that the previous manoeuvres were intended to paralyse the prey. The last attempt led to the whole of the holothurian's body being absorbed. When the gastropod ceased moving, the observation was halted. No exposure of the Cuvierian tubes nor the dilation of the cloaca were noted in *A. echinites* over that half-hour. For this species to be a prey for *T. perdix*, despite its probable low palatability to this taxon because it only contains sulfated saponins (Bondoc et al. 2013), could be due either to a quantitative or qualitative failing in the development of saponin by the organism of the specimen concerned, or more probably to the fact that it was the first to be encountered by a specialised predator. The results of palatability tests carried out experimentally can be biased by the choice offered to the predator, which it may only infrequently encounter on a reef.

Morton (1991) recorded that, in an experimental situation, *Tonna zonatum* consumes approximately one holothurian per week. Also, juvenile holothurians suffer massive predation (Dance et al. 2003) as well as excessive fishing pressure (Uthicke and Conand 2005). Better knowledge of the impact of predation on adult holothurian population dynamics continues to be necessary in order to improve the effectiveness of management and conservation efforts for commercial holothurian species that suffer from overfishing, especially given the key ecological role these species play in nutrient recycling and bioturbation.

Acknowledgements

Chantal Conand and Igor Eeckaut are acknowledged for their participation in the elaboration of this communication.

References

Bolis L., Zadunaisky J. and Gilles R. (eds). 1984. Toxins, drugs and pollutants in marine animals. Springer Verlag, Berlin. 193 p.

Bondoc K.G., Lee H., Cruz L.J., Lebrilla C.B. and Juinio-Meñez M.A. 2013. Chemical fingerprinting and phylogenetic mapping of saponin congeners from three tropical holothurian sea cucumbers. Comparative Biochemistry and Physiology, Part B 166:182–193.

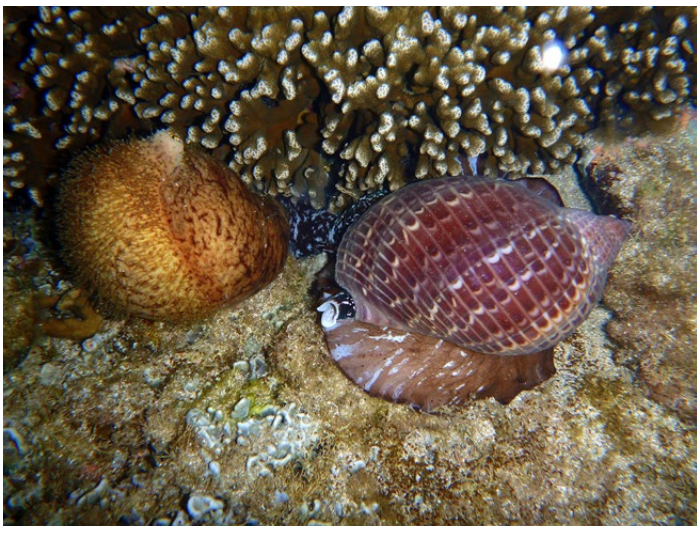

Figure 1. The holothurian *Actinopyga echinites* after contact with the predator *Tonna perdix*. Note the holothurian has swollen itself up with water (defence mechanism #3). (Image: © S. Vasquez)

Figure 2. *Tonna perdix* attempting to suck the holothurian *Actinopyga echinites* into its proboscis by grasping its sides. (Image: © S. Vasquez)

Caulier G., Van Dyck S., Gerbaux P., Eeckhaut I. and Flammang P. 2011. Review of saponin diversity in sea cucumbers belonging to the family Holothuriidae. SPC Beche-de-mer Information Bulletin 31:48–54.

Conand C. 1989, Les holothuries aspidochirotes du lagon de Nouvelle-Calédonie : biologie, écologie et exploitation. Etudes et Thèses. Editions de l'ORSTOM Paris. 393 p.

Dance S.K., Lane I. and Bell J.D. 2003. Variation in short-term survival of cultured sandfish released in mangrove-seagrass and coral reef flat habitats in Solomon Islands. Aquaculture 220(1-4):495–505.

Francour P. 1997. Predation on holothurians: a literature review. Invertebrate Biology 116(1):52–60.

Hamel J.-F. and Mercier A. 1999. Cuvierian tubules in tropical holothurians: usefulness and efficiency as a defence mechanism. Marine Freshwater Behaviour and Physiology, vol. 33:115–139.

Heron Island Research Station. 2009. https://www.youtube.com/watch?v=TbT5_p7W4s8

Kropp R.K. 1982. Responses of five holothurian species to attacks by a predatory gastropod, *Tonna perdix*. Pacific Science 36(4): 445-452.

Morton B. 1991. Aspects of predation by *Tonna zonatum* (Prosobranchia: Tonnoidea) feeding on holothurians in Hong-Kong. Journal of Molluscan Studies 57(1):11–19.

Purcell S.W., Conand C., Uthicke S. and Byrne M. (in press). Ecological roles of exploited sea cucumbers. Oceanography and Marine Biology: An Annual Review.

Toscano A., Bentivegna F. and Cirino P. 1992. Holothurian's responses to attack by the Tonnid *Tonna galea*. Echinoderm Research, 204.

Uthicke S. and Conand C. 2005. Local examples of beche-de-mer overfishing: An initial summary and request for information. SPC Beche-de-mer Information Bulletin 21:9–14.

VandenSpiegel D. and Jangoux M. 1993. Fine structure and behaviour of the so-called Cuvierian organs in the Holothuroid genus *Actinopyga* (Echinodermata). Acta Zoologica (Stockholm) 74:43–50.

Van Dick S., Gerbaux P. and Flammang P. 2010. Qualitative and quantitative saponin contents in five sea cucumbers from the Indian Ocean. Marine Drugs 8:173–189.

Vos C. 2013. Overview of the Tonnidae (Mollusca: Gastropoda) in Chinese waters. Gloria Maris 52 (1–2):22–53.

Figure 3. After almost being completely absorbed twice into the predator's proboscis, the holothurian is kept captive until the next attempt. Observe the contraction of the anterior part (paralysed during previous attempts?). The last attack began from the contracted area.
(Image: © S. Vasquez)

Figure 4. The gastropod's last attempt results in the absorption of the whole of the holothurian's body, in progress here. The predator remains motionless at the end of the operation.
(Image: © S. Vasquez)