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Unreported predatory behavior on crustaceans by *Ilyella gigas* (Schmarda, 1859) (Polycladida: Ilyplanidae), a newly-recorded flatworm from Taiwan

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Abstract

The polyclad *Ilyella gigas* (Schmarda, 1859) is formally reported and described from Taiwan for the first time. Its color patterns, external characters and details of anatomy are recorded and its unusual behavior of preying on crustaceans is described. After capturing a crustacean with its membranous yet highly ruffled pharynx, the flatworm wraps up its prey with the rear half of its body. Its pharynx digests the crustacean externally. Since 2011 we observed individual *I. gigas* capture two rock crabs, *Actaeodes tomentosus*, one collector crab, *Camposcia retusa*, one dark fingered crab, *Eriphia scabricula* and one snapping shrimp, *Alpheus strenus* in tidal pools during both the daytime and nighttime. In all cases, the preys were consumed without effective resistance, implying that *I. gigas* may release some narcotic secretions during prey capture.

Key words: acotylean polyclads, predatory behavior, crustacean

Introduction

Ilyella gigas (Schmarda, 1859) was first described from Sri Lanka in 1859 (Schmarda, 1859). Hyman (1959) suggested that its distribution also included Guam and the Caroline Islands in Micronesia. Tajika et al. (1991) reported that it actually had a much wider distribution in the Indo-West Pacific after collecting it in Viti Levu Island, Fiji. In summary, the sites in the Indo-Pacific Ocean from which *I. gigas* is already known are Ambon, Timor, Funafuti, Onotoa, Kapingamarangi, Palau, Guam, Bonin Island and Japan (Laidlaw, 1902; Kato, 1934; Hyman, 1959; Tajika et al., 1991).

In Taiwan, *I. gigas* was also recorded by some popular field guidebooks published in Chinese (Chen, 2001). Even though this species is one of the commonest polyclad flatworms of Taiwan tidal zone (Table 1), it still has not formally been recorded in the scientific literature. Furthermore, ecological and biological information for it from anywhere in the Indo-west Pacific is absent.

Most polyclad flatworms are benthic carnivores (Newman & Cannon, 2003). Acotylean polyclads are generally known as 'oyster leeches' and have been well known as predators of bivalves (oysters and mussels) for many years (Newman et al., 1993). The flatworms most commonly associated with bivalves are members of the acotylean family Stylochidae. Once inside the oyster, the flatworm wraps its body around the mollusk, everts its pharynx and consumes the tissue externally (Newman & Cannon, 2003). Field investigations conducted in Taiwan have indicated that the mortality of oysters was correlated with the number of stylochid flatworms (Shu & Lin, 1980).

Lee et al. (2006) described a stylochid flatworm, *Imogine lateotentare*, and its feeding behavior on the barnacle *Amphibalanus variegatus*. Since the barnacle

Table 1. *Ilyella gigas* (Schmar da, 1859) geographic distribution around Taiwan.

Specimen location	Spot	Geographic Coordinate Position	Year of Records	Specimen No.	Collecting Situation
Northeast Coast	Ruibin	N25°07'24" E121°49'10"	2005		Tidal pool, * daytime
Little Liouciou Island	"Lobster Hole"	N20°20'44" E121°23'18"	2012	NMNS-7153-001 NMNS-7153-002	Under rubble, nighttime
Kenting	Haikou	N22°04'57" E120°42'02"	2010		Tidal pool, *daytime
	Houbihu	N21°56'11" E120°44'46"	2011, 2012, 2013	NMNS-7153-004	Tidal pool, daytime or nighttime
	Wanlitong	N21°59'50" E120°42'06"	2013		Tidal pool, * nighttime
Green Island	Zhongliao	N22°40'35" E121°28'28"	2013	NMNS-7153-003 NMNS-7153-005	Tidal pool, nighttime

*= photo recording

was unable to close its opercular valves properly once the flatworm had inserted its pharynx, it was suggested that these polyclads may paralyze their barnacle prey with toxins (Lee et al., 2006). There are no other records of polyclads preying on crustaceans.

Ritson-Williams et al. (2006) found an undescribed planocerid polyclad from Guam that contained high levels of the neurotoxin tetrodotoxin (TTX) and its analogs. During feeding trials, it rapidly killed and ate a wide variety of mobile gastropod mollusks from at least 11 different families, as well as other flatworms. Their data show that these toxins do not protect flatworms from predators but are used to capture mobile prey instead (Ritson-Williams et al. 2006).

In the case of the cotylean polyclads, such as those of family Pseudocerotidae, the large muscular pharynx is used to suck up or engulf solitary or colonial ascidians for food (Newman & Cannon, 2003; unpublished data). The corallivorous cotylean, *Amakusaplana acroporae* is described from aquarium. Unfired nematocysts and commensal zooxanthellae from acroporid coral are abundantly distributed in the multibranched gut and parenchyma (Rawlinson et al. 2011). Therefore, no other food sources other than ascidians, barnacles, mollusks and cnidarians have ever been documented as suitable foods for polyclads untill now.

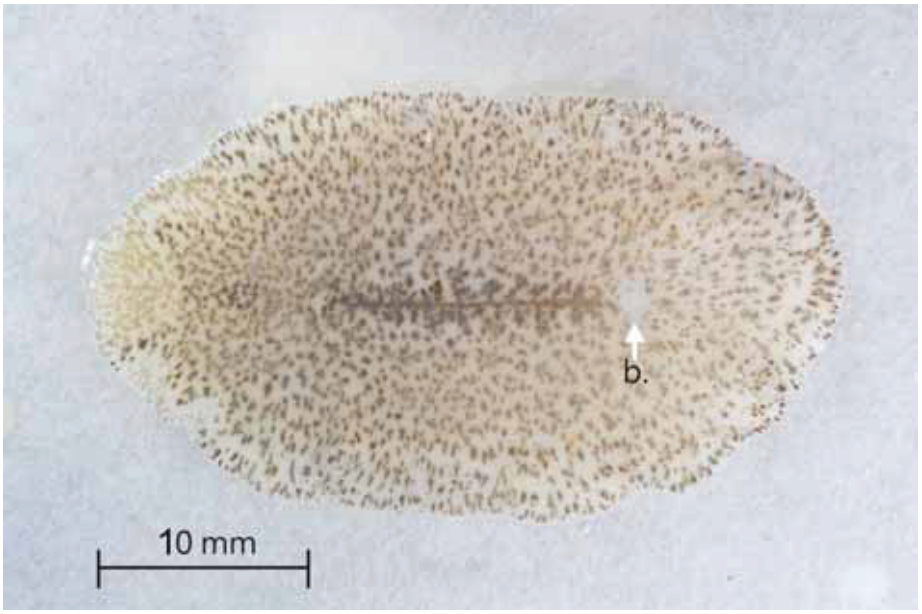
Materials and Methods

All of the underwater video and photographic records that document the behavior reported in this article were taken in Taiwan by snorkeling, generally in tidal pools. Specimens were photographed whenever possible either in *situ* or in the laboratory. The observations on behavior reported here and the collection of specimens were made between 2011 and 2013. Nomenclature updated after Faubel (1983).

Specimen localities: NMNS-7153-001. *I. gigas* length 36 mm, width 21 mm; locality: “Lobster Hole” study site, Little Liouciou Island, Pingtung County. Under rubble, free-living. 18 Nov.2012 (Fig. 1). Other specimens and photographic records from Taiwan are listed in Table 1.

All specimens were fixed in frozen 10% seawater formalin (FCA-PGPP), a fixation method modified from that of Newman and Cannon (1995). The specimens were then preserved in 70% ethanol for histological studies and long-term storage. For histological study, specimens were fixed in frozen FCA-PGPP for at least two days. Longitudinal serial sections of reproductive organs were prepared by embedding the tissue in 56℃ paraplast, cutting at 5-8 μm, and staining with hematoxylin and eosin. All the specimens and the serial sections have been deposited in the National Museum of Natural Science.

(A)



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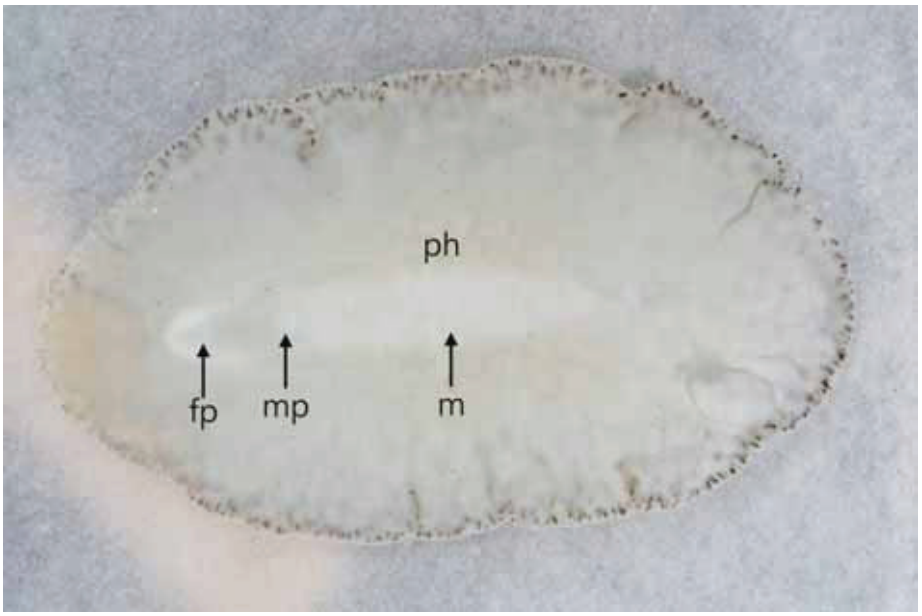

Fig. 1. *Ilyella gigas* (Schmarda, 1859). Whole animal; anterior end on the right in both images. (A) Dorsal view. (B) Ventral view. b, brain; fp, female pore; m, mouth; mp, male pore; ph, pharynx.

Results

Description of *I. gigas*

Body shape ovate, anterior end slightly broader than posterior end. Dorsal background color creamy white, with various sizes of brown speckles distributed all over back and concentrated in the middle line forming a narrow brown medial line. Brain anterior with no tentacle. Eyespots forming two clusters around brain area (Fig. 1A). Mouth at the center of body ventral. Pharynx very large and highly ruffled. Male pore single, closed behind pharynx. Female pore single, far from male organ (Fig. 1B).

Mouth opening narrow with numerous muscles. Pharynx highly folded and packaged inside the cavity (Fig. 2A). Both anterior and posterior ends of the mouth with several longitudinal, symmetrical folds (Fig. 2B).

Penis long, corncob shape with sheath. Muscular ejaculatory duct long and coiled (Fig. 3A). Long, coiled vagina extends backwards posteriorly to Lang's vesicle. Paired oviduct stretched separately forward (Fig. 3B).

Distribution

Surveys found that *I. gigas* (Schmarda, 1859) is common in and around the coasts of Taiwan and its adjacent islands (Table 1). Individuals are often encountered slowly crawling in tidal pools or sheltering under rubble during both the day and the night.

Feeding behavior

The first instance of feeding behavior by this species was observed at night (23.07 hr) in a tidal pool at Hou-Bi-Hu, Kenting, on May 12, 2011. Video and photographic records (Fig. 4) were made during this encounter. An individual rock crab, *Actaeodes tomentosus*, was trying to escape from an *I. gigas* that was 'stalking' it. *I. gigas* had covered this crab with the posterior half of its body and this was slowing the crab down. We turned them both over as the crab seemed to stop fighting with the flatworm. The crab had apparently been paralyzed deeply and was unable to escape. We saw that the *I. gigas* had everted its highly branched pharynx to hold the crab tightly.

The second instance was also observed at night (23.54 hr) in the same tidal pool as the previous one on January 20, 2012 (Fig. 5). The rock crab *Actaeodes tomentosus* was paralyzed and gripped by the flatworm's membranous-like pharynx. In this, and in other field observations of prey capture by *I. gigas*, the flatworm tried to escape from the observer's flashlight, and to drag its prey into a nearby hole.

The third instance was videotaped at daytime (17.10 hr) in the same pool as both previous instances on May 21, 2011 (Fig. 6), but on this occasion the prey was a collector crab, *Camposcia retusa*. In this instance, human disturbance released the crab and it recovered, walking away in a

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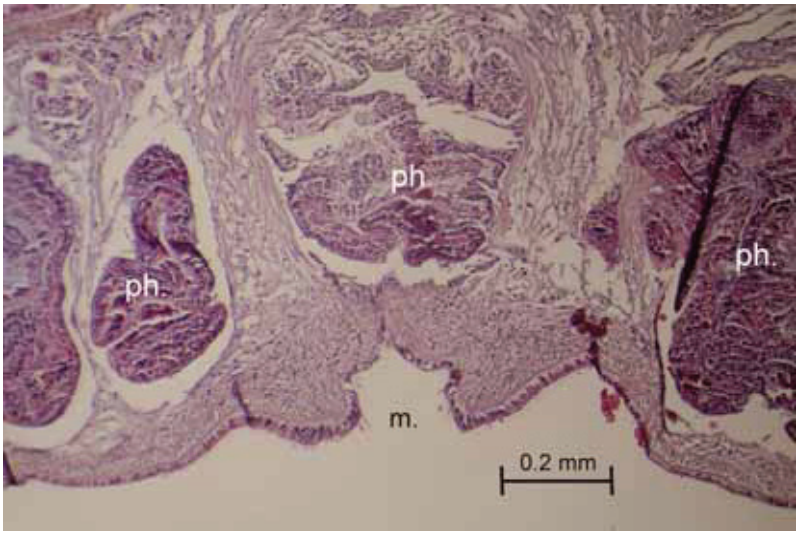

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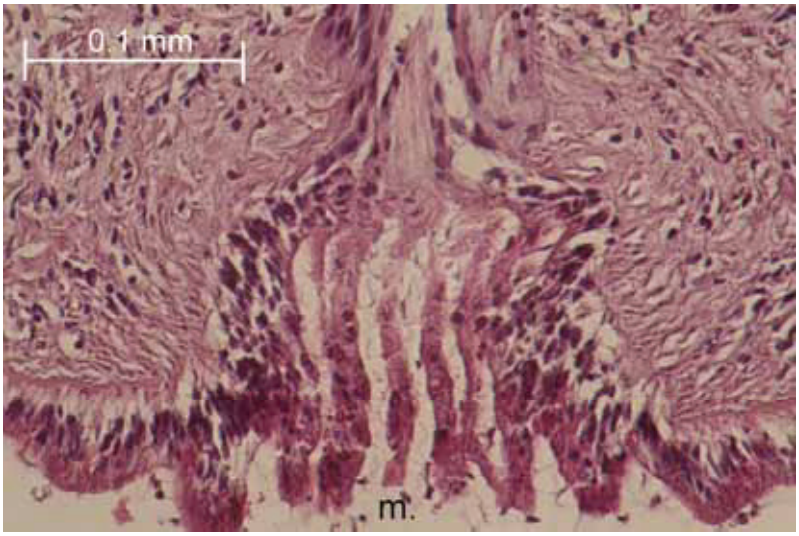
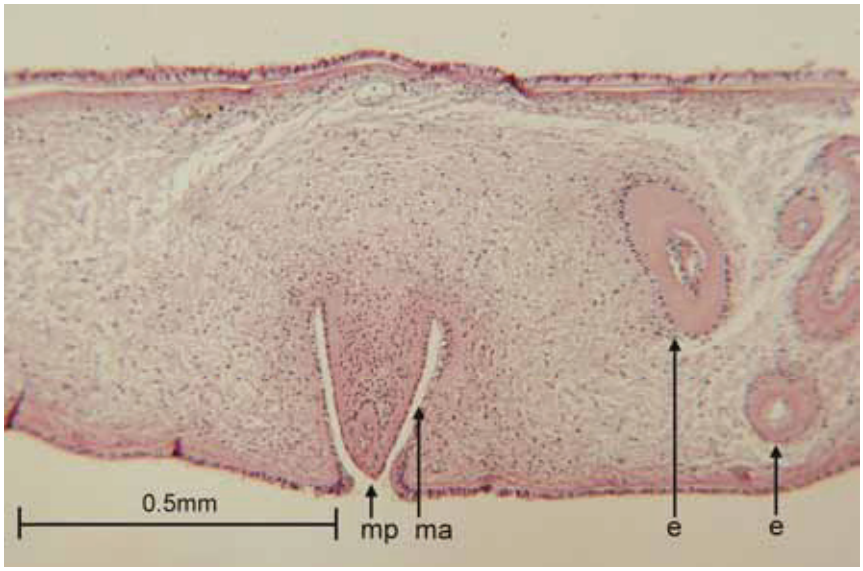


Fig. 2. Transverse sections of *Ilyella gigas* (Schmarda, 1859). Ventral surface downward in both images. (A) Muscle-enriched mouth opening narrow; pharynx highly folded and packaged. (B) Several longitudinal folds are symmetrically arranged at the anterior and posterior ends of the mouth. m, mouth; ph, pharynx.

(A)



(B)

Fig. 3. Longitudinal sections of *Ilyella gigas* (Schmarda, 1859). Anterior end on the right in both images. (A) Male organ. (B) female organ. dl, duct to Lang's vesicle; e, ejaculatory duct; fp, female pore; lv, Lang's vesicle; ma, male antrum; mp, male pore; ov, oviduct; v, vagina.

Fig. 4. *Ilyella gigas* feeding on the rock crab *Actaeodes tomentosus* (indicated by the arrow in the lower photo) at night, May 2, 2011.

Fig. 5. *Ilyella gigas* feeding on the rock crab *Actaeodes tomentosus* (indicated by the arrow in the lower photo) at night, January 20, 2012.

Fig. 6. *Ilyella gigas* feeding on the collector crab, *Camposcia retusa* (indicated by the arrow in the lower photo) during the day, May 21, 2011. Still frame from video recording.

few minutes seemingly without serious damage.

The last instance was recorded at night (21.44 hr) in a tidal pool at Green Island on July 2, 2013 (Fig. 7). The prey was a juvenile dark fingered crab, *Eriphia scabricula*. In this instance, the crab had been semi-digested and was abandoned probably because we had disturbed the flatworm during its meal. We collected both the flatworm (*I. gigas.* NMNS-7153-005. Length 38 mm, width 16 mm) and its prey (*E. scabricula* Carapace width 7 mm, Body length 4 mm) for future study.

On only one occasion did we observe *I. gigas* feeding on a shrimp. This case was observed at night (22.26 hr) on March 7, 2013 (Fig. 8) in the same tidal pool as the previous case at Hou-Bi-Hu, Kenting. In this instance the prey was the snapping shrimp, *Alpheus strenus*. This dead snapping shrimp was abandoned by the flatworm, which was dragging it towards a small cave.

Discussion

Marine scientists have studied marine flatworms for over one hundred and fifty years yet we know little more about them than basic taxonomy. It's hard to know why so few scientific studies have been conducted on them, especially since we found that flatworms are easy to find, capture and/or record systematically by photos and videos. Following Newman and Cannon's (1995) method, it is also very easy to fix specimens in the field. We think that a large-scale survey of marine flatworms around Taiwan is urgently needed.

Predation by polyclads on mobile crustaceans (crabs and shrimps) is a completely new scientific discovery. It seems that *I. gigas* normally feeds on the commonest crab species in its habitat, but *I. gigas* can also eat other mobile crustaceans as well.

Crabs, and even alpheid shrimps are very active animals and we still do not know how they are actually captured by the flatworms. We found evidence that *I. gigas* possess a large, highly ruffled, folded, and packaged pharynx for prey capture. This pharynx extends out through its membrane-like pharynx and through the narrow mouth opening for catching crustaceans. The crustaceans are paralyzed and digested outside of the flatworm's body when enwrapped by *I. gigas*. In fact, the mobile prey crustaceans seem unable to resist or only weakly attempt to escape. These observations suggest to us that narcotic secretions from the flatworm must be involved. These substances need to be researched to know their mechanism of operation and potential value.

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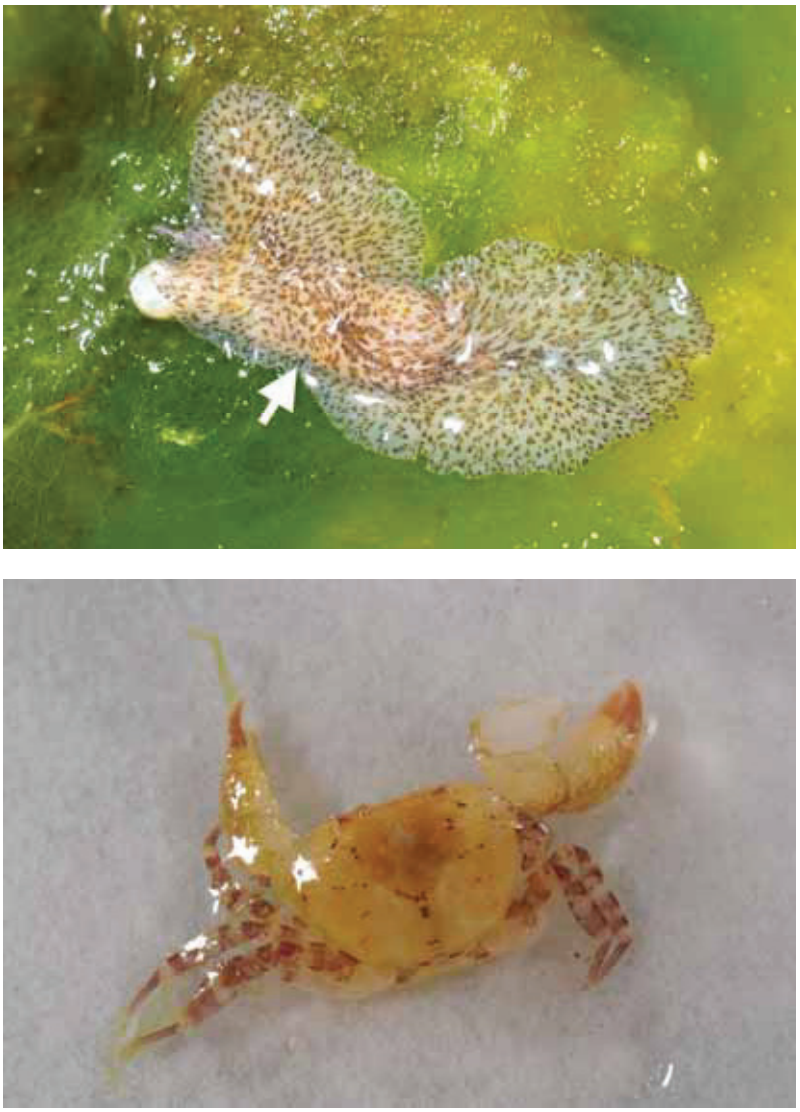

Fig. 7. *Ilyella gigas* (NMNS-7153-005. Length 38 mm, width 16 mm) feeding on a juvenile dark fingered crab, *Eriphia scabricula* (Carapace width 7 mm, Body length 4 mm; indicated by the arrow on the upper photo), at night, July 2, 2013.

Fig. 8. *Ilyella gigas* feeding on the snapping shrimp, *Alpheus strenus* at night (indicated by the arrow on the lower photo), at night, March 7, 2013.

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新紀錄種大盤扁蟲*Ilyella gigas*首次發現的食蟹行爲

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摘 要

大盤扁蟲*Ilyella gigas* (Schmarda, 1859)在台灣的正式新記錄。本文描述體色、外觀與解剖的詳細特徵。描述野外觀察中發現世界上未曾報導過的特殊食蟹行爲。在捕食的過程中，大盤扁蟲會伸出薄膜狀摺疊於體內的咽，利用身體的後半段包覆包腹其獵物並體外消化食物。自2011年起，至少發現絨毛仿銀杏蟹(*Actaeodes tomentosus*)、鈍額曲毛蟹(*Camposcia retusa*)、粗糙酋婦蟹 (*Eriphia scabricula*)與敏捷槍蝦(*Alpheus strenuus*)等甲殼動物，於日或夜間海岸潮池內被捕食的紀錄。所有的觀察記錄中，獵物均無反抗或有效的脫逃行爲，推論大盤扁蟲補食能分泌某種未知的麻醉物質。

關鍵詞：無吸盤多歧腸目扁蟲，獵食行爲，甲殼動物。