

# First Record of a Rare Aggregation of the Neustonic Nudibranch *Glaucus marginatus* (Mollusca: Gastropoda: Glaucidae) from Kenting National Park, Southern Taiwan

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**Abstract.** This study reports on an aggregation of more than 100 neustonic blue sea slugs *Glaucus marginatus* (Bergh, 1860) observed at Hejie, Kenting National Park, southern Taiwan in April 2017. These upside-down floating sea slugs, which were following their prey, the pelagic colonial hydroid *Porpita pacifica* Lesson, 1826, were swept ashore and temporarily trapped in tidal pools during the ebb tide. At the site, the animals and their surroundings were recorded; in the laboratory, behaviors of *G. marginatus*, including feeding on *P. pacifica*, cannibalism, mating, and egg deposition, were also described.

**Key words:** *Glaucus marginatus*, *Porpita pacifica*, aggregation, Kenting National Park, Taiwan.

## INTRODUCTION

As the only lineage of truly pelagic sea slugs (Valdés and Angulo Campillo, 2004), glaucinins nudibranchs are floating travelers in tropical and subtropical seas. They are not strong swimmers. To maintain buoyancy, they periodically gulp a bubble and store the air in their gastric cavity (Thompson and McFarlane, 1967; Miller, 1974; Thompson, 1976; Valdés and Angulo Campillo, 2004) and use their long wing-like cerata (papillae) for increasing surface area (Miller, 1974). They are also voracious predators on neustonic colonial hydrozoan cnidarians, such as *Physalia physalis*, *Velella velella*, *Porpita porpita*, and *Por. pacifica* (Bayer, 1963; Bieri, 1966; Thompson and Bennett, 1969, 1970; Lalli and Gilmer, 1989). Feeding on these venomous stingers, glaucinins are not affected by the poisonous nematocysts of their prey, and also

have developed a unique mechanism to store the intact stinging cells at the tips of their cerata (Thompson and Bennett, 1970), as a defense against predators.

Based on morphological examinations, Valdés and Angulo Campillo (2004) concluded that glaucinins contain two valid species, *Glaucus atlanticus* Forster, 1777 and *G. marginatus* (Bergh, 1860). Along with minor anatomical differences in reproductive organs, *G. marginatus* was recently proposed as a complex of four genetically distinct cryptic species (Churchill *et al.*, 2013, 2014); the species name of the most widespread of these species in the Indo-Pacific region, *G. marginatus*, was suggested to be retained (Churchill *et al.*, 2014). Different from its sibling counterpart, members of the *G. marginatus* clade are considerably smaller in size. The body length of *G. marginatus* was recorded up to 18 mm (Ross and Quetin, 1990), whereas that of *G. atlanticus* reached a reported maximum of 43 mm (Miller, 1974). *Glaucus atlanticus*

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is characterized by a silvery-white dorsal and dark-blue ventral surface. Three distinct pairs of wing-like, single-row (uniseriate) cerata extend laterally from the elongated flat body (Valdés and Angulo Campillo, 2004). The dorsal surface of *G. marginatus* is bluish-brown, and the ventral side is bluish. The body has up to four groups of multiple rows of cerata on each side (Bergh, 1860), with the third and fourth groups being partially fused (Valdés and Angulo Campillo, 2004). Due to their oceanic neustonic lifestyle, glaucinins are only seen after being driven near the shore by winds and currents. In Taiwan, Lo *et al.* (2013) recorded individuals of *G. atlanticus* in the intertidal zone of Siao-Liouchiou Island off southwestern Taiwan. With only scarce cases of sightings or collected specimens, the behaviors of live *G. marginatus* have not been systematically observed or documented in Taiwanese waters.

This study reports observations of a group of the *G. marginatus* clade along with the hydrozoa cnidarian *Por. pacifica* that washed ashore at Hejie, Kenting National Park, southern Taiwan. In addition to a description of the site, the sea slug's behaviors, such as feeding, copulation, and egg deposition, are also presented and discussed.

## MATERIALS AND METHODS

### Study Site

In the late morning of a flood tide on April 20, 2017, more than 100 individuals of *G. marginatus*, accompanied by dozens of *Por. pacifica*, were found floating on the surface of tidal pools in an approximately 5 × 20m area of a reef shore at Hejie (21.9555°N, 120.7124°E), Kenting National Park (Fig. 1). The air temperature was 28~32 °C and the water temperature was 24~26 °C. *Glaucus marginatus* ranged 3~8 mm in body length; pneumatophores of *Por. pacifica* ranged 10~30 cm in diameter. These animals had been washed ashore by earlier on-shore southwesterly wind and waves, where they became trapped in tidal pools on the ebb tide in the afternoon. When the tide flooded again in early evening, the animals drifted offshore with the tide. The next day, only one *G. marginatus* and three *Por. pacifica* individuals were found at the site.

### Collection and Maintenance

In the field, we recorded *G. marginatus* and



Fig. 1. A scene from the study site. Individuals of *Glaucus marginatus* (yellow arrows) and a *Porpita pacifica* (red arrow, blurred by sun glare) are shown in the picture. The photograph was taken in the late morning on April 20, 2017 by Coco Liang.

*Por. pacifica* by taking photos and videos of their behaviors and surroundings. Ten individuals of *G. marginatus* (5~9 mm long) and two *Por. pacifica* (approximately 2 cm in diameter) were carefully hand-collected in plastic bags and brought on land. The animals were kept in a container with gently aerated seawater for further examination. Within 24 h after collection, all animals, except for three *G. marginatus* individuals had become inactive and weak and so were released at the original site. Specimens of the three other *G. marginatus* were preserved in 70% ethanol and are housed at the National Museum of Natural Science.

## RESULTS AND DISCUSSION

In the field, *G. marginatus* tended to drift or swim toward any object floating on the surface: debris, algae, the hydrozoan cnidarian *Por. pacifica*, as well as other congeners. When in contact with debris or algae, they began to explore with their oral tentacles and rhinophores on the front of the head. If not interested, they would stop, float in the water, and then drift away. Once they came into contact with prey, the exploring behavior soon turned into foraging (Fig. 2). The sea slug began with nibbling at its prey on the water surface and then tore the flesh apart by shaking its head or swimming backwards. Occasionally one would grasp a *Por. pacifica*

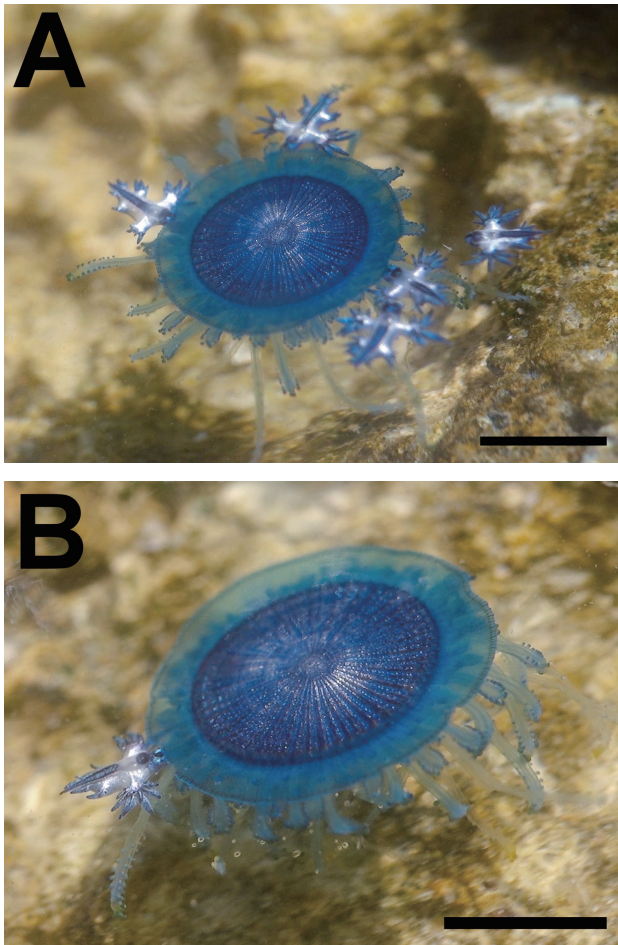


Fig. 2. Foraging behavior of *Glaucus marginatus*. (A) In a tide pool, a colony of *Porpita pacifica* being attacked by five *G. marginatus*. (B) A sea slug chomping on the pneumatophore of the prey. Scale bar = 1 cm.

with its jaws so that it was not pushed away by the waves. Foraging behavior persisted for up to 2 min, and then the predator would stop attacking the prey and drift away for a couple of minutes before it initiated another round of foraging. *Glaucus marginatus* seldom dived. They explored and attacked the prey part encountered on the water surface, preferring the pneumatophore, but seldom the gonozooids and gastrozooids beneath the pneumatophore.

In captivity, *G. marginatus* displayed more active swimming than in the field by slowly moving their bodies and cerata. When there was no prey but only congeners, one voracious *G. marginatus* tended to chomp on the cerata of others. Several victims lost most of the first cerata group of one side, which led to imbalanced swimming. Such cannibalism may occur in conditions of limited food (Bieri, 1966). Preying on others' cerata may be favored for reasons of

nutrition and armor reinforcement.

During the captive period, two *G. marginatus* individuals engaged in reciprocal copulation in a container (Fig. 3). Initially, the two sea slugs swam toward each other in a head-to-head posture and everted their penises behind the right side of the head. The couple then headed downward and twisted their bodies leftward at the same time. They appeared to avoid touching the partner's lateral body areas, where they store cnidarian nematocysts for defense. This movement also facilitated alignment of the two penises to touch each other and become intertwined. When copulating in such an unstable posture on a wavy water surface, intertwining of the penises usually ensured successful reproduction. Through the conjugated penises, each sea slug donated its sperm to the partner and received that of the partner's (Ross and Quetin, 1990). Coitus lasted approximately 1 min. One *G. marginatus* individual was observed laying a string of whitish egg capsules (Fig. 3D). Glaucinin nudibranchs lay egg strings either in the sea, or attach them onto a solid surface of a floating object, such as a prey carcass, or a piece of driftwood (Valdés and Angulo Campillo, 2004).

*Glaucus marginatus* behaviors of feeding and copulation indicated differences in resistance to nematocyst venom among the body parts. The avoidance of the lateral cerata during penis alignment implied that the ventral surface might be vulnerable to nematocyst stings (Ross and Quetin, 1990). Their jaws, however, could chomp on nematocyst-bearing tissue without triggering their discharge.

The few records (Lo *et al.*, 2013; this study) and undocumented observations of stranded glaucinin nudibranchs around Taiwan indicate that these neustonic sea slugs tend to follow their preys, including the siphonophore *Physalia physalis* and the chondrophore *Por. pacifica*. When these animals ride the central Kuroshio Current from the tropical Pacific region into the Taiwan Strait, there may be a good chance to observe these neustonic molluscs on shores of western Taiwan and the Penghu Islands.

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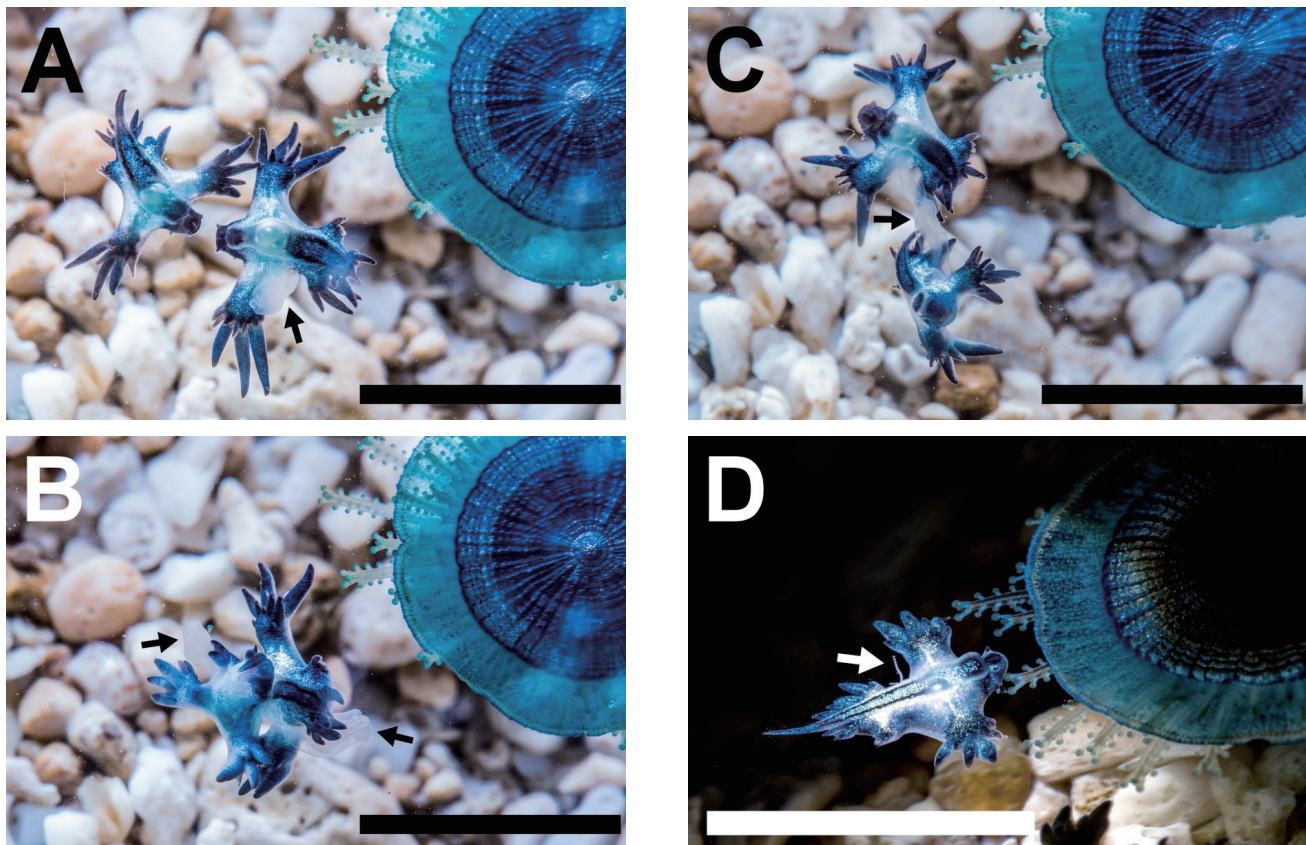


Fig. 3. Reproduction of *Glaucus marginatus*. (A) As a prelude to copulation, the couple touched each other with their jaws and oriented themselves in a head-to-head position. The penis of one sea slug had emerged (arrow) at this stage. (B) The bodies of the animals were arched and their heads downwards so that their ventral surfaces would touch. At the same time, both penises (arrows) emerged. (C) The sea slugs twisted their bodies leftward so the everted penises became intertwined (arrow). (D) A *G. marginatus* depositing a string of whitish egg capsules (arrow). Scale bar = 1 cm.

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## 墾丁合界海域的緣邊海神海蛞蝓群集觀察

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本研究報導2017年4月20日墾丁國家公園合界海岸漂浮性後鰓類緣邊海蛞蝓群聚出現記錄。當日退潮時分，超過100隻背下腹上姿態漂浮的緣邊海蛞蝓，隨著牠們的獵物，太平洋錢幣水母，在合界海岸的珊瑚礁潮池被發現。這些動物的當時周圍環境、被帶上岸觀察的海蛞蝓之覓食、交配、與產卵行為均在文中描述呈現。

關鍵詞：緣邊海神海蛞蝓、太平洋錢幣水母、合界、墾丁國家公園、台灣。