Field Observations of Group Reproduction in Gymnodoris ceylonica (Kelaart, 1858) (Gastropoda: Nudibranchia) at Lanyu (Orchid Is.), Taiwan

Hsin-Drow Huang

National Museum of Natural Science, 1 Kuan-Chien Rd., Taichung 40453, Taiwan

(Received September 14, 2010; Accepted December 6, 2010)

Abstract. Widely distributed in the Indo-Pacific area, the translucent white Gymnodoris ceylonica is moderately common and usually found in seagrass or algal zones preying on other opisthobranchs (Debelius and Kuiter, 2007; Gosliner et al., 2008). Incidentally encountered in mid-July 2009, groups of breeding G. ceylonica were observed at Lanyu (Orchid Is.), off the southeastern coast of Taiwan. At least 32 individuals occurred on a 20 × 20-m² reef flat with a sandy bottom at 4~8 m deep. Body (head-to-foot) lengths of G. ceylonica individuals ranged 50~80 mm. Over 70% of the G. ceylonica at the site were ovigerous, judged by the yellow eggs visible through their translucent body wall. During the observation of approximately 60 min, about 60% individuals mated or laid eggs. Distances between mating pairs or spawning individuals ranged 30 cm to 3 m. Mating pairs copulated with everted sex organs at the right side of the body for reciprocal fertilization. Gymnodoris ceylonica deposited light-yellowish messy egg string masses instead of the spiral bands like most other dorid nudibranchs do. At the site, no G. ceylonica was foraging; some individuals were found to be unresponsive or dead with no eggs in the body. No animal in the area fed on eggs of G. ceylonica, while some eggs may have been captured by filter feeders on the sea bottom.

Key words: nudibranch, Gymnodoris ceylonica, group reproduction, Taiwan.

INTRODUCTION

The natural history of sea slugs is an area full of unsolved mysteries. As the diving population grows and underwater photography becomes more affordable, knowledge of sea slug behavior is significantly accumulating owing to observations by divers and scientists around the world. The ecology of this diverse group is now better understood.

In the field, sea slugs of various species usually occur alone or as small groups (of fewer than ten individuals). Mass aggregations, of dozens or even hundreds of individuals occurring in proximity, are recorded in environments containing their food resources or for the purpose of breeding (Behrens, 2005; Claverie and Kamenos, 2008). Sometimes events of mass stranding or mass mortality of sea slugs were found due to pollution or unknown reasons (Rudman, 2001).

Materials and Methods

The aggregation of Gymnodoris ceylonica was witnessed at coastal Landao (22°4’45.5”N, 121°31’50.8”E) in northern Lanyu, Taiwan. The survey was conducted by scuba diving on July 11, 2009 during the slack tide between 09:00 and 10:00; the water temperature was 25 °C. At a reef flat of 4~8 m deep, at least 32 G. ceylonica within an approximately 20 × 20-m² area had congregated for reproduction. Their behavior and the morphology of the genitals and egg masses were recorded with underwater cameras. The numbers of individuals engaged in reproductive activity was counted, and the behavioral characteristics were recorded. Length
measurements were determined by measuring tapes at the site and judged from photographs.

RESULTS AND DISCUSSION

_Gymnodoris ceylonica_ is characterized by a translucent white body covered with small orange-red dots; the gills are white with an orange to red lining; the tips of the rhinophores and margin of the foot are orange.

In the surveyed area, 32 individuals of _G. ceylonica_ were found and observed. They were all adults with body (head-to-foot) lengths ranging 50–80 mm. Ovigerous _G. ceylonica_ could be recognized by the yellowish egg mass inside the translucent body (Fig. 1). In total, 24 of 32 individuals (75%) were ovigerous; among them, 19 individuals (79% of the ovigerous and 59% of all individuals) mated or deposited eggs during the survey time of approximately 60 min. The distance between mating pairs or spawning individuals ranged 30 cm to 3 m.

_Gymnodoris ceylonica_, like all other opisthobranchs, are hermaphroditic. Their sex organs, comprised of genital papillae, are located on the lateral right behind the head. When copulating, two mature _G. ceylonica_ positioned themselves head to tail, with their right sides facing each other (Fig. 2A). The everted genital papilla has two openings: one at the tip is the sperm donor (male organ) and the other lateral one accepts sperms (female duct). Once the genital papillae of the mating individuals touched, the male organ of each individual entered the female duct of the partner (Fig. 2B). At the end of copulation, the two nudibranchs moved in different directions to separate (Fig. 2C). In some cases, one nudibranch tended to twist its body causing them to be in a head-to-head position, which highly stretched the connected genital papilla (Fig. 2D). In the survey, only pair copulation by _G. ceylonica_ was noted.
After exchanging sperm and fertilization had occurred, mated *G. ceylonica* individuals were capable of laying egg masses in tangled strings. As they moved, egg strings were extruded from the oviduct opening at the right side of the animal, and deposited on the substrate (Fig. 3A). The yellowish eggs were secured by transparent mucus strings; the width of the strings ranged two to four clusters of 20~40 eggs each (Johnson and Boucher, 1983). Many opisthobranchs lay their eggs in delicate forms of coiled or spiral ribbons, which are anchored by mucus strings (Behrens, 2005). Eggs strings of *G. ceylonica*, despite some circled segments (Fig. 3B), were rather messily deposited (Fig. 3C). During the reproductive activity, *G. ceylonica* was able to copulate more than once; one individual was observed to follow its mate which was laying eggs, and then both individuals everted their genital papilla and attempted to mate again (Fig. 3D).

As to predation on other nudibranchs, *Gymnodoris* was reported to feed on several species of nudibranchs (Behrens, 2005; Gosliner et al., 2008); *Gymnodoris ceylonica* preys on the seahare *Stylocheilus longicauda* (Johnson and Boucher, 1983) and aglajid *Nakamigawaia* sp. (Nakano *et al*., 2007). At the site of the study, no *G. ceylonica* was noted to be foraging except one individual found in pursuit of prey that escaped down a crevice. There were four individuals found to be unresponsive (no reflex or obvious response when touched) or dead at the site; no eggs or mature ovaries were identified inside the body wall (Fig. 4). *Gymnodoris ceylonica* was previously observed to migrate from greater depths to a shallow reef for mating and spawning, sometimes accompanied by predation on other opisthobranchs (Johnson, 1999). Since at the site of this study, there were no signs of prey of *G. ceylonica*, these opisthobranch predators might not have been attracted by food sources and possibly died of starvation at the end the journey of no return.

![Fig. 3. Egg deposition of *Gymnodoris ceylonica*. (A) An egg-laying individual. (B) and (C) Egg strings deposited by *G. ceylonica*. (D) When depositing eggs, an individual tended to copulate with another one. Photo provided by H.-T. Hung.](image1)

![Fig. 4. An unresponsive *Gymnodoris ceylonica* lying on its side at the site. Such unresponsive and dead individuals contained no eggs or mature ovaries inside the bodies.](image2)
Due to the loose deposition, eggs of *G. ceylonica* were apt to become loose and scattered on the substrate. The eggs did not attract egg predators to the site during the observation period. Opisthobranch mollusks tend to deposit unpalatable eggs that taste caustic or even toxic (e.g., Pawlik *et al.*, 1988; Pennings 1994). Such characteristics may protect eggs of *G. ceylonica* from predators. Some eggs, however, were found inside filter-feeding ascidians nearby (Fig. 5).

This photographic evidence reveals the group mating and spawning of *G. ceylonica* as described by Johnson (1999). The present observations indicate that *G. ceylonica* may migrate to shallow water by following conspecifics; at the site, they engage in mating and spawning. *Gymnodoris ceylonica* may forage if prey is available. If not, they may starve to death before they can migrate elsewhere.

So far, the life history of *G. ceylonica* remains unclear, because the observations of their habits and behaviors are based upon occasional encounters when diving. Fortunately affordable underwater photographic equipment and internet availability mean that fragmented information can be communicated among diving groups and biologists. Therefore, such observations and information can be further integrated to complete the puzzle of understanding their life history.

**ACKNOWLEDGEMENTS**

I thank H.-T. Hung of the National Museum of Natural Science for providing photographs used in this paper. I am also grateful for the valuable comments and suggestions by Prof. M. H.-K. Mok and Mr. W.-B. Jie. The survey was partially supported by a grant (NSC97-2621-B-178-002-MY3) from the National Science Council, Taiwan.

**REFERENCES**


蘭嶼海域錫蘭裸海蛞蝓的群集生殖行為

黃興倬
國立自然科學博物館動物學組

廣泛分佈於印度—太平洋珊瑚礁海域的錫蘭裸海蛞蝓棲息於海草或藻類生長區，以其他後鰓類海蛞蝓為食。本研究報導在台灣海域錫蘭裸海蛞蝓群集生殖行為的首次紀錄。2009年7月中旬，在蘭嶼東岸近岸海域水深4–8公尺處，超過32隻錫蘭裸海蛞蝓個體（頭足圍長度範圍50–80公釐）在約20 × 20平方公尺範圍內進行交配與產卵。現場超過70%的個體體內含有淺黃色的卵；在將近60分鐘的調查活動中，約有60%的海蛞蝓正在進行交配或產卵。配對的個體伸出位於身體右側的交接器相互將精子注入對方體內。受精後，錫蘭裸海蛞蝓一面移動一面產下隨意交纏的淡黃色卵絲圈。在調查期間，並沒有發現海蛞蝓進食的行爲；少數無反應或是死亡的個體橫陳在淺處，體內沒有明顯的卵或生殖腺。當場沒有其他動物攝食海蛞蝓的卵團，但在附近度食性海鞘體內發現少量的卵。

關鍵詞：裸鰓類、錫蘭裸海蛞蝓、群集、生殖行為、台灣