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LATE INSTAR CATERPILLAR AND METAMORPHOSIS OF *SPODOPTERA PICTA* GUÉRIN-MÉNEVILLE (LEPIDOPTERA: NOCTUIDAE: NOCTUINAE) WITH NOTES ON ITS CANNIBALISTIC BEHAVIOUR

W. F. Ang[*], S. Teo, Alvin Francis S. L. Lok, S. M. Suen and **Beatrice Y. Q. Ng**
Department of Biological Sciences, National University of Singapore
14 Science Drive 4, Singapore 117543, Republic of Singapore
([*]Corresponding author: weefoong@nus.edu.sg)

INTRODUCTION

Spodoptera is a moth genus that belongs to the tribe Prodeniini, in the subfamily Noctuinae of the family Noctuidae (see Lafontaine & Schmidt, 2010). *Spodoptera* is a cosmopolitan genus with species distributed across all continents. Some common species include *Spodoptera eridania* (America), *Spodoptera exigua* (Southeast Asia, and America), *Spodoptera frugiperda* (America), *Spodoptera littoralis* (Mediterranean Europe, and Africa), and *Spodoptera litura* (Asia, and Australia) (Brown & Dewhurst, 1975; Capinera, 2005; Capinera, 2006; Capinera, 2008; Herbison-Evans & Crossley, 2009a). This genus consists of a high proportion agricultural pests that feed on a wide range of economically important crop species such as cassava (*Manihot esculenta*), oil palm (*Elaeis* species), and cereals (members of the family Poaceae) (Holloway et al., 2001). *Spodoptera picta* (Fig. 1), has gained importance as a horticultural pest as more of its host plant species such as *Crinum asiaticum*, *Crinum pendunculatum*, and *Clivia miniata* (members of the family Amaryllidaceae) are becoming popular ornamental plants for urban plantings. These voracious caterpillars are known to "easily eat a plant to the ground" (Pendlebury, 1947). It has a distributional range in the Indo-Australian tropics, China, and Japan and is also the largest of its genus in Borneo (Holloway, 1989; Wang, 1996; Chen, 1999).

Fig. 1. Final instar caterpillar of *Spodoptera picta* resting on a *Crinum asiaticum* leaf. The body length of the caterpillar measured 46 mm. (Photograph by: Si Min Suen).

SPECIMEN DETAILS

On 22 Oct.2009 (ca. 0930 hours), while doing a routine nursery work in the Native Plant Demonstration Garden at the Department of Biological Sciences, National University of Singapore, several *Crinum asiaticum* plants were found to be badly damaged by leaf herbivores. Initially, three caterpillars were spotted feeding on the inflorescence of a *Crinum asiaticum* plant. However, upon closer examination, more caterpillars were found hiding on the underside of the leaves, in the crevices between the leaf base and the stem, and also within the folds of the terminal leaf. Subsequently, based on the fecal trails scattered on the leaves and ground, more caterpillars were found on the adjacent *Crinum asiaticum* plants. Sixteen individuals were collected for ex situ rearing and observation, while the rest were killed using a common commercial insecticide, Malathion™ to prevent further damage to the leaves. The morphology of the larva was compared against literature and subsequently identified as *Spodoptera picta.* The distinctive and diagnostic features of the larva were the thick, prominent, yellow line that runs along the whole dorsum, a black band that traverses under the yellow streak near the head capsule and also the black and white markings on both sides of the dorsal, yellow line (Fig. 1). These features matched those given in Herbison-Evans & Crossley (2009b), and Sevastopulo (1939).

The caterpillar continued to feed on the leaves of the host plant when reared in captivity. Its body measured 46 mm long × 5 mm wide and was glabrous (Fig. 1). On the dorsal side and flanks of the body, a distinctive bright yellow line extends from the posterior to the red head capsule, terminating just behind it (Fig. 2). A prominent, transverse, black strip was observed beneath the dorsal yellow line at the first abdominal segment. Between the dorsal and the lateral yellow lines were several black and white markings. The white markings adjacent to the dorsal yellow line were irregularly-patterned, while those below it formed two distinct white lines against a black base that extend the whole length of the body. As characteristic of Noctuidae caterpillars, three pairs of legs were joined to each of the three thoracic segments while the 3rd, 4th, 5th, 6th, and 10th (last) abdominal segments each possessed a pair of prolegs (fleshy false legs) (Maier et al., 2004).

Fig. 2. Anterior view of the last instar caterpillar. The yellow dorsal and lateral lines can be seen extending to the region just behind the red head capsule. (Photograph by: Si Min Suen).

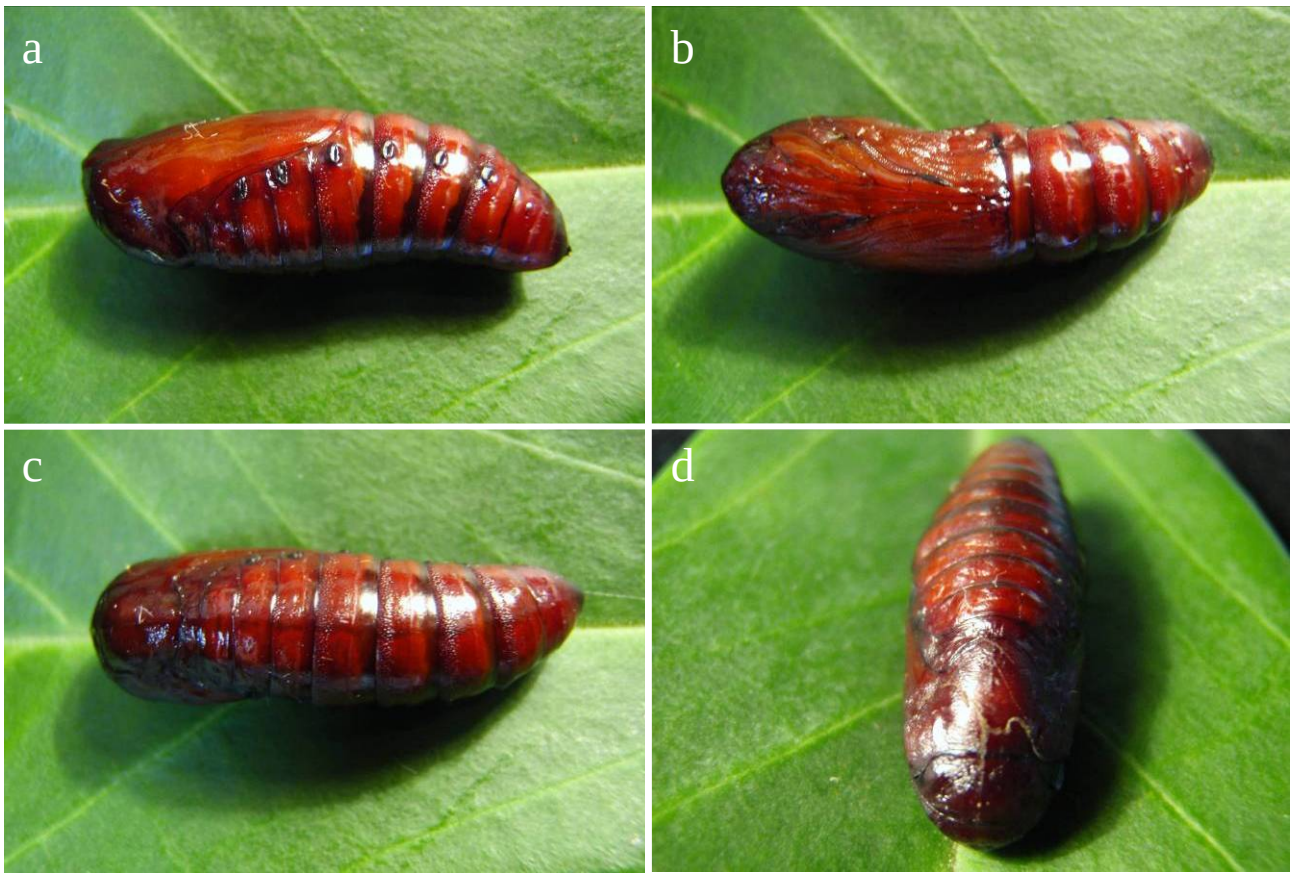

Fig. 3. (a) Lateral, (b) ventral, (c) dorsal, (d) and anterior views of the *Spodoptera picta* pupa. During this stage, the pupae are capable of wriggling when disturbed. The average length and width of the pupae were 20 mm and 6 mm, respectively. (Photographs by: Wee Foong Ang).

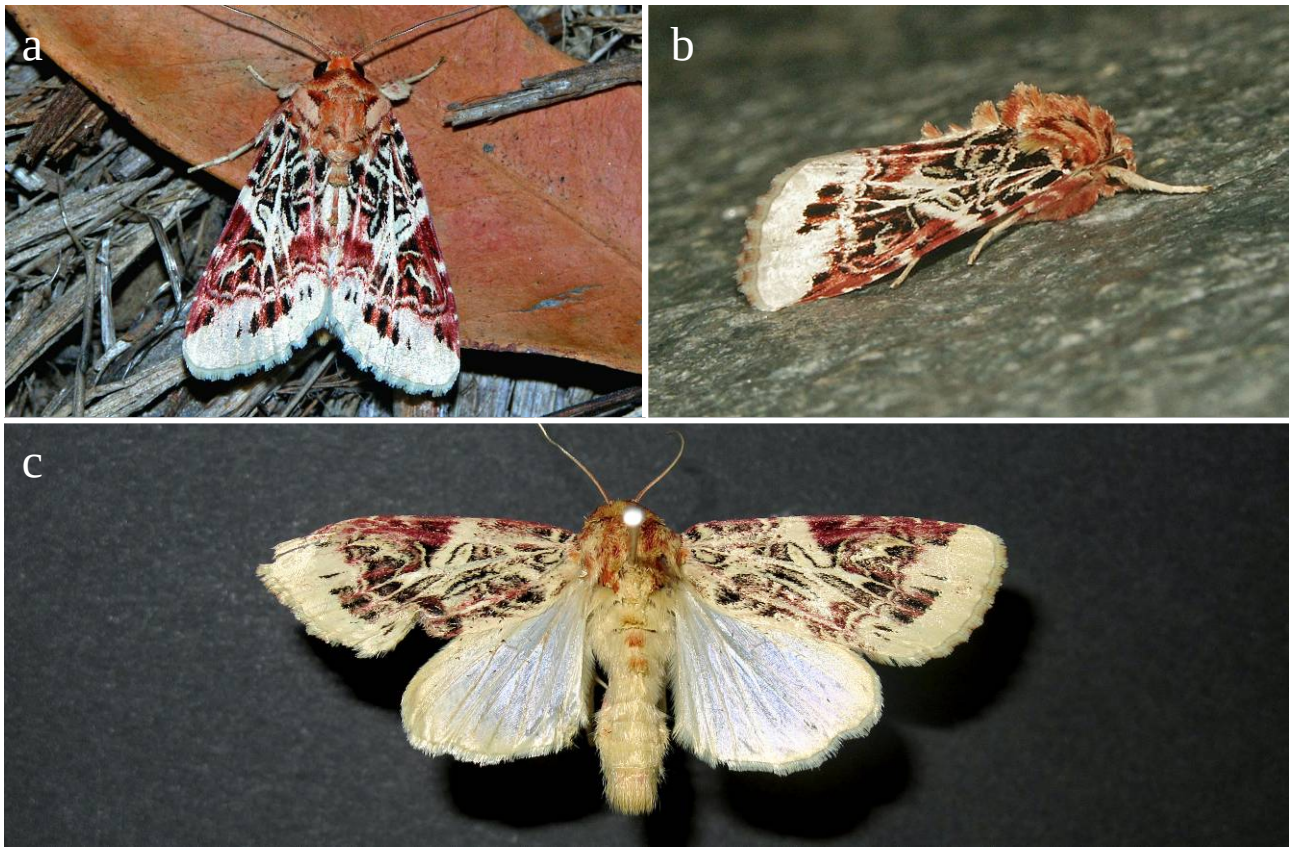

Fig. 4. (a) Dorsal and (b) lateral views of the adult *Spodoptera picta* in Queensland, Australia. (Photographs by: Buck Richardson). (c) The mounted specimen of the adult that emerged on 15 Nov.2009. (Photograph by: Siyang Teo).

The caterpillars pupate four to eight days later under the shelter of *Crinum asiaticum* leaves. When pupating, the caterpillar compresses its body laterally, with each thoracic and abdominal segment becoming more pronounced. Overall, the prepupa caterpillar shortens in length. The pupae on average are about 20 mm long by 6 mm wide, encapsulated in a shiny, honey-brown, glabrous, hard casing (Fig. 3). After two days, the colour of the pupae was observed to turn darker into rosewood-brown. Holloway (1989) described that the pupation is "subterranean in an earthen cocoon", indicating that the caterpillars burrow underground into the soil around the host plant before going into pupation. When disturbed, the pupae were observed to wriggle its abdominal segments in response.

Three weeks later, the adult moths emerged from the earthen cocoons on 15 Nov.2009. The moths measured 23 mm in length and had a maximum width of 18 mm. Its head, thorax, and abdomen were covered with brown, hair-like scales (Fig. 4). The forewings, like all other species of the genus, are more strikingly patterned than the hindwings which are pale yellow. Each forewing has an intricate pattern that consists of a mixture of dark red, brown, and black markings on a pale yellow background (Fig. 4). One adult (ZRC.LEP.253, forewing length: 20 mm) and one larva (ZRC.LEP.254) were preserved as voucher specimens in the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research (RMBR), National University of Singapore.

Fig. 5. Late instar caterpillars of *Spodoptera picta* cannibalising a pupae (middle top) and a pupating caterpillar (bottom right). (Photograph by: Alvin Francis Siew Loon Lok).

DISCUSSION

Amaryllidaceae species, which are host plants of *Spodoptera picta,* are known to produce toxic Amaryllidaceous or lycorine-type alkaloids that are unique to this family (Geerinck, 1993). It is recorded that *Polytela gloriosae* (Noctuidae: Glottulinae), a moth that is specialised in feeding Amaryllidaceae species, has co-evolved with its host plants in that it sequesters the compounds in its body for defensive purposes, while the host plant responds to this herbivory stress by releasing more alkaloids (Geerinck, 1993). For *Spodoptera picta* and some species of the Glottulini tribe that feed on Amaryllidaceae species (e.g., *Brithys crini*, and *Xanthopastis timais*, and *Diaphone eumela*) (Robinson et al., 2009), these caterpillars must be able to metabolise or sequester the alkaloids produced by the host plant. Sequestration of such toxic compounds from the host plant in the caterpillar's body makes it unpalatable and renders protection against predators (Nishida, 2002).

In captivity, the caterpillars fed voraciously on the leaves of *Crinum asiaticum*, finishing about one large leaf (approximately 103 cm × 11 cm, tapering towards the tip) within two days. On 26 Oct.2009, one caterpillar was observed to have pupated under a mass of *Crinum asiaticum* leaves. The caterpillars and the pupae were then removed from the tank and placed in a small plastic container while a routine tank clean-up was carried out to remove fecal matter and replace food leaves. The authors observed that in the absence of the food plant, the foraging caterpillars began to congregate around the pupae and cannibalise it (Fig. 5). Initially, the pupae wriggled its abdomen but stopped subsequently while the other caterpillars continued feeding on it. Another caterpillar that was in the process of pupating was not spared either (see video clip).

Cannibalism has been reported in some Lepidoptera families, such as Lycaenidae (e.g., *Eumaeus minyas*) (Castillo-Guevara & Rico-Gray, 2002), Nymphalidae (e.g., *Danaus plexippus*) (Zalucki & Kitching, 1982) and Pieridae (e.g.,e.g. *Ascia monuste*) (Zago-Braga & Zucoloto, 2004), with many occurring in Noctuidae such as *Utetheisa ornatrix* (Bogner, 1996), and within the genus *Spodoptera* (Wagner et al., 2009). Most of this observed phenomenon in Noctuidae is considered as "facultative cannibalism" whereby the caterpillars predate on other caterpillars (either of other species or cannibalism of same species) or small insects, most likely under conditions whereby there is a supply shortage of the food plant, or a risk of being predated upon in movement to another feeding site. In the congeneric species, *Spodoptera frugiperda*, cannibalism among caterpillars has been well-documented and studied (e.g., Morrill and Greene, 1973, Raffa, 1987; Chapman et al., 1999a; Chapman et al., 1999b; Chapman et al., 2000). Chapman et al. (1999a, b) observed that this behaviour incurred heavy costs in terms of lower survival and development rate, lower body weight and the risk of obtaining lethal viruses from their conspecifics. However, Chapman et al. (2000) found in his field experiments that predators of *Spodoptera frugiperda* larvae were more abundant on medium and highly defoliated plants. From this result, the authors proposed that cannibalism can confer direct benefits (i.e., reduce predation) as cannibalism reduces the conspicuousness from visual or chemical cues because there are less larvae to be seen or detected, respectively. Some other possible hypotheses are that it helps to reduce potential predators or act as an alternative food source during food-scarce conditions. The observed behaviour in *Spodptera picta* might thus confer similar functions.

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