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RECORDS AND NATURAL HISTORY OF THE OCELLATED SHIELD BUG, *CANTAO OCELLATUS* (THUNBERG) IN SINGAPORE, WITH OBSERVATIONS ON EGG GUARDING, HATCHING, PARASITOIDS, MOULTING, FEEDING, AND MATING (HEMIPTERA: SCUTELLERIDAE: SCUTELLERINAE)

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ABSTRACT. — Historical and recent records of the ocellated shield bug, *Cantao ocellatus* (Thunberg) are consolidated for Singapore, based on museum specimens and extensive field observations. The major aspects of their natural history and behaviour were documented, with corresponding photographs and videos. Significant events described and illustrated here include: (a) maternal guarding of egg clutches, (b) simultaneous hatching of first instars, (c) attack by parasitoid wasps, (d) moulting of various nymphal instars, (e) feeding preferences, and (f) mating behaviour.

KEYWORDS. — *Cantao ocellatus*, Scutelleridae, natural history, *Mallotus paniculatus*

INTRODUCTION

Bugs in the genus *Cantao* belong to the tribe Scutellerini within the subfamily Scutellerinae, and is represented by four valid species with a broad Australasian distribution (Kumar, 1965; McDonald, 1988). The four recognised species are: (i) *Cantao parentum* (White), (ii) *Cantao pupuratus* (Westwood), (iii) *Cantao variabilis* Montrouzier, and (iv) *Cantao ocellatus* (Thunberg) (McDonald, 1988). The ocellated shield bug, *Cantao ocellatus*, is characterised by symmetrical arrangements of dark spots encircled by light ocelli on its prothorax and mesoscutellum, which can have a background colour ranging from dull yellowish beige to bright orange red. At rest, the wings are concealed and protected underneath the mesoscutellum, which also covers the entire dorsum of the abdomen. This shield-like extension is analogous to the elytra of beetles (order Coleoptera). Its pair of well developed wings is only exposed when in flight (Fig. 1).

Fig. 1. Dorsal view of adult female ocellated shield bug, *Cantao ocellatus* (Thunberg), with wings outspread. Specimen collected from Kent Ridge on 9 Dec.2011 (ZRC.6.23215, total length: 23 mm).

The species has been recorded from Pakistan, India, Sri Lanka, Bangladesh, Myanmar, Thailand, Vietnam, Malaysia, Indonesia, Philippines, Papua New Guinea, Tibet, China, Taiwan, and Japan (Distant, 1902; McDonald, 1988). A number of species names have become subsequently synonymised under the original, including, most recently, *Cantao pakistanensis* Ahmad & Kamaluddin (McDonald, 1988; Tsai & Rédei, 2010).

LOCAL RECORDS AND DISTRIBUTION

For Singapore, the earliest record of *Cantao ocellatus* dates back to Dec.1916, when a single female specimen was collected from Fort Canning (see: Material Examined—Table 1). Since then, the representation of this species has only grown at a modest pace, with sporadic contributions from various collectors. Between Sep.2011 and Feb.2012, a localised population of these bugs was closely monitored at Kent Ridge, National University of Singapore. They were consistently found on the native plant, balek angin, *Mallotus paniculatus* (family Euphorbiaceae), which is one of their known host plants (Fig. 2). Small populations of this bug have also been encountered along secondary forest edges at Admiralty Park, Bukit Batok Nature Park, Ang Mo Kio Town Park, Mount Faber, Mandai Road, Dover Road, Holland Road, and Winchester Road, always associated with *Mallotus paniculatus*. Other known hostplants for *Cantao ocellatus* include: *Trewia nudiflora*, *Macaranga roxburghii*, *Mallotus japonicus* (all in the Euphorbiaceae), and *Camellia sasanqua* (Theaceae; Distant, 1902; Ayyar, 1920; McDonald, 1988; Kaiwa et al., 2010).

EGG GUARDING

In the field, females usually attached their eggs onto the undersides of leaves, but in well-shaded areas, eggs may also be plastered onto the upper surface of leaves. Freshly laid eggs (ca. 2 mm × 1 mm) are ivory white and closely arranged to form a hexagonal disc (Fig. 3). The egg clutch size can range between 50–100 eggs, based on local observations. Ayyar (1920) reported an upper limit of 150 eggs per clutch. The mother positions herself over this clutch day and night, never leaving to feed. On a regular basis, the mother performs a wiggling ‘dance’ over the eggs, swaying its body from left to right vigorously, as if it were polishing the eggs. A video clip of this behaviour was recorded in Sep.2011 at Kent Ridge and subsequently uploaded (http://www.youtube.com/watch?v=TA990laY0Lo). This motion is most likely a deterrent against potential wasp parasitoids that target hemipteran eggs. Parental care in the Hemiptera has been recorded in at least 74 genera (31 Homoptera, 43 Heteroptera), belonging to 19 families (Tallamy & Schaefer, 1997). The purpose of maternal care is to protect eggs against parasitoids, as well as predators. Within the subfamily Scutellerinae, females of the genera *Cantao* and *Augocoris* are known to guard large clutches of eggs that have been glued onto leaves.

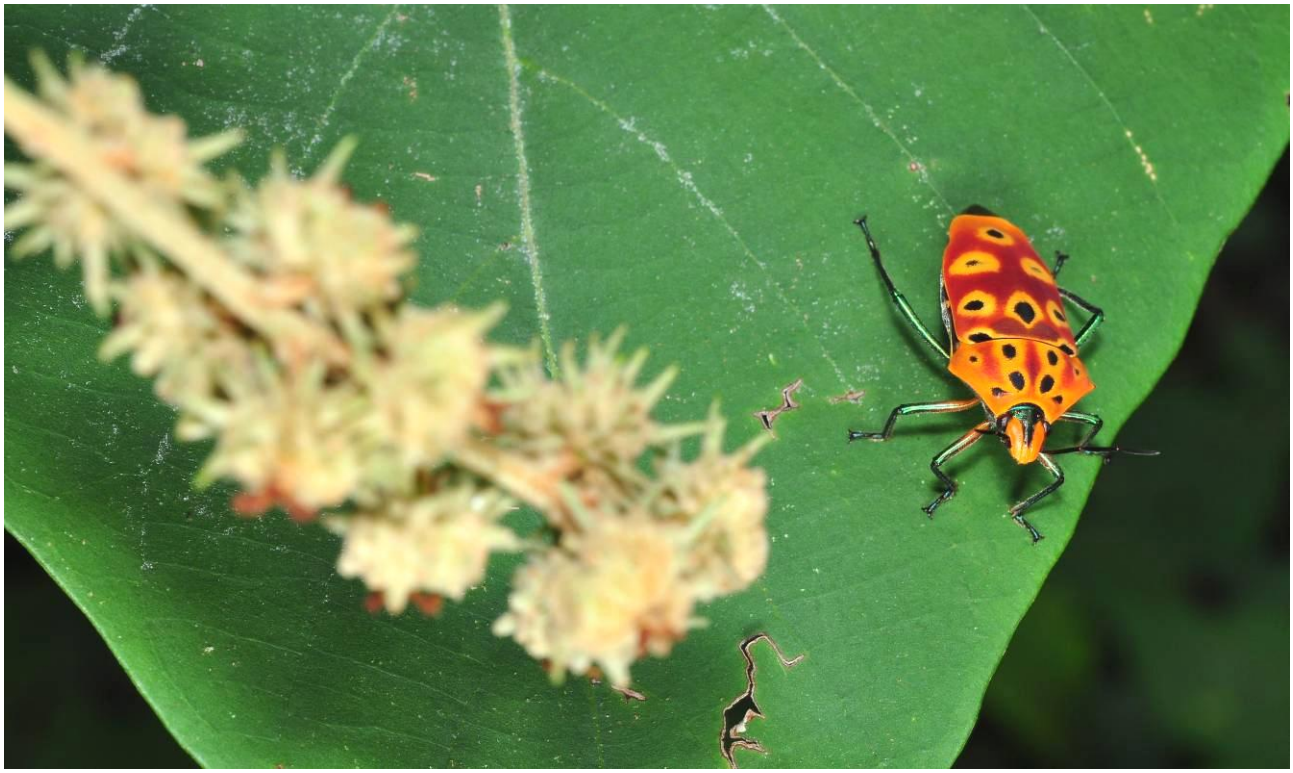

Fig. 2. The majority of recent sightings of *Cantao ocellatus* in Singapore have consistently been on the native balek angin tree, *Mallotus paniculatus* (Euphorbiaceae). This specimen was photographed at Kent Ridge on 28 Sep.2011.

Fig. 3. Dorsolateral view of female bug (total length: 22 mm) guarding a recently laid clutch of eggs attached to the underside of a *Mallotus paniculatus* leaf at Kent Ridge (28 Sep.2011). This female would sway its body sideways over the egg clutch periodically.

HATCHING

As the eggs develop, they progressively turn orange, becoming darker as hatching time draws nearer. Hatching often occurs between five to six days after oviposition. Upon emergence from their egg cases, the first instar nymphs huddle together to form a bright orange mound. The freshly hatched nymphs are about 2 mm in length. The mother continues to guard over them with its elevated body (Figs. 4–6). A video clip of this was recorded at Kent Ridge in Oct.2011 and subsequently uploaded (http://www.youtube.com/watch?v=s9Nopg_qAYI).

Fig. 4. Dorsal view of two females encountered at Admiralty Park on the night of 19 Oct.2011. The egg clutch of the female on the right has matured, while that on the left has recently hatched.

Fig. 5. Dorsolateral view of females (as in Fig. 4) to show recently hatched nymphs (total length ca. 2 mm) being guarded by female at left.

Fig. 6. Ventral view of female protecting first instar nymphs at Winchester Road on 24 Oct.2011.

EGG PARASITOIDS

When the first instar nymphs appear, it may be noticed that not all the eggs had successfully developed and hatched. Very often, a number of eggs along the periphery of the clutch may acquire a greyish brown colour, visible through the translucent egg cases. These darker colours provide indication that they have fallen victim to tiny parasitoid wasps, such as *Telenomus* species (family Scelionidae). These can often be seen as the adult wasps (2 mm long) linger around the abandoned egg cases, waiting for a mate (Fig. 7).

Fig. 7. A parasitoid wasp, *Telenomus* species (arrowed, total length ca. 2 mm), lingers around the abandoned egg cases of *Cantao ocellatus* post-hatching. Photographed at Kent Ridge on 15 Oct.2011.

MOULTING

Approximately three days after hatching, the nymphs begin to moult to their second instar, still being guarded by their mother (Fig. 8). This usually happens in the morning, and by evening time the second instar nymphs would have already changed colour. Their head, thorax, and limbs would have turned glossy black, while the abdomen would be deep red with black bars. At this point, they begin their departure from the security of maternal protection and travel gregariously to the outer reaches of the hostplant (Figs. 9, 10). In Oct.2011, a video clip of the second instar nymphs leaving their mother was recorded at Kent Ridge in the evening hours. This was subsequently uploaded (http://www.youtube.com/ watch?v=g1T4k99uPaw). At this stage, their proboscis is relatively long in comparison with their body length and the tip can be seen protruding beyond the abdomen.

Over the course of two to three weeks, the nymphs continue to moult, move, feed, and rest together right up till their fifth and final instars, when they would have acquired a total length of 12–15 mm (Fig. 11). They have a striking appearance as their head and thorax are black with a metallic green sheen, while the abdomen is a brilliant orange with shiny black dots and bars. During their final moult to the adult stage, they emerge head-first from the exuvia and appear as a truncated bug, exhibiting a uniform orange body with pinkish limbs and antennae (Fig. 12). Approximately one hour later, the fresh emergent would have acquired a deeper tone of orange, with initial signs of the spots and ocelli appearing on its prothorax and mesoscutellum (Fig. 13). The limbs and antennae would have also become deep purple.

Fig. 8. Close-up of nymph in the process of moulting to its second instar (arrowed). Photographed at Kent Ridge on the morning of 15 Oct.2011.

Fig. 9. Second instar nymphs (total lengths: 3–4 mm) in the process of leaving their mother (as in Fig. 8). Photographed at Kent Ridge on the evening of 15 Oct.2011.

Fig. 10. Close-up of second instar nymphs (as in Fig. 9) as they travel gregariously away from their hatching site. Photographed at Kent Ridge on the evening of 15 Oct.2011.

Fig. 11. Fifth instar nymphs (total lengths: 12–15 mm) resting on a young leaf of *Mallotus paniculatus*. Photographed at Kent Ridge on 2 Oct.2011.

Fig. 12. Final moult to the adult phase, observed at Kent Ridge on 9 Oct.2011 (0940 hours).

Fig. 13. By 1030 hours, the newly eclosed bug (as in Fig. 12) had begun to exhibit faint, but discernible patterns on its dorsum.

FEEDING

Field observations of feeding have consistently been on the fruits of *Mallotus paniculatus*, where adults and nymphs may be seen sharing this relatively abundant resource (Fig. 14). With careful manoeuvering, the proboscis is employed to pierce and penetrate the fruit, in order to extract the juices within (Fig. 15). This is often accompanied by up and down movements of the head, as the proboscis is gradually inserted deeper into the flesh of the fruit. A video clip of this feeding activity was recorded in Sep.2011 at Kent Ridge and subsequently uploaded (http://www.youtube.com/watch?v=cDC4pL0Sv90).

Fig. 14. Lateral views of adult (left) and nymph (right) feeding on the fruits of *Mallotus paniculatus* at Kent Ridge (11 Oct.2011).

Fig. 15. Lateral close-up of adult feeding on fruit (as in Fig. 14).

MATING AND SEXUAL DIMORPHISM

A number of mating pairs were encountered at Kent Ridge, whereby the male and female were adjoined at the terminal segment of their abdomens (Figs. 16, 17). The male's mobile pygophore would be securely attached to the female genitalia and the pair would either remain motionless in one location or crawl about clumsily in this formation. A video clip of a colourful, mating pair was recorded in Oct.2011 at Kent Ridge and subsequently uploaded (http://www.youtube.com/watch?v=mFctzIbbjOA). Mating can be a prolonged affair and has been known to last up to 36 hours (Ayyar, 1920).

In terms of sexual dimorphism, there are no noticeable differences in colour patterns or markings on the dorsum. However, there is a distinct difference in size, with males generally smaller than females by ca. 18% among the local specimens examined. Based on measurements of available adult specimens (reflected in Table 1), the mean total length of males was calculated to be 19.2 mm (range: 16–23 mm, n=19), while that of females was 22.7 mm (range: 20–25 mm, n=19). This size difference had been recognised earlier by Ayyar (1920), who also pointed out that female bugs have the tendency to exhibit more bluish black spots on the ventral side of their abdomen. The trend of smaller males was also consistently reported by McDonald (1988). The genitalia of both male and female, as well as the associated internal reproductive organs have previously been described and illustrated in fine detail by McDonald (1988: Figs. 4–11).

FURTHER RESEARCH

In Singapore, encounters with *Cantao ocellatus* have not been year-round, but predominantly within the period from September to February. Collection dates from earlier specimens also fall largely within this period (Table 1). However, based on accounts from India, this bug only appears between April to July (Ayyar, 1920). Hence, it would be interesting to further explore the seasonality of this species in other parts of its geographic range and determine the extent to which it may be migratory. A female specimen (ZRC.6.22182) collected at Horsburgh Lighthouse provided us with a clue to its flying capabilities, which probably should not be underestimated.

Recently, the wing coupling mechanisms in 19 species (belonging to 19 genera) of Afrotropical Scutelleridae were examined in an attempt to explore the phylogenetic significance of such morphological modifications (Czaja, 2012). Subsequent attempts to focus on such structures in Asian and Southeast Asia scutellerids (including *Cantao*) might help to shed light on the relationships and lineages between genera and species in this region.

Fig. 16. Lateral view of mating pair (male on top, female below) observed at Kent Ridge on 2 Oct.2011.

Fig. 17. Dorsal view of mating pair (male on top, female below, as in Fig.16).

Other than *Cantao ocellatus*, other hemipteran species also demonstrate a close affiliation with *Mallotus paniculatus*, such as *Physopelta gutta* (Burmeister), belonging to the subfamily Physopeltinae within the family Largidae. On a number of occasions, individual examples of this bug were found feeding on the fruits of balek angin, alongside *Cantao ocellatus*. The bugs have total lengths between 12–14 mm, and may be recognised by distinct black markings on their thorax and wings, over a pinkish orange background (Fig. 18). The most prominent pattern is a pair of attractive, closely spaced black spots in the middle of the forewing. The limbs are black and the antennae are black with whitish terminal segments. Representative voucher specimens of this bug were collected for reference (see: Material Examined—Table 2). *Physopelta gutta* has a broad distribution throughout South and Southeast Asia, from Sri Lanka to the Malay Archipelago, adjacent areas of the Palaearctic region, east to Papua New Guinea and Australia (Rédei et al., 2009; Voigt, 2006). Its hostplant has been reported as *Mallotus* species (Euphorbiaceae) (Rédei et al., 2009). In the field, *Physopelta gutta* was not found in great abundance (two to three individuals at any one time) and probably does not present any substantial competition for food with *Cantao ocellatus*.

Having witnessed the intimate dependence of *Cantao ocellatus* on *Mallotus paniculatus* as a preferred hostplant in Singapore, we have seen how much colour and vibrancy such bugs contribute to the habitats. Indeed, balek angin has been recommended as one of the many species of native plants that are worthy of being propagated and promoted locally (Tan & Morgany, 2001: 96–97). Perhaps concerted efforts to grow this plant in gardens and parks may encourage visits by the ocellated shield bug, which would enhance the insect diversity and beautify such green spaces.

Fig. 18. Dorsal view of *Physopelta gutta* (total length: 14 mm) feeding on the fruit of *Mallotus paniculatus* at Kent Ridge on 9 Oct.2011.

MATERIAL EXAMINED

Table 1. Specimens of *Cantao ocellatus* from Singapore deposited at the ZRC, RMBR. TL = Total Length (mm); NUS = National University of Singapore.

S/No.	ZRC.6.	quantity/sex	TL	Locality	Collected by	Date
1.	22181	1F	23	Fort Canning	Ahmat	23 Dec.1916
2.	22182	1F	24	Horsburgh Lighthouse	P. M. de Fontaine	12 Oct.1921
3.	22183	1F	23	Bukit Timah	C. M. Yang	17 Apr.1987
4.	22185	1M	19	'Singapore'	?	1 Sep.1976
5.	22186	1F	23	Geylang, house	YTK	22 Oct.1976
6.	22187	1F	23	Pasir Panjang coast	D. H. Murphy	20 Dec.1976
7.	22188	2M 2F	21, 21 22, 24	Kent Ridge, on *Mallotus paniculatus*, in large numbers	C. P. Khow	29 Sep.1989
8.	22189	1M 1F 5 nymphs	20 23 5–11	NUS, Kent Ridge, on *Mallotus paniculatus*	T. M. Leong	late Sep. to early Oct.2011
9.	22190	5 exuviae of last nymphal instar	—	NUS, Kent Ridge, on *Mallotus paniculatus*	T. M. Leong	6 Oct.2011
10.	22191	5M	16–20	NUS, Kent Ridge, on *Mallotus paniculatus*	T. M. Leong	Mid Oct.2011
11.	22193	1F	25	Admiralty Park, sheltering from rain under leaf	T. M. Leong & B. P. Y-H. Lee	19 Oct.2011
12.	22194	4M 3F	18–19 21–24	Mount Faber, on *Mallotus paniculatus*	T. M. Leong	21–22 Oct.2011
13.	23203	3 clutches of hatched eggs	—	Holland Road, on undersides of leaves of *Mallotus paniculatus*	T. M. Leong	28 Oct.2011
14.	23204	1M 1F	17 21	Winchester Road, on *Mallotus paniculatus*	T. M. Leong	24 Oct.2011
15.	23205	1F	21	Dover Road, on *Mallotus paniculatus* growing on slope beside road	T. M. Leong	27 Oct.2011
16.	23206	1 clutch of hatched eggs	—	Mandai Road, underside of leaf of *Mallotus paniculatus*	T. M. Leong	3 Nov.2011
17.	23209	1M	19	NUS, Kent Ridge, on *Mallotus paniculatus*	T. M. Leong	8 Nov.2011
18.	23215	1M 4F	18 20–24	NUS, Kent Ridge, on *Mallotus paniculatus*	T. M. Leong	9 Dec.2011
19.	23216	1M	21	Depot Road	W. H. Koo	3 Jan.1990
20.	23217	1M 1F	23 21	Rifle Range Road, on *Mallotus paniculatus*	H. H. Tan	11 Feb.1995
21.	23218	1M	21	NUS, Kent Ridge, on *Mallotus paniculatus*	T. M. Leong	6 Jan.2012

Table 2. Specimens of *Physopelta gutta* from Singapore deposited at ZRC, RMBR. TL = Total Length (mm); NUS = National University of Singapore.

S/No.	ZRC.6.	quantity/sex	TL	Locality	Collected by	Date
1.	22192	1F	14	NUS, Kent Ridge, feeding on fruit of *Mallotus paniculatus*, alongside *Cantao ocellatus*	T. M. Leong	9 Oct.2011
2.	23207	1F	14	Mandai Road, feeding on fruit of *Mallotus paniculatus*	T. M. Leong	3 Nov.2011
3.	23214	1M	12	Upper Peirce Reservoir, on *Mallotus paniculatus*	T. M. Leong	24 Dec.2011

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