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RECORDS OF THE CICADA, *CHREMISTICA UMBROSA* (DISTANT, 1904) IN SINGAPORE, WITH ACCOUNTS OF ITS MASS EMERGENCE (HOMOPTERA: CICADIDAE: CICADINAE)

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INTRODUCTION

The cicada genus, *Chremistica* Stål, 1870 has a predominant Southeast Asian distribution, with a few species recorded from China, Taiwan, and Sri Lanka (Chen, 2004; Salmah, Duffels & Visser, 2005; Salmah, Duffels & Zaidi, 2005; Sanborn et al., 2007; Lee, 2008). To date, at least 24 species are recognised in this genus, with a considerable number of new species having been described only in the last decade, and potentially more that await further examination and formal description (Salmah, Duffels & Visser, 2005; Sanborn et al., 2007). In Singapore, three species of *Chremistica* are known to occur thus far, based on field observations, museum specimens and available literature (Zaidi & Ruslan, 1997; Salmah, Duffels & Visser, 2005). These include: (i) *Chremistica nesiotes* Breddin, 1905, (ii) *Chremistica pontianaka* (Distant, 1888), and (iii) *Chremistica umbrosa* (Distant, 1904). Here, we preview the existing records for *Chremistica umbrosa* in Singapore, and highlight events of synchronous emergence at the Labrador Nature Reserve. Additional natural history observations include bioacoustics, communal feeding, fluid discharge and accounts of predation. The geographic distribution of *Chremistica umbrosa* includes the southern Malay Peninsula, the east coast of Sumatra, Banka Island, and a few islands along the southern Straits of Malacca (Salmah, Duffels & Visser, 2005).

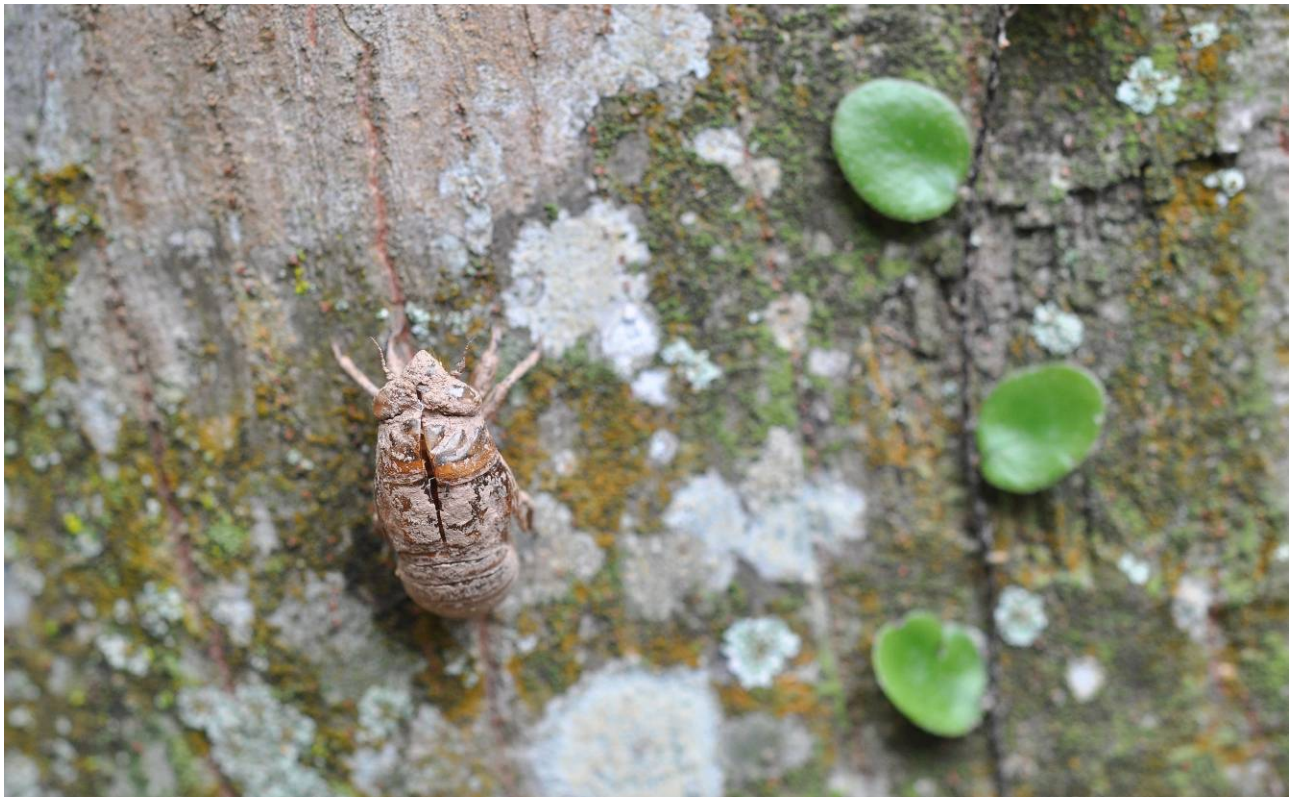

Fig. 1. The vacated exuvia of the cicada, *Chremistica umbrosa* on the trunk of a tree at the Labrador Nature Reserve, encountered on 31 Mar.2010. Note the longitudinal, mid-dorsal slit along its thorax, from which the adult emerged. Between Mar.–Apr.2010, a total of 331 exuviae were collected.

LOCAL DISTRIBUTION

In Singapore, records of *Chremistica umbrosa* have been largely from forested regions. At the Bukit Timah Nature Reserve (BTNR), a single emergent male was sighted along Taban Loop past midnight of 17 Mar.2009 (ca. 0030 hours). Its emergence sequence was documented (till 0055 hours) and the cicada (with corresponding exuvia) was collected as a voucher specimen for deposition at the Zoological Reference Collection (ZRC), Raffles Museum of Biodiversity Research (RMBR), National University of Singapore, with measurements of its body length (BL) and forewing length (FW) acquired. It was catalogued as ZRC.6.20959 (BL: 35 mm, FW: 46 mm). An adult female specimen of this species (ZRC.6.21667, BL: 34 mm, FW: 45 mm) was collected by H. B. Tang on 16 Apr.2009 from a high-storey residential apartment at Sin Ming Avenue. It was likely to have originated from the nearest forest patch (MacRitchie Reservoir forest) and was possibly attracted to the household lights.

Fig. 2. Examples of adult *Chremistica umbrosa* from the Labrador Nature Reserve. The male (left, dorsal view) was resting under a leaf of the sendudok shrub (*Melastoma malabathricum*) at eye-level on the night of 29 Mar 2010 (2055 hours). The female (right, lateral view) was perched on a tree trunk at knee-level on the morning of 31 Mar.2010 (1120 hours). Note its white, waxy ventral surface.

In addition to these isolated accounts, the species is best represented by a robust collection from the Labrador Nature Reserve (LNR), situated along the west coast of the island. A prior attempt by visiting entomologists (Universiti Kebangsaan Malaysia) to identify the cicada specimens at the ZRC had attributed three specimens from LNR (ZRC.6.22140, 3 males, coll. H. K. Lua, 2 Apr.1989) as belonging to *Chremistica pontianaka* (Distant, 1888) (see: Zaidi & Ruslan, 1997: 220). Subsequently, a mass emergence of cicadas at LNR in Mar.–Apr.2010 granted us an opportunity to obtain additional fresh specimens to verify its identity. Upon careful examination of a substantial series of male and female specimens (see: Material Examined — Table 1), there was clear agreement with the diagnostic characters of *Chremistica umbrosa*, based on well defined morphological features, including its unique male genitalia (see: Salmah, Duffels & Visser, 2005: 289–291, Figs. 56–59, 90).

EMERGENCE

Between late Mar.2010 and early Apr.2010, we had the privilege of witnessing the synchronous emergence of *Chremistica umbrosa* at Labrador Nature Reserve. The presence of numerous vacated exuviae was readily detected throughout the reserve (Fig. 1). They were variously perched on tree trunks, fallen branches, wooden signposts, or under leaves at heights of between calf-level to shoulder-level. Many were understandably covered in a clay-sand mixture, testimony to their earlier larval period spent underground. An extensive collection of these exuviae was made, as they would potentially provide clues to the sex ratio or estimated population size (see: Material Examined — Table 2). Adults could also be observed occasionally, as they rested on the vegetation by night or day (Fig. 2). The adults were an olive green with symmetrical black markings on their dorsum. In contrast, their venters were a shade of waxy white instead. In males, the abdomen was broad and stout, but in females, it was slender and tapered towards the apex.

On the night of 29 Mar.2010, numerous cicadas were observed at various stages of emergence from 2030 hours onwards. However, there appeared to be localised sites within Labrador Nature Reserve where the density was relatively higher. Upon crawling out from the forest substrate, each nymphoid larva immediately seeks a suitable perch to climb up onto, in preparation for the emergence process. The nymphoid larva has an overall dark olive colour, but the body may often be shrouded in moist clay and sand to varying degrees (Fig. 3). The larva will then remain in this position, motionless for one to two hours, before commencement of emergence.

Fig. 3. A nymphoid larva perched on a branch at eye-level at Labrador Nature Reserve on the night of 29 Mar.2010 (2155 hours). It had recently crawled up from beneath the forest floor and was coated with moist clay and sand.

Fig. 4. On 29 Mar.2010 (2245 hours), a cicada (upper) began to emerge from within its exuvia at the Labrador Nature Reserve. Another cicada (lower) had emerged earlier and was allowing its wings to stiffen.

The early stages of emergence were first witnessed for an individual cicada at 2245 hours (29 Mar.2010). It was perched at the apex of a fallen, forked branch at knee-level, and its head and thorax were already extruded from within the exuvial casing (Fig. 4: upper). On the lower fork, another cicada had already emerged entirely but was still clinging onto its exuvia and allowing its wings to stiffen (Fig. 4: lower).

At 2252 hours, more of its limbs were extracted, along with the revelation of more abdominal segments (Fig. 5). Its wings were still in their compressed state. At 2257 hours, its body was then arched backwards and earthwards, by which time the limbs were able to articulate and tuck inwards (Fig. 6). Tracheal threads emanating from within the exuvia were clearly visible.

Fig. 5. At 2252 hours, its limbs were still relatively straight when they first appeared. The wings were still highly compressed at this stage. Tracheal threads could be seen.

Fig. 6. At 2257 hours, the cicada arched its body backwards and downwards, accompanied by the articulation of its limbs.

At 2312 hours, the wings were already being steadily elongated. At this point, it began to tuck its body forwards and upwards (Fig. 7). At 2314 hours, the cicada had successfully grasped onto its own exuvia with all three pairs of limbs, providing leverage for it to extricate the posterior-most portion of its abdomen (Fig. 8). The ovipositor of the female cicada was immediately recognisable. Wing elongation proceeded at a rapid rate and by 2318 hours, both fore- and hindwings had become inflated close to their full extents (Fig. 9).

Fig. 7. At 2312 hours, its wings had become steadily inflated. It was also beginning to flex its body forwards and upwards.

Fig. 8. At 2314 hours, it was able to obtain a secure grasp onto its exuvia with all three pairs of limbs, thus facilitating the final extrication of its entire body from within the exuvia. The ovipositor confirmed this individual to be a female cicada.

Fig. 9. By 2318 hours, extension of its wings was near completion. Eventually, the wings would straighten further and fold in a roof-wise posture over its body (as in Fig. 4, lower cicada).

The cicada remained in this position (Fig. 10), until it wings had sufficiently stiffened and folded over its body, roof-wise. While exploring the forested areas of Labrador Nature Reserve on the same night of mass cicada emergence, we sighted an adult common palm civet (*Paradoxurus hermaphroditus*, family Viverridae) foraging among the dense vegetation. There was a reasonable chance that this omnivorous mammal might have been an opportunistic predator on the nutritious bounty of newly emerged cicadas, as many of them were within easy reach.

During a visit to Labrador Nature Reserve on 27 Nov.2010, exuviae belonging to *Chremistica umbrosa* were found (ZRC.6.22143). However, a proportion of these were already relatively brittle to the touch, washed clean of mud by rainwater, or had spider webs constructed within and without. These indications pointed to the fact that the emergence event would have occurred earlier, approximately one to two weeks before (i.e., early Nov.2010).

Between late Mar.–mid-Apr.2011, yet another mass emergence of this species was encountered at Labrador Nature Reserve, where more than 300 exuviae were again collected (Table 2). During a nocturnal visit on 28 Mar.2011, numerous cicadas were observed and photographed in various stages of emergence. The relative abundance was comparable to that witnessed during the same period in the previous year (2010).

Fig. 10. Anterior perspective of cicada (as in Fig. 9), viewed from above, still clinging onto its exuvia. Photographed at 2321 hours.

BIOACOUSTICS

On 31 Mar.2010, the combined tymbalisation concert of *Chremistica umbrosa* could be heard during a noon visit to Labrador Nature Reserve. The calls were predominantly originating from high up in the canopy level. After on-site recording and subsequent analysis, it was found that the frequency range spanned 4.09–5.46 kHz, with an intensity peak at 4.81 kHz. A representative spectrogram was generated to visualise its tymbalisation (Fig. 11). This is possibly the first time that the call of this species has been recorded and analysed. A corresponding sound file sample (MP3, 30 sec) of this recording is available for download.

In Southeast Asia, the tymbalisation characteristics for at least four other species of *Chremistica* have been previously analysed by various authors. These include: (i) *Chremistica guamusangensis* Salmah & Zaidi, 2002 from Peninsular Malaysia (Gogala & Trilar, 2004: 68, Figs. 4, 5), (ii) *Chremistica pontianaka* (Distant, 1888) from Peninsular Malaysia (Gogala & Trilar, 2004: 69, Fig. 6), (iii) *Chremistica bimaculata* (Olivier, 1790) from Thailand (Boulard, 2007: 40, Fig. 24), and (iv) *Chremistica numida* (Distant, 1911) from Thailand (Boulard, 2007: 41, Fig. 25).

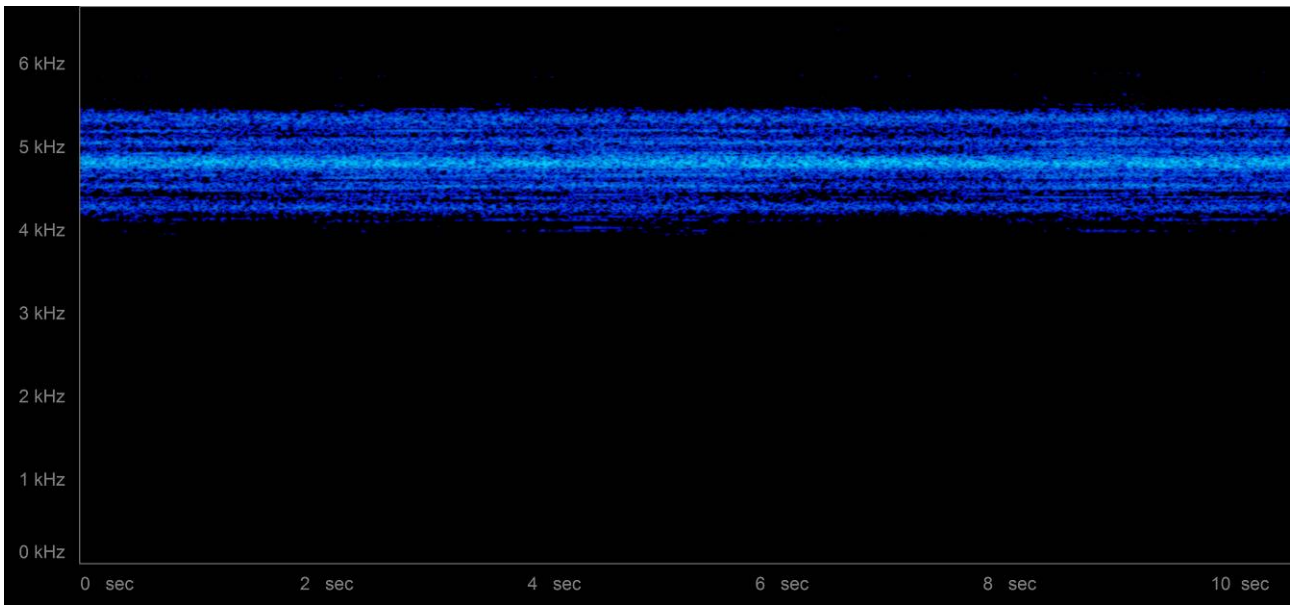

Fig. 11. Representative spectrogram of a 10 sec segment illustrating tymbalisation characteristics of *Chremistica umbrosa*, recorded at the Labrador Nature Reserve on 31 Mar.2010 (ca. 1215 hours). Its frequency range was between 4.09–5.46 kHz, with an intensity peak at 4.81 kHz. Corresponding sound file sample (MP3, 30 sec) available for download.

COMMUNAL FEEDING AND CICADA 'RAIN'

Detailed observations of communal feeding were conducted between late Mar.–mid-Apr.2011 at Labrador Nature Reserve, where dense aggregations of cicadas occupied the upper branches of particular trees to feed on their sap. Using their sharp probosces, the cicadas pierce their mouthparts into the underlying tissues to extract the plant fluids. As a relatively large volume of sap is being withdrawn and processed, each cicada needs to excrete the excess fluids (urine) at a pace that allows it to continue imbibing a steady flow of sap. This cicada urine is jettisoned from the tip of its abdomen as a fine, straight squirt (Fig. 12).

Hence, the simultaneous squirting of these fluids when the cicada population has reached its periodic peak can give rise to the natural phenomenon of cicada 'rain', best experienced if the observer is standing directly beneath or downwind of the spray zone. In the field, video recordings of this unusual event were obtained and representative sample clips have been uploaded (e.g., http://www.youtube.com/watch?v=jUrC4AX2bIw). By mid-Apr.2011, the intensity of this cicada 'rain' had progressively dwindled, as the ephemeral population of this species began to decline naturally.

PREDATION

In the field, live examples of natural predators of these cicadas were witnessed. At Labrador Nature Reserve, a female spider (*Cyrtophora unicolor*, family Araneidae) was found to have overcome a cicada within its web at knee-level on the night of 28 Mar.2011 (Fig. 13). The cicada prey had already been wrapped with silk, as the spider continued to bite it and inject more venom. On the afternoon of 29 Mar.2011, a collared kingfisher (*Todiramphus chloris*, family Halcyonidae) succeeded in capturing a cicada prey at Labrador Nature Reserve (Fig. 14). It was perched on the overhead branches, but soon flew away, either to consume the cicada in peace, or offer it as a potential nuptial gift to its mating partner.

Also at Labrador Nature Reserve, plantain squirrels (*Callosciurus notatus*, family Sciuridae) were observed to deliberately pursue and pounce upon cicadas as they were feeding on sap among the branches. These rare sightings were documented on 1 Apr.2011 and 3 Apr.2011, and clearly demonstrated the squirrel's omnivorous diet and opportunistic feeding of insects to supplement its protein intake. During one hunting session of ca. 30 mins, a single male squirrel was seen to successfully catch and consume at least ten cicadas in quick succession, without taking any breaks in between (Fig. 15). Most often, the wings and head of the cicada were bitten off and discarded, while the thorax and abdomen were consumed.

During an exploratory excursion to Pulau Ubin on 29 Apr.2011, cicadas identified as *Chremistica umbrosa* were encountered in the field, based on bioacoustic comparisons and sightings of adults and exuviae. Two fresh adult specimens (ZRC.6.22165, Table 1) were in fact found entangled in, and subsequently retrieved from a spider's web (*Cyrtophora unicolor*, family Araneidae, Fig. 16).

Fig. 12. Community feeding of cicadas on the leopard tree, *Caesalpinia ferrea* (Fabaceae), observed at Labrador Nature Reserve on the afternoon of 31 Mar.2011. While processing the plant sap, excess fluids were regularly squirted out in fine jets of dilute urine. The combined sprays from multiple cicadas in high densities created the natural phenomenon of cicada 'rain'.

Fig. 13. A female cicada, securely wrapped in sheet silk, had become immobilised and subdued by a female spider, *Cyrtophora unicolor* (Araneidae), at knee-level. Photographed at Labrador Nature Reserve on 28 Mar.2011 (ca. 2220 hours).

Fig. 14. On the 29 Mar.2011 (1540 hours), a collared kingfisher, *Todiramphus chloris* (Halcyonidae) captured a cicada prey at Labrador Nature Reserve.

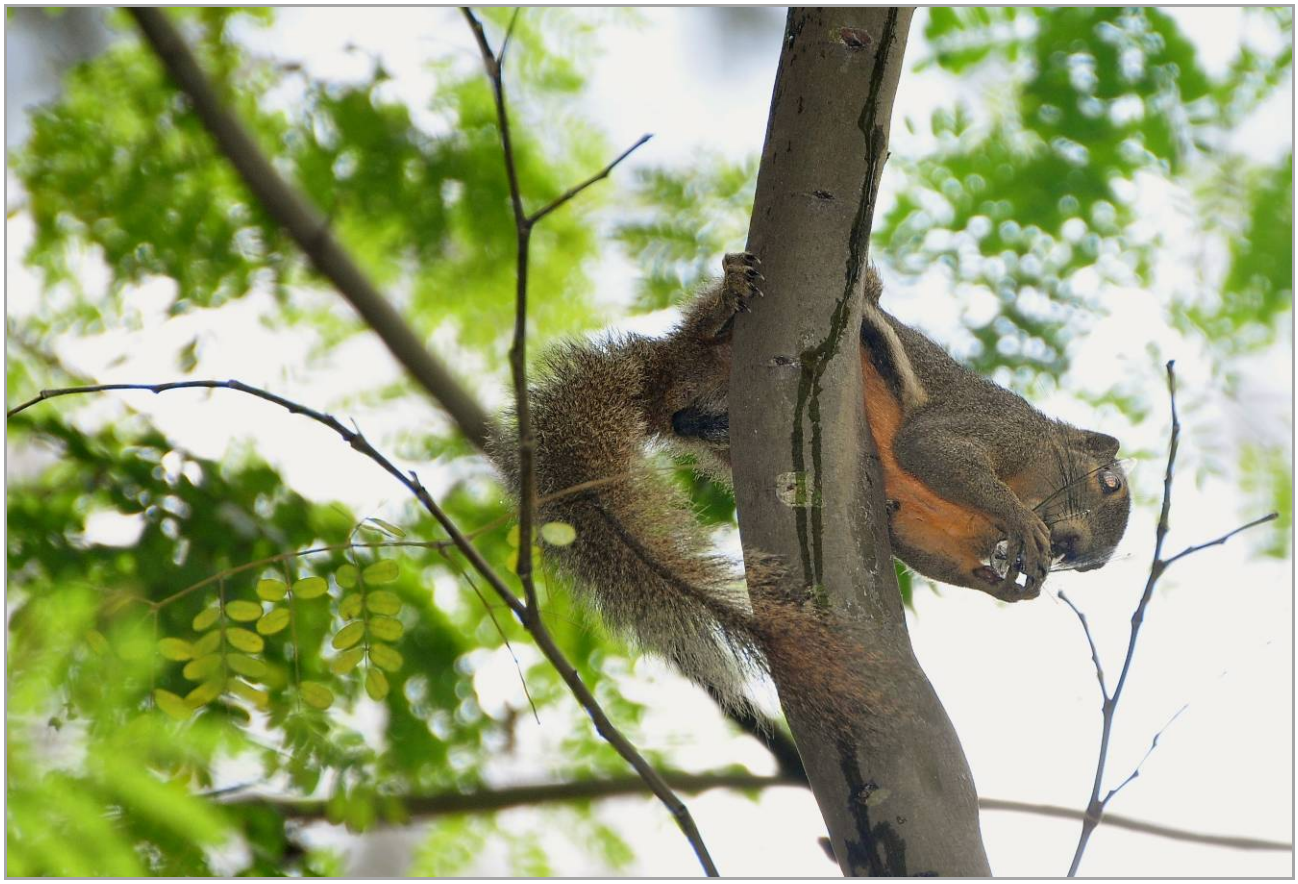

Fig. 15. An adult male plantain squirrel, *Callosciurus notatus* (Sciuridae) was observed to actively pursue and capture cicadas for food. This individual continually hunted down and consumed at least ten cicadas in a span of 30 minutes. Photographed at Labrador Nature Reserve on 3 Apr.2011 (ca. 1200 hours).

Fig. 16. Frontal view of a live cicada, recently entangled in the web of a spider, *Cyrtophora unicolor* (Araneidae), at eye-level. Photographed at Pulau Ubin on 29 Apr.2011 (ca. 1330 hours).

FURTHER RESEARCH

At present, our understanding of the life history of *Chremistica umbrosa* remains incomplete. While we are aware that this cicada has consistently appeared during the months of March–April and/or early November, we cannot be certain if these are necessarily annual events. Hence, long term monitoring over the following years and decades would allow us to identify cyclical trends and determine the periodicity of specific broods. As the adults appear to be largely canopy-dwellers, subsequent detailed observations using binoculars and telescopes would enhance observations of its sap-feeding, tymbalisation, mating and oviposition activities. Finally, the natural history of other species of *Chremistica* in Singapore would also warrant increased investigation, thus contributing to a wealthier pool of cicada data from which to make reliable ecological and behavioural comparisons.

MATERIAL EXAMINED

Table 1. Specimens of adult *Chremistica umbrosa* at ZRC, RMBR. (BTNR = Bukit Timah Nature Reserve, LNR = Labrador Nature Reserve, PU = Pulau Ubin, M = male, F = female, BL = body length, FW = forewing length, wet = specimen preserved in ethanol).

ZRC.6.	quantity/sex	BL (mm)	FW (mm)	Locality	Collected by	Date
20959	1M	35	46	BTNR: Taban Loop, fresh emergent, exuvia preserved.	T. M. Leong	17 Mar.2009
21667	1F	34	45	Sin Ming Ave.; residential apartment, high floor.	H. B. Tang	16 Apr.2009
21780	1F (wet)	35	45	LNR	T. M. Leong et al.	8 Nov.2007
21791	7M, 4F	M: 35–36 F: 32–33	M: 44–46 F: 43–45	LNR	T. M. Leong & Aminurashid	29 Mar.2010
21793	19M, 10F	M: 34–36 F: 32–34	M: 43–46 F: 43–45	LNR	T. M. Leong	1 Apr.2010
21799	3M, 4F	M: 33–36 F: 32	M: 43–45 F: 43–44	LNR	T. M. Leong & T. P. Leong	7 Apr.2010
22140	3M	32–33	44–45	LNR	H. K. Lua	2 Apr.1989
22163	28M, 4F	M: 35–38 F: 32–35	M: 45–47 F: 43–45	LNR	T. M. Leong	late Mar.–early Apr.2011
22165	1M, 1F	M: 37 F: 32	M: 47 F: 46	PU: Jalan Endut Senin.	T. M. Leong & Ali bin Ibrahim	29 Apr.2011

Table 2. Specimens of *Chremistica umbrosa* exuviae at ZRC, RMBR. (LNR = Labrador Nature Reserve, PU = Pulau Ubin, M = male, F = female).

ZRC.6.	quantity/sex	Locality	Collected by	Date
21789	6M, 3F	LNR	C. Low & K. K. P. Lim	27 Mar.2010
21790	106M, 78F	LNR	T. M. Leong & Aminurashid	29 Mar.2010
21792	67M, 43F	LNR	T. M. Leong	31 Mar.2010
21797	12M, 16F	LNR	T. M. Leong & K. K. P. Lim	2 Apr.2010
22143	27M, 42F	LNR	T. M. Leong	27 Nov.2010
22156	31M, 7F	LNR	T. M. Leong	17 Mar.2011
22161	208M, 121F	LNR	T. M. Leong	late Mar.–mid Apr.2011
22166	3M, 4F	PU: Jalan Endut Senin.	T. M. Leong & Ali bin Ibrahim	29 Apr.2011

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