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COMMUNICATION

ADDITIONS TO THE CICADA (INSECTA: HEMIPTERA: CICADIDAE) FAUNA OF INDIA: FIRST REPORT AND RANGE EXTENSION OF FOUR SPECIES WITH NOTES ON THEIR NATURAL HISTORY FROM MEGHALAYA

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Additions to the cicada (Insecta: Hemiptera: Cicadidae) fauna of India: first report and range extension of four species with notes on their natural history from Meghalaya

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Abstract: In order to broaden our understanding about cicada diversity of northeastern India, a comprehensive survey was conducted in the year 2017, in Garo, Khasi, and Jaintia hills of Meghalaya and an occasional opportunistic survey was carried out in northern West Bengal and Arunachal Pradesh. During these surveys, we came across four species of cicadas, viz., *Meimuna duffelsi*, *Dundubia annandalei*, *Balinta tenebricosa*, and *Orientopsaltria fangrayae*, which were not reported from India earlier and among them the genus *Orientopsaltria* is being reported for the first time from the country. This work provides an account of the taxonomy, natural history, distribution, and acoustics of these four species of cicadas along with their attribute to the culture and customs of the indigenous tribes of the landscape.

Keywords: Acoustics, Garo Hills, Jaintia Hills, Khasi Hills, new distribution report, natural history, northeastern India, northern Bengal, *Orientopsaltria*, taxonomy.

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Competing interests: The authors declare no competing interests.

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Author contribution: VS—conceived the project, collected samples, recorded acoustics and other field data, inspected collected specimens, compiled data, verified records, and wrote the manuscript. CM—assisted in manuscript writing and verified records. PPM—assisted in manuscript writing and verified records. MVN—collected samples and related field data for *Dundubia annandalei* and *Balinta tenebricosa* in 2019, assisted in manuscript writing and verified records.

Acknowledgements: See end of this article.



INTRODUCTION

Considering the crucial biogeographic role that the Indian subcontinent plays and the fact that the generic diversity of cicadas in India ranks highest in the world, it is unfortunate that very little research has been conducted on them since the early part of the 20th century (Price et al. 2016). In order to aid in the understanding on the cicada diversity of India, we conducted rapid surveys from February to December 2017, in different localities of Garo Hills, Khasi Hills, and Jaintia Hills of the Indian state of Meghalaya which falls under the Indo-Burma biodiversity hotspot. We also conducted an opportunistic survey in the northern parts of West Bengal from the year March 2014 to May 2019 and in Assam in the year 2017 and 2018 where the cicadas were only recorded and observed but not collected. A more focused survey was conducted in Arunachal Pradesh in October 2018 where cicadas were extensively sampled. The primary objective of these surveys was to prepare an inventory of cicadas of the region, along with their natural history and acoustic profiling. During the study period, we came across many known and lesser-known species of cicadas along with some interesting species. After a proper taxonomic diagnosis and call analysis of those, four of them, viz., *Meimuna duffelsi* Boulard, 2005, *Dundubia annandalei* Boulard, 2007, *Balinta tenebricosa* (Distant, 1888), and *Orientopsaltria fangrayae* Boulard, 2001 turned out to be new reports for India.

MATERIAL AND METHODS

Most of the cicadas in the field were spotted by their calls. Individual cicadas were observed through a Canon EOS-600D Rebel T3i Digital SLR with Sigma 70–300mm APO-Digimacro lens, and the observed behavior was noted down. All the cicadas were collected by a sweeping hand net. A few of the specimens of *Dundubia* were collected using a light trap. After collection, two legs and part of the thoracic tissues were extracted in order to preserve the DNA for future molecular work. Each insect was fixed with a pin through the mesonotum with wings outstretched after the extraction of tissue. After fixing the insect it was kept in a hot air oven for 48 hours at 56° C. Panasonic Lumix DMC FZ-35 and Canon EOS-600D Rebel T3i DSLR with Sigma 70–300mm APO-Digimacro lens was used to photograph the live cicadas in the field where the same camera along with a Canon 100mm Macro lens was used to photograph the specimen for morpho-taxonomic work. Live cicadas were photographed as instructed in Sarkar (2015). A

Canon 18–55mm lens with reverse mount ring was used to take images of the male genitalia. After taking images of different parts of the male genitalia, multiple images were stacked in Adobe Photoshop 7.0 for proper representation of the male genitalia. Image plates were prepared in Adobe Photoshop as well. The terminology used for the description of the adult cicada is adopted from Moulds (2005). Morphometric measurements of the adult cicadas were taken from images using ImageJ (64-bit Java 1.6.0) software. The measurements presented here are adopted from Sarkar (2019) (Figure 1). The male tymbalization was recorded using Telinga unidirectional microphone with parabola connected to Zoom H6 digital sound recorder. The sound was recorded in .WAVE format at a sampling rate of 48Khz in 24 bit dynamic range. The recorded sound files were transferred to HP Notebook laptop powered by Intel core i5, 7th generation for further analysis. For viewing, analysing song signals, and preparation of ‘Cards for Identification by Acoustics’ (here onward mentioned as CIA), Raven pro 1.5 (Cornell Lab of Ornithology) was used, and Microsoft Excel was used for statistical evaluation.

RESULT AND DISCUSSION

Meimuna duffelsi Boulard, 2005 (Figure 2; Table 1; Images 1, 2, 3)

The species belonging to the genus *Meimuna* Distant, 1905 has clear wings; the males have tymbal covers as wide as their length with external edges close to the opercula, but not attached; male abdomen significantly longer than the forebody; head broader than the mesonotum; pronotal margin has one tooth almost at the middle (Distant 1905; Boulard 2013). This genus is represented by seven species in India (including Bangladesh), viz.: *M. cassandra*, *M. gamameda*, *M. microdon*, *M. pallida*, *M. silhetana*, *M. tripurasura*, and *M. velitaris* (Sanborn 2014; Price et al. 2016). *Meimuna duffelsi* stands out from rest of the species by its stocky opercula and large rich brown abdomen and, in addition, the series of spots on the dorsal side are considerably underdeveloped compared to its closely related species (Boulard 2005; Boulard 2013). The male genitalia of the collected specimen are as same as the one represented in ‘Cicadas of Thailand, Vol. I’ (Boulard 2007a).

Collected specimen

Specimen Code: VS-AA219, 01.v.2017, 1 adult male; VS-AA220, 01.v.2017, 01.v.2017, 1 adult male; VS-

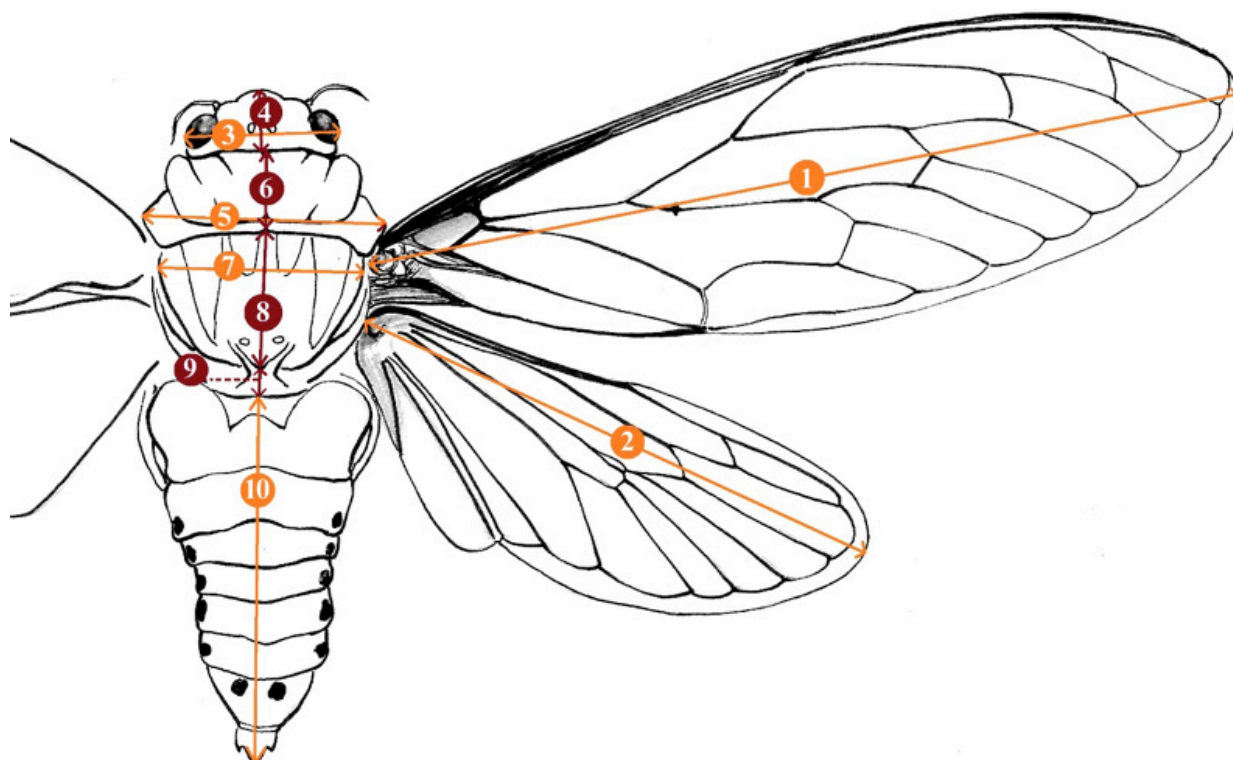


Figure 1. Cicada showing the area measured (Sarkar 2019).

Table 1. Measurement of specimen.

	Name of the body part	<i>Meimuna duffelsi</i> VS-AA222	<i>Dundubia annandalei</i> VS-AA532	<i>Balanta tenebricosa</i> VS-AA268	<i>Orientopsaltria fangrayae</i> VS-AA438
1.	Forewing	39.24mm	38.15mm	26.95mm	52.00mm
2.	Hindwing	20.91mm	20.92mm.	14.51mm	28.66mm
3.	Width of the head	9.82mm	10.17mm	7.80mm	14.46mm
4.	Length of the head	2.53mm	3.10mm	1.94mm	2.36mm
5.	Width of pronotum	10.24mm	11.07mm	8.00mm	15.13mm
6.	Length of pronotum	3.59mm	4.30mm	2.92mm	6.16 mm
7.	Width of mesonotum	9.13mm	9.26mm	7.46mm	12.97mm
8.	Length of mesonotum	5.98mm	5.49mm	4.18mm	8.06mm
9.	Length of metanotum	1.31mm	1.00mm	1.33mm	2.75mm
10.	Length of abdomen	17.88mm	14.55mm	15.29mm	21.29mm
11.	Length of Proboscis (length of rostrum including labrum and mentum)	6.61mm	5.23mm	4.99mm	12.17mm

AA221, 01.v.2017, 1 adult male; VS-AA222, 01.v.2017, 1 adult male; NCBS-PZ562, 11.v.2014, 1 adult male. Four specimens were collected in 2017, from one of the streams in the outskirts of Mawlynnong Village of East Khasi Hills District and out of these four, only one (VS-AA222) is presented in the paper. Apart from that a single specimen was collected in 2014 from Ribhoi District.

Description

Head: The head is dark from above, almost the entire epicranium is black except the thin area adjacent to the eyes and the ocular tubercle towards the pronotum which appears as an imperfect squarish pale olive green patches with a black dot in the centre in the live insect. Postclypeus is dark throughout the median region which

spreads toward the frontoclypeal suture and anteclypeus. Spaces between the pale transverse grooves of postclypeus are dark. The front of postclypeus has a pale olive green streak at the middle in the live insect which turns rich brown in the pinned specimen. The eyes are dark brown, almost appearing black in the live insect. The ocelli are white in the live insect which turns pale sanguine in the pinned specimen. The median ridge of dark anteclypeus is pale brown with olive green which broadens towards the postclypeus. The mentum and labium is pale brown in colour even in the live specimen with 1/5th darker region at the tip of the labium. The frontal and dorsal part of the specimen is smooth but the ventral part of the head is covered with a fine white hair like structure gena and mandibular plate onward which turns brown in the pinned specimen.

Thorax: Entire thorax is different shades of dark green from top in live insect which turns pale brown in the pinned specimen (Image 1.A, 1.F). Pronotum has dark green base colour. The median part of the pronotum has a black bordered, inverted Christmas tree shaped patch with oval apex (Image 1A). The black border of this oval-apex inverted Christmas tree has a broad base towards pronotal collar and even broader base toward the head. The paramedian fissure is dark, broken almost at the centre and approaching the black border of the median patch but not adjoining. A faint trail of black line goes down toward the pronotal collar from the middle of the paramedian fissure. The ambient fissure is dark which is in contiguity with the dark lateral fissure, giving an impression of a Trapezium. The dark edge of pronotal collar extends below lateral angle, towards mesonotum. Mesonotum is green with a tinge of pale yellowish brown towards the upper side with paler upper lateral sides. Mesonotum has a median dark arrow mark pointing towards the scutellum. Submedian sigilla have a club like black patch towards the outer side in such a way that parapsidal suture is at the outer edge of this club-shaped patch. There is a small triangular spot at the inner side of lateral sigilla, towards the base of the club-shaped patch of submedian sigilla. The outer edge of lateral sigilla have a dark elongated patch which somewhat resembles the blade of an imperfect bowie knife. The scutal depression is covered by a comma-shaped spot which extends to the upper arms of cruciform elevation. Metanotum is brownish green in the live insect and uniform pale brown in the pinned specimen. Thorax below is green and yellow, covered with fine white coloured hair like structure. Coxa is entirely green in fore leg, yellowish green with a triangular yellow patch in mid leg and yellow with green in meracanthus in hind leg. The trochanter

is yellowish green in fore leg, predominantly yellow with traces of green in mid leg and entirely yellow in hind leg. Femur is green to yellowish green in all legs, most greenish in fore leg and most yellowish in hind leg. Primary and secondary spine of the fore femur is entirely greenish yellow with darker tips. The tibia of fore and mid legs are distinctly green to turquoise towards the outside and brown towards the inner side without any diffusion in the middle. In hind leg, the green is prominent towards the outer side and they start turning yellowish from the starting of the tibial spur and turns entirely yellow towards the tibial comb. The tibial comb and the tibial spurs are dark rich brown. The triangular orange operculum has green at the base and partially covered with white hair like structure. Operculum have prominent orange ridge at the edges. Operculum can reach till 6th abdominal sternite in the live males as the abdominal segments contract in, however, the tip of the operculum can be between 5th to 6th sternites in the pinned specimen depending on the stretching of the abdomen. Both wings are entirely transparent without even any apical infuscations in the fore wings. The basal veins are green including the basal part of the costa whereas the other veins are black in the fore wing. The basal membrane of the forewing is greyish brown. The costal vein till radius anterior, the entire cubitus anterior veins and the 1st anal vein except the marginal area is green in colour where rest of the veins in hindwing are black.

Abdomen: Whole abdomen is rich brown, overlaid with golden hair-like structures at the dorsal side and paler at the ventral side with overlaying of fine white hair-like structures. All the sternites are light rich orange coloured and covered with fine white scales towards the hypopleurite. Epipleurites have a rich chestnut base colour which appears darker than the base colour of sternites and entirely covered with fine white scales. The first tergite is entirely black with the traces of rich brown at the part adjoining to the scutellum. The second tergite has thin black area adjacent to the 1st tergite which looks like a continuity of it. The mid dorsal area has an imperfect triangle or rather a trapezium shaped black patch which also appear as a continuity of the black 1st tergite. This spot does not adjoin the lower part of the 2nd tergite. 3rd Tergite has the imperfect 'T' shaped spot where the upper area of the 'T' is nearly as broad as the space between the tymbal covers. Similar but thinner median T-shaped spot also occurs in the 4th tergite. 5th and 6th tergites has traces of these median black spots on them. 3rd, 4th and 5th tergites have deficiently triangular lateral black spots and 6th tergite has more of an oblong spot.

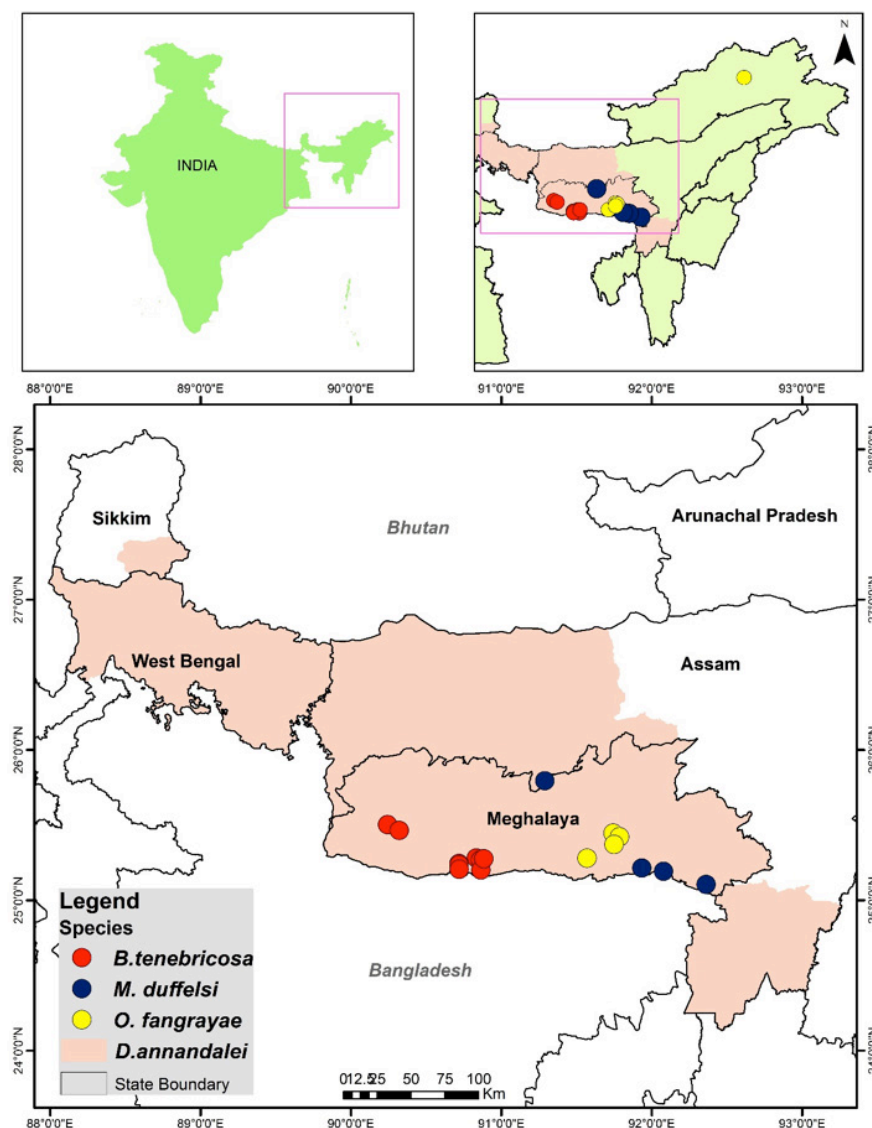


Figure 2. Location of four newly reported cicadas from India.

Male Genitalia: The pygofer is pale brown, cup shaped, with an oval opening from where the bifurcated, dark claspers come out. One of the two arms of the bifurcated claspers is long, tapered and curved and the other arm is small, undeveloped and situated towards the outer side. Median lobe of the uncus rudimentarily pointed. The upper lobe of pygofer is in a continuum with joint basal lobe providing a contiguous edge of the cup shaped pygofer.

Distribution

The only known distribution of this species was from Thailand until now (Boulard 2005a,b, 2008a,b, 2014) and this will be its first record outside Thailand. We recorded the species from Norpu Wildlife Sanctuary and Dawki of Jaintia Hills and Mawlynnong, Shella, Saiden, and

Nongpoh of Khasi Hills and apart from these localities, the species was also seen and heard in Rani Reserve Forest of Assam (Figure 2). This species is likely to occur in areas that are south of Brahmaputra River, including parts of southwestern Assam, Manipur, and Mizoram having its preferred habitat.

Bionomics

Habitat type: The species predominantly prefers the riparian forests of hilly torrential streams.

Annual appearance period of adults: The first individual was spotted in second week of April during the field work of 2017 and they were active till the end of May. In the second week of May 2014. We spotted one individual mud-puddling in community reserve of Iewsier, Saiden Village of Nongpoh, and was caught by



Image 1. *Meimuna duffelsi*: A—Dorsal side of the pinned specimen | B—Ventral side of the pinned specimen | C—Front view of the male genitalia | D—Side view of the male genitalia | E—Lateral image of the live cicada | F—Dorsal image of the live cicada | G—Lateral close up of the live cicada | H—Ventral image of the live cicada. (© Vivek Sarkar)



Image 2. *Meimuna duffelsi*: A—Preferred habitat | B—Bushes and shrubs surrounding the stream where this drinking cicada take shelter once disturbed | C—Resting individual in the bushes adjacent to stream | D—Mud-puddling of male Cicada from the seepage. (© Vivek Sarkar)

Dr. Krushnamegh Kunte.

Behaviour: Sun-loving and dendrophilous in nature. In sunny morning, the males usually call from the higher perches of tall trees and as the day progress they come down to the under growth and often emit sound signals from the small bushes adjacent to the stream. By the latter part of the morning when the day turns hotter, the males emit sound from the seepage and riverbed while drinking water. *Meimuna duffelsi* is one of the very few well studied cicadas due to their unique behaviour. This is one of the very few cicadas that exhibits the phenomenon which is popularly known as ‘mud-puddling’ in case of lepidopterans. The males of this species settle down in the wet patches, often adjacent to small streams and river banks and suck water from the seepage or wet soil or smaller water pool on large rocks and consistently excrete water like a jet spray from the tip of the abdomen. We have seen multiple males group together in such puddling and even producing a synchronized sound. Michel Boulard, who discovered this cicada from north of Chiang Mai Province, Thailand in 2004, named such puddling site “duffelsi pub” in his cicadas of Thailand book (Boulard 2013). Boulard described this phenomenon in great details on multiple

occasions (Boulard 2005, 2006, 2013). If disturbed, the males fly straight up and settle on higher parts of the adjacent tree trunk or the high branches. Usually one alarmed cicada starts a series of chain reaction that makes all the cicadas fly within a few seconds. The males of this cicada were also seen drinking from wet forest floors of Saiden and Lewsier community forest, Ribhoi District, Meghalaya. We observed large congregation of this cicada on the stony riverbed of the torrential streams of Mawlynnong and Shela of East Khasi Hill District. In the first week of May 2017, a few individuals were also spotted in a seepage situated at the edge of Ramakrishna Ashram boundary at Shela. The species was never reported from the upper part of Meghalaya and they occur at a maximum height of 880m at one of the hill streams of the Jaintia Hills.

Acoustic: Image 3.A showing two complete sequences of calling tymbalization. Each begins with preliminary sizzling phase (G) which consist of gradually increasing groans and alternate short bursts of whistle like crackling (g). Although the overall call and the spectrum matches the description given by Boulard (2013) but, unlike his finding, we found the average spectrum centred at 2660Hz. Image 3.B showing the temporal spectrogram of two different frequency zone G and mgs/MS phase which alternate with exact repetitiveness. Image 3.C magnifies the selected area in Image 3.B and showing the alternate crackles and whistling (g) of the group of modules (mgs) becoming shorter as the call progresses till they get completely replaced by only the whistle phase which is a much condensed module (MS). According to Boulard (2013), every MS module ends with the very fleeting but powerful emission of sound which goes up to 18000 Hz.

Proposed common name

Based on the unique behaviour the common name proposed for this cicada is Duffels’ Drinking Cicada.

Justification

Originally Boulard, the authority on this species, termed this cicada as ‘Sand Cicada’ as he saw the mass aggregation of males of this species for mud-puddling in the sandy banks of torrential Huai Mae Kam Pong River in the month of April–May (Boulard 2013). The males often tymbalize while sucking water from these sandy banks. The substrate of the river banks chosen by this cicada is not necessarily always sandy. It has been observed in our study area that this cicada drinks from the seepage of mud banks next to the village roads, wet humus soil of the forest floor, as well as the stony river banks. Drinking is a unique trait in this cicada that makes it stand out

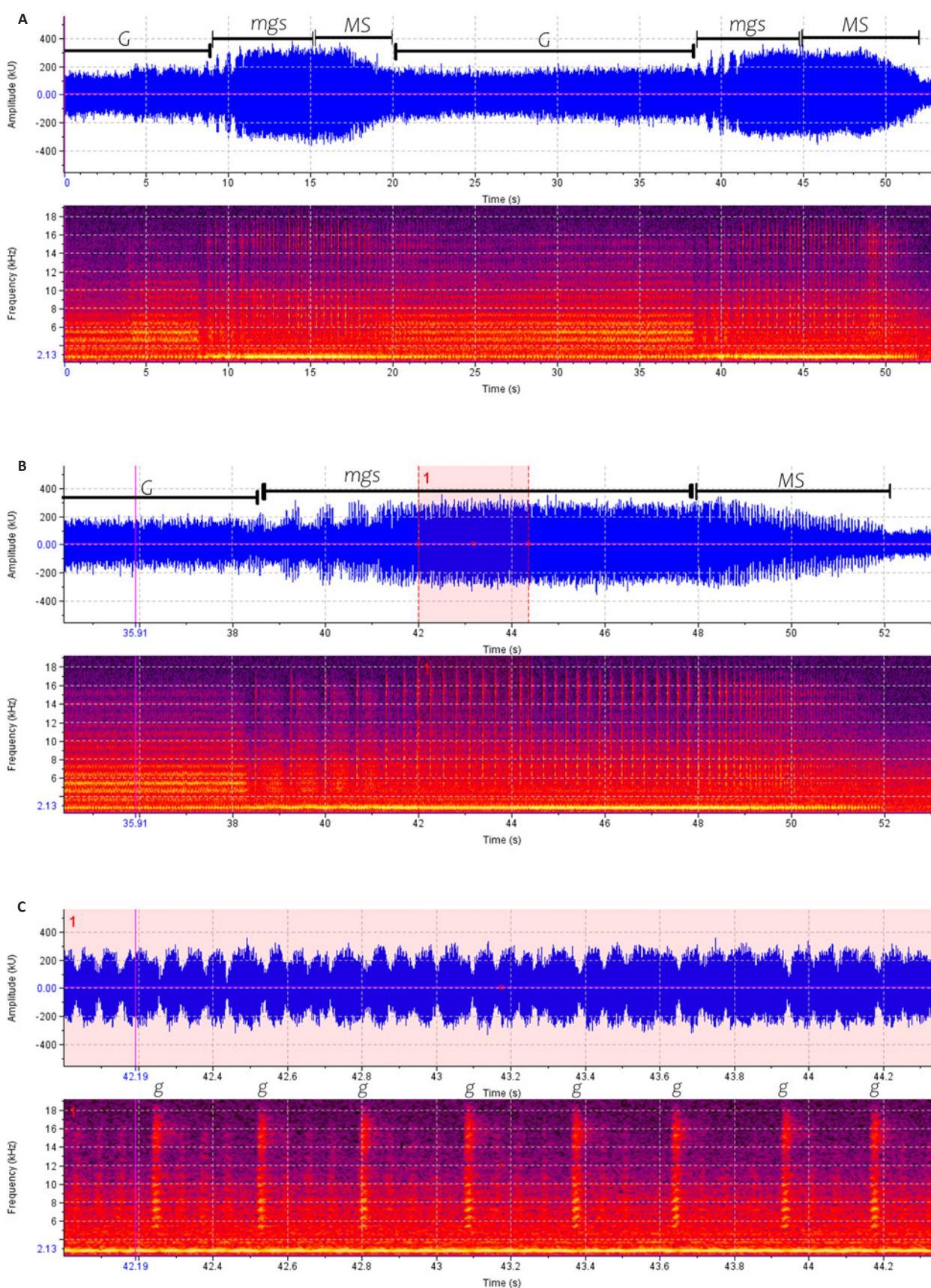


Image 3. *Meimuna duffelsi*: A, B & C—Cards for Identification by Acoustics (CIA).

from most of the cicada of its preferred habitat and only seen in a very limited group of cicadas.

***Dundubia annandalei* Boulard, 2007**
(Figure 2; Table 1; Images 4, 5)

The species belonging to the genus *Dundubia* Amyot & Audinet-Serville, 1843, have a head wider than mesonotum, postclypeus fairly prominent; rostrum scarcely or not reaching the posterior coxae; thorax with pronotal collar laterally amplified and rounded, then towards the front marked with one or several denticles, sometime faint; male opercula monochromatic, hyper-developed, well separated at the base and more than two third of the abdomen length; male abdomen equal or mostly longer than the forebody; tymbal covers dorsally closing the dorsal acoustic chambers, but not adjoining the opercula laterally, revealing the tymbals at the side (Distant 1906; Boulard 2013). This genus is represented by nine species in India, viz.: *D. emanatura* Distant, 1889, *D. ensifera* Bloem & Duffels, 1976, *D. hastata* (Moulton, 1923), *D. laterocurvata* Beuk, 1996, *D. nagarasingna* Distant, 1881, *D. oopaga* (Distant, 1881), *D. rufivena* Walker, 1850, *D. terpsichore* (Walker, 1850), and *D. vaginata* (Fabricius, 1787) (Sanborn 2014; Price et al. 2016). *Dundubia annandalei* stands out from all other species due to its uniform grass-green colour and the comma-shaped male opercula. This cicada, however, has confused many workers due to its morphological similarities with *Dundubia terpsichore* as pinned specimens of both the species are brown and both of them have similar shaped opercula. These twin species were initially thought to be distinguished only based on the male tymbalization, however after studying both the cicadas in nature, Boulard found out that *Dundubia annandalei* is teneral-looking, uniform green when live and turn brown in the pinned specimen unlike *Dundubia terpsichore* which is brown, alive or dead (Boulard 2013).

Collected Specimen

Specimen Code: VS-AA532, 14.v.2017, 1 adult male; VS-AA533, 14.v.2017, 1 adult male; NCBS-AK278, 10.v.2015 1 adult male; NCBS-AK279, 10.iii.2015, 1 adult male.

Two specimens were collected in 2017, from Karwani Village of Baghmara, South Garo Hills District, Meghalaya and out of these two, only one (VS-AA532) is presented in the paper. Apart from them, two male specimens were collected in 2015 from Koler par Village, Coochbehar District, West Bengal.

Description

Head: The entire head is leaf green with orange to golden eyes and pale sanguine ocelli. The anteclypeus and mentum is also leaf green but the labium of the rostrum is brown which turn darker towards the piercing end. The pedicel of antenna is usually green with brownish second flagellomere but in relatively freshly enclosed individuals the entire antenna appear green after developing colour.

Thorax: Thorax is also leaf green in colour. The younger individuals have minute silvery hairs on the body making the body appear as greyish green which later turn leaf green with yellow patches towards the end of their lifecycle. The base of the legs, viz., coxa and trochanter, however, are always yellow, irrespective of the age and so is the tip of the leg, viz., tarsus and claw, which is yellowish-brown. The opercula are elongated comma shaped with prominent ridge. Wing is completely transparent. The basal veins are that of the body colour which turn darker towards the marginal area. In older specimen, the basal vein of the forewing can turn greenish-yellow or completely yellow. The radius and subcostal vein is dark roseate brown to black in appearance.

Abdomen: The abdomen is mostly in same green colour like rest of the body except the median part of all the eight sternites which varies from yellowish-green to rich yellow.

Male genitalia: Upper lobe of pygofer reduced, exposing the base of the clasper. The clasper has two pointed lobes split vertically, make it appear as inverted 'Y' from the side, giving an impression of the claw of a crab. Each of these lobes are further bifurcated in two outwardly curved pointed projections, forming a structure of inverted 'V' toward the distal end. Median lobe is attached to the upper part of the clasper leaving an opening for the head of the aedeagus. Anal tube and anal style are prominent.

Distribution

This cicada was first observed by Annandale in Phatthalung region and later described by Boulard from Thailand and the occurrence of this species has been reported from Thailand, Malacca and peninsular Malaysia (Boulard 2003, 2007a,b, 2008b). Boulard found this cicada in the surroundings of Lampang, surroundings of Ban Mae Kam Pong and in the King's orchard of Chiang Mai Province and Wiang Papao, near Wang Nua and Ban Pha Kang of northern Thailand whereas it has been recorded in Tungka Forest of Ranong Province and Khao Sok rainforest of Surat Thani Province in southern



Image 4. *Dundubia annandalei*: A—Dorsal side of the pinned specimen | B—Ventral side of the pinned specimen | C—Male genitalia from the front | D—Male genitalia from the side | E—Lateral image of the live cicada | F—Dorsal image of the live cicada | G—Ventral image of the live cicada | H—Close up of the head. (© Vivek Sarkar)

Thailand (Boulard 2007a). This cicada is widespread in Meghalaya, Assam, and West Bengal. We have recorded this cicada in the lower to mid elevations of Meghalaya such as almost the entire Ri-bhoi District; Norpu Wildlife Sanctuary, Dawki, Umsyiem, Burhill and adjacent areas of Riwai-Dawki Road of Jaintia Hills; Mawlynnong, Shella and the lower part of Mawlong-Tyrna road and all other low elevation areas from Khasi Hills; and the entire Garo Hills except the peak of the Nokrek National Park and a few parts of the Balpakram National Park plateau. The species has also been recorded in the plains of Assam such as Karimganj, Silchar, Haflong, Guwahati, Boko, Dudhnoi, Goalpara, Joghigopa, Nalbari, Bongaigaon, Barapeta, Manas National Park, Kokrajhar, and Dhubri. In northern part of West Bengal, the species is distributed similarly in the foothills and the plains of Coochbehar, Alipur, Jalpaiguri, Siliguri, foothills of Darjeeling, and all the way to the lower elevations of Sikkim (Figure 2) making it a desideratum for the foothills of eastern Nepal.

Bionomics

Habitat type: This cicada is an epitome of generalists, recorded in the secondary hill forests, primary riparian forests, disturbed and degraded forests in the hill slope of Jhum plantation, fragments of kitchen gardens in the vast paddy fields of Assam and Bengal, avenue plantations of the state highways and national highways, children's park, almost omnipresent through its range. This cicada can often be heard in the middle of heavily urbanised locations as well such as in the middle of Guwahati, Siliguri or Cooch Behar.

Annual appearance period of adults: As Boulard recorded in Thailand, this cicada is mostly active between February to April (Boulard 2007). We have recorded this cicada between March to May between 2013 to 2018. Most likely the emergence of this cicada is rain driven. They show irregularities in their emergence timing. For example, in 2015 the cicada emerged in great numbers in the first week of March, whereas in 2017 the species emerged in the third week of April and stayed till the first week of June. In 2019, the species emerged in the last week of January in a few places in southeastern Meghalaya and northern West Bengal and stayed on until April. Their annual emergence pattern and the driving factors of the emergence event are yet to be explored and subjected to long term monitoring.

Behaviour: The male of the species calls rigorously right before the sunrise in the morning along with *Pomponia* sp. during April–May. It is followed by a prolonged pause from 06.00h to almost 11.00h after which they again start calling. Initial calls have irregular

intervals inbetween which gradually decrease as the day progresses and the calls become more rigorous in the late afternoon with almost no intervals in between. Locally this cicada is known as 'Phegol' in most part of the South and West Garo Hills whereas in parts of Assam such as Boko Village, it is known as 'Phodaning' or 'Phodaring'. Both the names having no particular meaning and mostly refer to pale-coloured cicadas, even soft bodied teneral cicadas. But it has been recorded in Daribokgre Village of East Garo Hills that this cicada is known as 'Phegol' and *Euterpnosia madhava* is known as 'Phodaning' or 'Phodaring'. In Ri-Bhoi District of Khasi Hills it is called 'Jamalang', comprising two words, 'Jah' and 'Malung' meaning 'food' and 'soft body', respectively. In this region, collection of teneral *Chremistica ribhoi* as a source of food is a common practice in the mass emergence year (Hajong & Yaakop 2013). The coloration of matured and hardened *Dundubia annandalei* is very similar to the newly emerged teneral cicada which makes it a preferred food for local communities hence this species along with *Euterpnosia madhava* is a popular source of nutrition in the region. Both the sexes are attracted to light. The locals light up torches and beat two dry sticks to attract this cicada, a technique used for collection of the adult *Chremistica ribhoi* as well. Though it is a known practice yet not documented by Hajong (Hajong 2013), as only the matured and hardened adult cicadas get attracted by this technique and not the soft-bodied teneral cicadas which are preferred as a local delicacy. Although *D. annandalei* is attracted to light, the beating of sticks bring more individuals to light which we documented in April 2017 in Baghmara. The male cicadas perhaps perceive the sound of this stick beating as the female wing flicking response signals. Male calls by lifting their bodies up (Image 5A).

Acoustic: Image 5B representing temporal oscillogram of 128 seconds of tymbalization of this species. The call consists of two parts, repeating for alternately for long time, sometime more than 30min. The relatively longer and melodious comb scrapping that lasts for about 6.8 to 8.8 seconds, consists of 18 to 21 number of equidistant pulses. In between these comb scraping, there is crackling sequence which lasts for around 2–4 seconds. Image-5.C magnifies the selected part of temporal oscillogram of Image 5B, representing the 18 pulses of the longer and melodious comb scrapping sequence.

Proposed common name

Based on the male tymbalization, the name 'Comb Scraper' seems appropriate for this species.

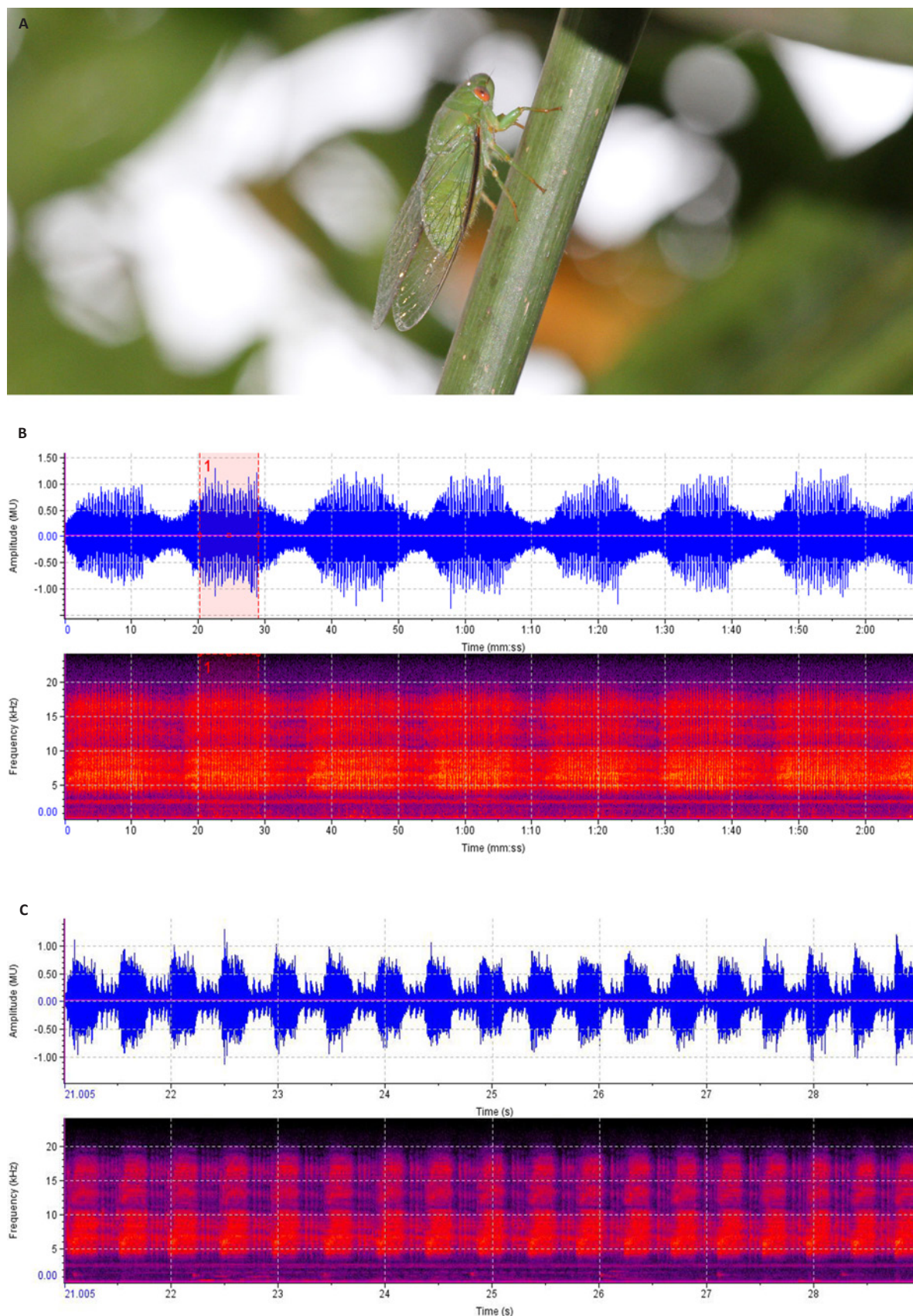


Image 5. *Dundubia annandalei*: A—Tymbalizing male | B & C—Cards for Identification by Acoustics (CIA). (© A—Pushpal Goswami; B&C—Vivek Sarkar).

Justification

The tymbalization of the males of this species resembles the comb scraping sound.

***Balinta tenebricosa* (Distant, 1888) (Figure 2; Table 1; Images 6, 7, 8)**

Balinta tenebricosa was described from the 'Teinzo on the Moolay River' originally as *Gaeana tenebricosa* (Distant, 1888). The genus *Balinta*, however, differs from *Gaeana* by having its head obliquely depressed in front of eyes, not longer than pronotum and having the widest part of tegmina only about one-third of the length of the tegmina (Distant 1905). There are three species of *Balinta* that are known from India (including Bangladesh), viz., *Balinta delinenda* (Distant, 1888), *Balinta octonotata* (Westwood, 1842), and *Balinta sanguiventris* Ollenbach, 1929 (Price et al. 2016); among them *B. tenebricosa* resembles closely *B. octonotata*. But, as the name suggests, *B. octonotata* has four distinct white spots in each tegmina which gave them an impression of a black cicada with eight prominent white spots from above and the colour of the abdomen is rich sanguine with dorsal black spots whereas *B. tenebricosa*, as the name suggests, have completely black abdomen and have three small spots on the wing. Apart from Burma or present-day Myanmar (Distant 1888, 1905; Metcalf 1963; Boulard 2013; Sanborn 2014; Price et al. 2016), *B. tenebricosa* has been collected from Tonkin in Vietnam by R.V. de Salvaza (Price et al. 2016), Laos (Metcalf 1963), Guangxi in China (Sanborn 2014), and Thailand (Boulard 2007a, 2013; Sanborn 2014).

Collected specimen

Specimen Code: VS-AA276, 17.v.2017, 1 adult male; VS-AA268, 15.v.2017, 1 adult male. Two specimen were collected in 2017, one from the Chimitap Village and another from Hatisia Village of South Garo Hill District and out of these two, only one (VS-AA268) is presented in the paper.

Description

Head: Head is creamy white to yellow from the top with black frons, ocular tubercle and supra-antennal plate. Eyes dark brown with prominent pseudopupil in the live specimen. Ventral part of the head is mostly black, anteclypeus, lorum, and vertex black. Postclypeus broadly black at the centre with yellowish-orange at the adjacent edge of anteclypeus and lorum and turns paler towards the epistomal suture. The transverse grooves of postclypeus entirely black which appear as series of black lines towards the yellow edge.

Thorax: Pronotum dorsally black with pale patches at the edge joining the head and pronotal collar. A pale median longitudinal fascia continues from the pale area adjacent to the head and narrows down the most at right before the imaginary confluence point of two paramedian fissure, from where it widens and form a club like shape which joins the pale pronotal collar. The base of paramedian fissure is pale and broad which narrow down and appear as a traces of pale line along the fissure as it moves towards the pronotal collar. The pronotal collar is entirely yellowish-beige with a very thin dark edge towards the mesonotum and dark lateral angle. Mesonotum entirely black below with all the legs entirely black. Dorsally the submedian sigillas, lateral sigillas and the area adjacent to scutal depressions are entirely black. Area between submedian sigilla and lateral sigilla pale which runs towards the pale scutellum, constituting dorsolateral pale fasciae which are narrow and more yellowish towards the end adjacent to submedian sigilla and broadens at the posterior end. Metanotum rich orange till wing groove. Scutellum prominently pale creamy white which looks like the extension of pale elongated dorsolateral fascia of mesonotum. The borders of scutellum have traces of dark colouration which continue with the dark area adjacent to scutal depressions anteriorly and of uniformly dark first tergite posteriorly. Forewing dark brownish-black with three pale yellowish spot. Hindwing bright red with very broad dark outer border, making the red restricted to almost one third basal area of the wing. However, the anal lobe is only about one third black at the outer edge.

Abdomen: Entire abdomen is black. The overlaying brown hairs may give the appearance of the abdomen bronze-brown.

Male genitalia: The male genitalia identical to the one represented in the Cicadas of Thailand (Boulard 2013). The pygofer is dark towards the upper side with a thin pale band and paler on the side and base but the colour varies from individual to individual. There are males recorded with entirely dark pygofer as well. The upper and basal lobe of pygofer is fused and appear as a ridge. Pygofer very similar to that of the *B. octonotata* as illustrated by Hayashi (1978a & b) but unlike it the distal shoulder of pygofer is not protruded and pointed dorsally and in addition the pygofer is broader at the base toward the basal lobe and narrows down towards the apex where as in *B. octonotata* the entire pygofer appear as oblong rectangle. Median lobe of uncus is prolonged and bifurcated from where the aedeagus comes out. Aedeagus tapered ridge like structure which often appear as a hook at the opening. The claspers appear as globous



Image 6. *Balanta tenebricosa*: A—Dorsal side of the pinned specimen | B—Ventral side of the pinned specimen | C—Male genitalia from the front | D—Male genitalia from the side | E—Lateral image of the live cicada | F—Dorsal image of the live cicada | G—Ventral image of the live cicada | H—Lateral close up of the live cicada. (© Vivek Sarkar)

structure at the base of the median lobe of uncus.

Distribution

This species was only seen in the southern areas of Garo Hills whereas in Ribhoi, Khasi Hills and Jaintia Hills of Meghalaya, parts of Assam, northern West Bengal and Chhattisgarh the species gets replaced by *Balinta octonotata*. The species was seen in different forested areas between Baghmara Reserve to Balpakhrum National Park not in continuity but in fragments. We have recorded this species in Karwani, Baghmara Reserve Forest, Gongrot, Hatisia, Chimitap, Rongcheng, Tura Peak, Nokrek National Park, and Balpakhrum National Park (Figure 2).

Bionomics

Habitat type: The insect was seen both in primary and secondary forests of the hill slopes and foot hills in Garo Hills. An association of species' presence with the forest patches with lot of soft bodied climbers as well as lianas was noticed.

Annual appearance period of adults: In the year 2017, this cicada was first recorded in the third week of April and the last individual was recorded in the second week of June. The peak of activity was recorded between the second and third week of May.

Behaviour: The cicada is dendrophilous and shade loving. They remain silently settled in the thick vegetation, mostly at the shaded areas of lianas which makes them very difficult to spot due to their dark appearance. They feed on the liana and other climbers throughout the day, as one can see them excreting the excess water with regular jet spray. As the direction of sun changes from east to west, the cicada also changes its resting position, however, there are areas where the sunlight hardly reaches and often more than one individual settle closely in these types of areas. The males start tymbalizing from late-afternoon, starting from around 14.30h and continues till about 18.00h. Initially the males call from one spot, after repeating few set of calls they walk slowly and change the position in the time between the calls. After repeating this a few times on the same plant or tree, they fly and change the tree or liana and repeat the process. They call almost in a sub-gregarious manner as the afternoon progresses and call rigorously and desperately as dusk approaches. Usually the males call from a little higher parts of the vegetation whereas the females prefer to settle 1.21–1.82 m from the ground on the climbers and lianas. Sometime, towards the evening, the males come down and settle close to the ground or even fall on the ground close to the plant where female is

resting and announce their acoustic signals desperately. While calling, the raised abdomen of the males, which is otherwise covered comes out in between two tegmina (Image 7E).

Acoustics: Image 7A representing temporal oscillogram of 68 seconds of tymbalized calling re-transcribed in real time, showing two complete calling sequence of this species. Each sequence consist of two uneven phases, The initial short phase is designated as ph-1 and prolonged phase designated as ph-2, as shown in Image 7A. Second phase consist of highly condensed signals as shown in Image 7B, which shows the partial oscillogram of 10/100^{ths} of a second of the ph-2. Towards the end of the prolonged second phase (as shown in Image 6) of the double motif at the rate of three per hundredth of a second as shown in the Image 7B get a regular interval (sandwiched between seven to eight crackling signals as shown in Image 7C) which is crescendo until the crackling signals reduced to four to five (Image 7D). Image 6 showing partial oscillogram stretching out in an arbitrary space-time unit showing the initial first phase (ph-1) and prolong second phase (ph-2) along with the ending of entire second phase. Sometime there is a minor variation in first phase that occur in different tymbalized calling, often of the same individual as shown in the Image 7F&G.

Proposed common name

Based on its appearance, this cicada can be called 'Variable Dark Balinta'.

Justification

In Latin, 'tenibracosa' means dark. This cicada is darker than closely related species *Balinta octonotata* in its general appearance by having three reduced pale spots on dark tegmina and black abdomen. Colour variations have been reported as well for the females of this species from Thailand such as some individuals having yellow abdomen instead of complete black with only dorsal black spots along with individual colour variations of hindwings (Boulard 2013). Hence, it is justified to add 'variable' in common name to represent the species better.

Orientopsaltria fangrayae Boulard, 2001 (Figure 2; Table 1; Images 9, 10, 11)

Genus *Orientopsaltria* Kato, 1944 consists of 33 species distributed across the Philippines Borneo, Sumatra, Malayan Peninsula, and Thailand (Duffels & Zaidi 2000; Boulard 2013; Sanborn 2014), with a recent record from Vietnam (Pham et al. 2019). The species

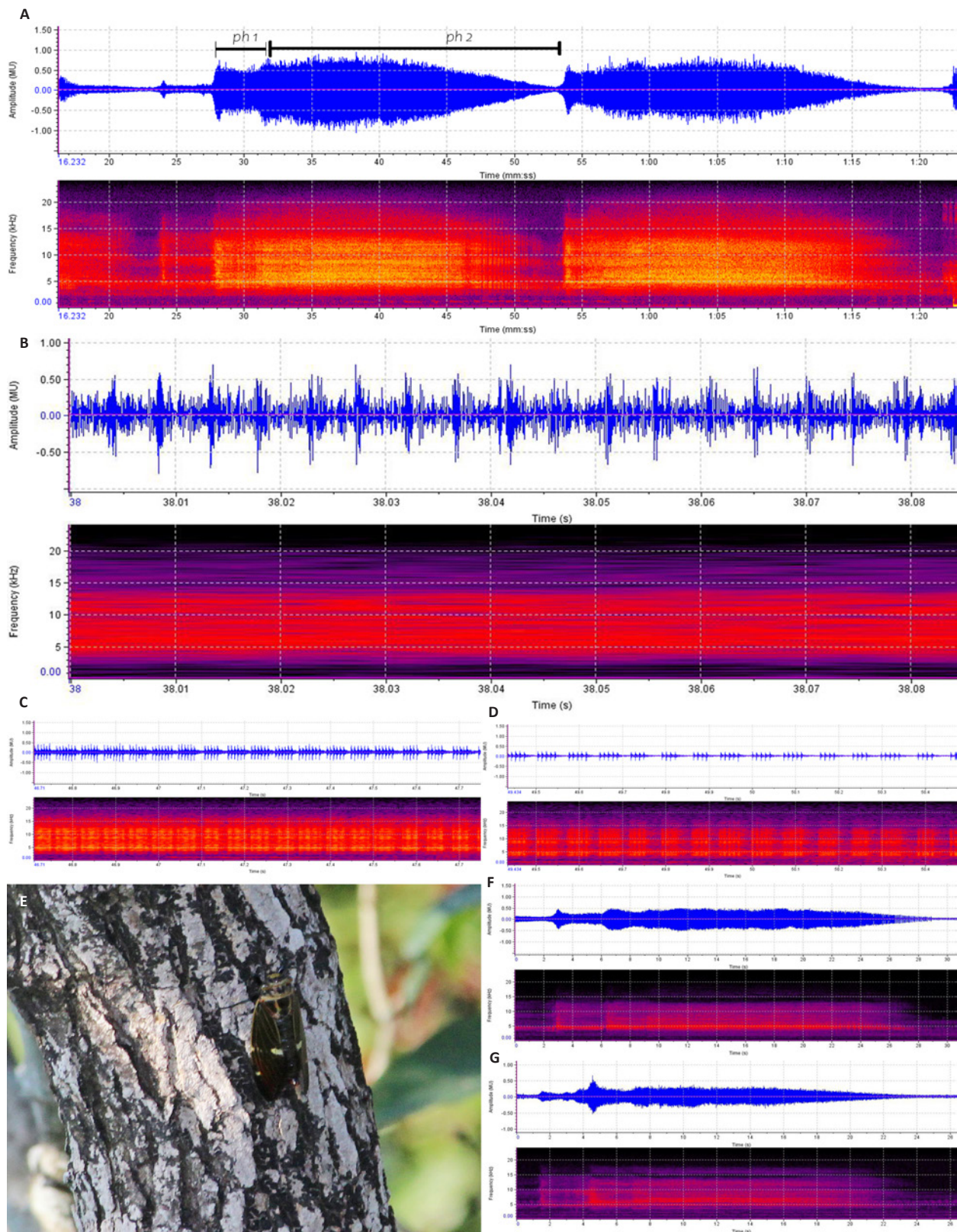


Image 7. *Balanta tenebricosa*: A, B, C, D, F, G & H—Cards for Identification by Acoustics (CIA); E—Tymbalizing male. (© Vivek Sarkar)

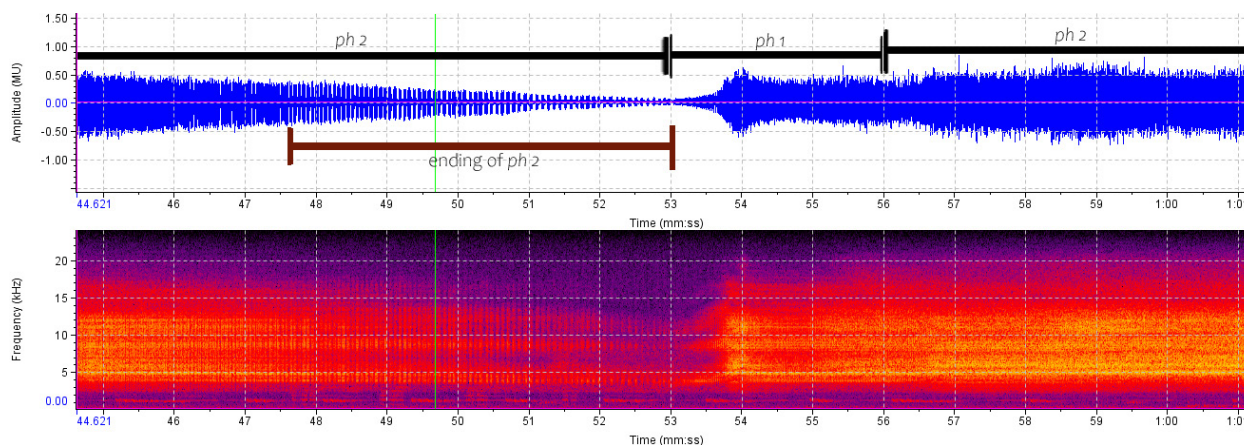


Image 8. *Balanta tenebricosa*: Oscillogram showing the magnified structure of both the phases of tymbalized call.

under the genus *Orientopsaltria* are medium to fairly large in size and very similar to the genus *Cosmopsaltria* Stål, 1866 or *Dundubia* Amyot & Audinet-Serville, 1843; however, unlike *Cosmopsaltria*, the genus *Orientopsaltria* have rounded pygoferal lobes and unlike unicolour male opercula and globous head of *Dundubia* they have bi or multi-coloured male opercula and head globous but not as much as *Dundubia*, postclypeus fairly strongly produced (Duffels & Zaidi 2000; Boulard 2013). The latero-posterior ocelli significantly closer to each other than from the corresponding eye; pronotum marked with two black parasagittal lines and possibly two black sub marginal bands; mesonotum, in most cases, heavily decorated with long black sagittal stripe with four black fasciae, as well as two maculae in front of scutellum; hyaline wing with only apical nervules highlighted or with transverse nervulation lined with bistre or without any infuscations; subapical and brownish spots often on the longitudinal nervules; hindwing with six apical cells; male opercula elongated, wide with either single green ochre tint or broadly greenish with black or bistre along internal margin and on apex (Kato 1944; Boulard 2013). *Orientopsaltria fangrayae* was first discovered from Chiang Mai Province (Boulard 2001, 2013). The species from India was first identified based on the CIA provided in Cicadas of Thailand (Boulard 2013) and later confirmed with acoustics, general morphology and the male genitalia which is identical to the description given in the book (Boulard 2013).

Collected specimen

Specimen Code: VS-AA438, 10.ix.2017, 1 adult male. Only one specimen was collected in 2017 from the upper hill slopes of Mawsinram Village of Khasi Hills and the same specimen is presented in the paper.

Description

Head: Eyes rich chestnut brown in live specimen which appear reddish from distance (Image 11) and turns dark brown in pinned specimen. Head green with heavy decoration. Supra-antennal plates black below and green on the top which sometime looks darker in live insect. Both side of epicranium have rectangular black spots and two traces of tiny spot posteriorly. Ocular tubercle including frons and epicranial suture black which sometime continues as parasagittal lines of pronotum in some individuals. Postclypeus not protruded, base colour light sea green with green coloured transverse grooves. A median black line at the front of postclypeus narrow at the adjacent area of anteclypeus and broadens as it goes towards the dorsal side and bifurcate which dorsally forms two big spots at the dorsal part of the postclypeus. Dorsally, the area adjacent to pronotum, behind the eyes have black elongated spot parallel to the border of the head. The part of lorum adjacent to anteclypeus have traces of black. Rostrum pale coloured with dark tip.

Thorax: Pronotum has a central greenish brown oblong spot, somewhat like the shape of a squid, bordered by dark parasagittal lines which originate from the back of the head and ends just above the pronotal collar. There is an Inverted “L” shape spot attached to parasagittal lines diagonally. Dark paramedian fissure join this L-shaped spot at the angle. Lateral fissure dark. The pronotum collar has the thin black margin in the inner part of the lateral margin which goes beyond lateral fissure. Pronotum collar green with thin black outer margin which crosses the pronotal collar just above the lateral angle. Submedian sigilla black which is incomplete at the median area but barely crosses parapsidal suture posteriorly and enters at the central part of mesonotum. The base of the lateral sigilla which

is adjacent to pronotal collar black. The lateral fasciae run below this basal dark area posteriorly along and within lateral sigilla. Scutal depression and surrounding area black, giving an impression of oval spots to some extent. A pointed, spear-head shaped, oblong median fascia runs from the posterior area between two submedian sigillas till above the cruciform elevation. Cruciform elevation uniformly brownish green. Femur of foreleg sea green coloured, similar to that of the postclypeus, with black joints and black edge with dark primary and secondary spines. The joint between femur and tibia in second and third pair of legs are prominently yellow with black spots. Opercula long, reaches till seventh sternite. The spoon shaped operculum is hyper-developed and as mentioned by Boulard and shown in Image 8G & H, strengthened laterally with a strong brilliant bistre helm, broadly separated from base, occurring initially in a short patch and then in large ventro-lateral spoon shapes (Boulard 2013). Less than two third of the opercula from the base are green and smoky dark with white overlaid scales towards the tip in live specimen. Wings entirely hyaline. Forewing have traces of pale brown infuscation at radial and radiomedial crossvein. Veins at the base of the forewing are green in live insect (Image 8E) which turns pale brown in pinned specimen (Image 8A).

Abdomen: Abdomen darker than the forebody. Sternites greenish-brown with darker margin posteriorly and overlaid with pollinosity which appear as in continuity with the tip of the opercula (Image 8G). First tergite reduced. All tergites are dark brown except second and third tergites which have prominent median green patch and traces of median green patch on them, respectively. Tymbal cover is brown and covers the tymbal completely from top and only opens laterally. Third tergite has two dorsolateral silver spot, one at each side. This is due to heavy pollinosity caused by silver overlaid hair like structure.

Male genitalia: The lateral lobe of the pygofer apically rounded without protrusion. Basal pygofer lobes appear as a distinct ridge with pointed apical protrusion. Uncus lobes look square like, with angular, robust lateral spine with internal median groove. The apical part of lateral margin straight and tapered.

Distribution

The species was first discovered in the wet mountain forest of Fang of Chiang Mai Province and later reported from Wiang Papao, Khun Lao Mountain and Doi Ang Kang in Thailand (Boulard 2001, 2003, 2005b, 2006b, 2007b, 2008, 2013; Sanborn et al. 2007). We had first recorded the species in East Khasi Hills in 2017, in the

hilly surroundings of Mawsinram Village and later in Mawphlang adjacent area. It has been recorded till Ladmawphlang but not beyond Mawkdok Valley. In 2018, we recorded the species only from the mid-elevation wet forests (up to 2000m) of Moulin National Park in Upper Siang District, Arunachal Pradesh. In this case the species was observed and recorded but could not be collected as they were settled high up in the trees.

Bionomics

Habitat type: The species was encountered between 890–1,400 m, mostly in the thick forests of the hill slopes consisting predominantly of *Prunus* sp., *Rhododendron* sp., and *Castanopsis* sp. trees. The presented specimen was collected at 1,161m. As rightly mentioned by Boulard (2013), they are ambrophilous, mostly prefer the wetter forests of the mid to higher elevation. Towards the end of their activity period a few desperate males wander off and can be found outside their preferred habitat.

Annual appearance period of adults: The first Individual was encountered on 28 August 2017 and the last individual was encountered in the second week of November 2017. Their activity is at peak from mid-September to third week of October. Boulard recorded the species in September in the year 2000, 2004 and 2006 and in November in the year 2004 (Boulard 2013). They are active mostly in the day time.

Behaviour: The males settle at the ventral side of the upper branches of tall trees of thick forest of the hill slopes, making them very difficult to spot due to their decorative forebody matching with the thick mosses of tree trunk. Usually they have been spotted using headlight and binoculars as they prefer forests where light barely penetrates but their red eyes give their position away in green mossy branches (Image 10). The males emit the acoustic signal randomly without any particular gap in between. Although Boulard (2013) described the species as heliophilous, in our observation, we find them certainly dendrophilous. Boulard mentioned that males often exhibit 'synchronous orchestra' (Boulard 2013), however, we noticed this behaviour in mostly prolonged rainy and extremely foggy days and occasionally during sunny days. Gregarious by nature, males settle in nearby trees and display this synchronous orchestra. They also often show this behaviour if a pre-recorded call is played in a portable speaker but not necessarily always. The males settle at one place and tymbalize, often they do not change the place for several days, moving only insignificantly from the settled area.

Acoustics: Calling tymbalization sounds like a scream which appear as extremely dense signal of spindle in



Image 9. *Orientopsaltria fangrayae*: A—Dorsal side of the pinned specimen | B—Ventral side of the pinned specimen | C—Male genitalia from the front | D—Male genitalia from the side | E—Lateral image of the live cicada | F—Dorsal image of the live cicada | G—Ventral image of the live cicada | H—Lateral close up of the live cicada, head from front in inset. (© Vivek Sarkar)

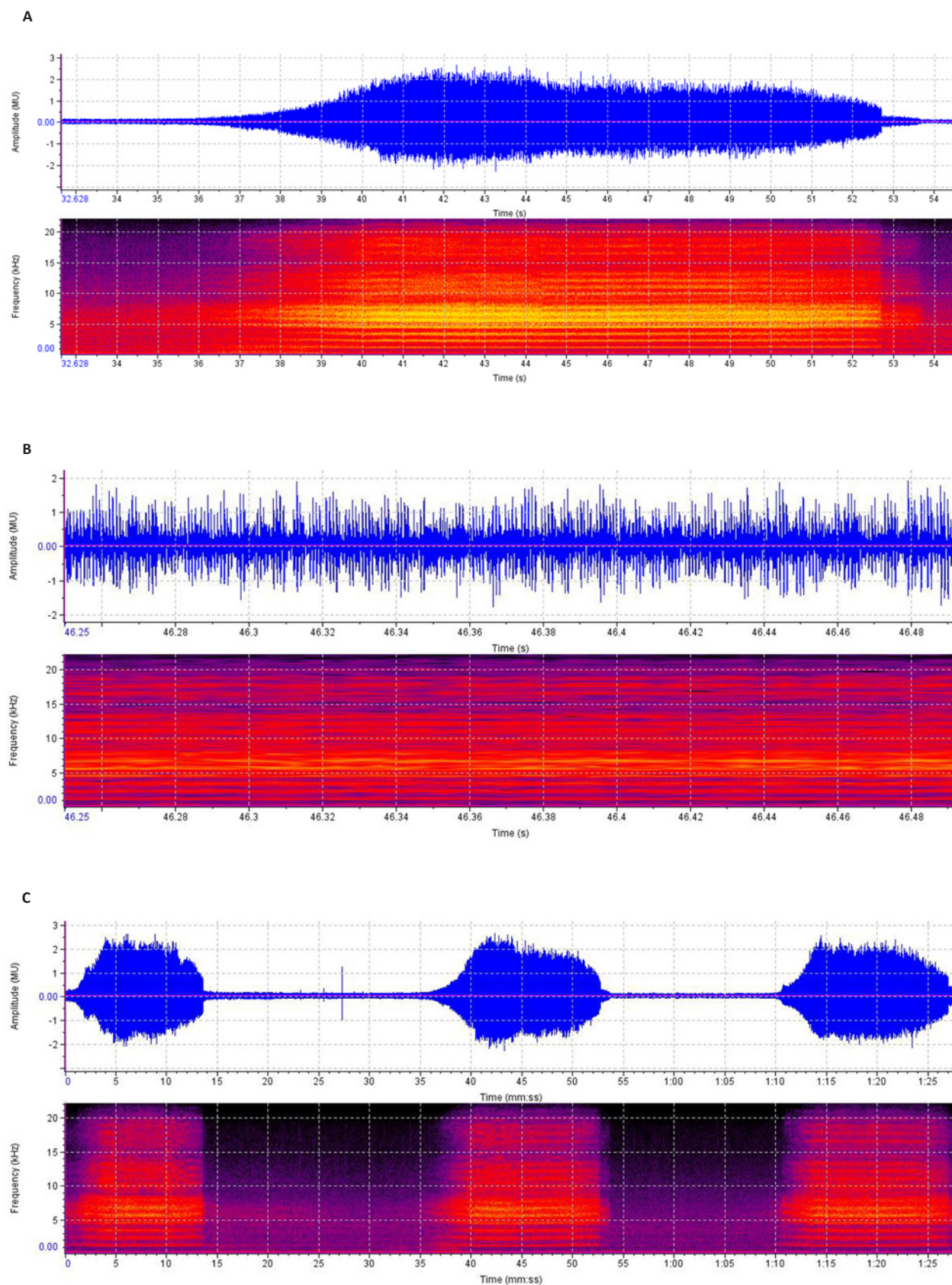


Image 10. *Orientopsaltria fangrayae*: A, B & C—Cards for Identification by Acoustics (CIA).



Image 11. *Orientopsaltria fangrayae* in natural habitat.

oscillogram without any detectable structures (Image 10A). Image 10B showing the sonogram stretching 25/100^{ths} of a second representing an arbitrary space-time unit to represent a magnified structural Image. Image 10C showing the synchronous orchestra where every spindle is of +/-18seconds and the distance varies from 16.2 to 21.8 seconds.

Proposed common name

Based on its appearance and behaviour, the name proposed is 'Red-eyed Hill Screamer'.

Justification

The call of this species is spindle-shaped with thick signals that gives an impression of screaming and this cicada prefers wet forests of the Hills throughout its range hence the 'Hill Screamer'. The first striking feature that anyone would observe in this cicada when they are alive is their red eyes (Image 11).

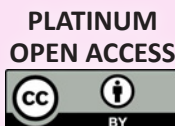
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