MARTIJN KOS[1] & MATIJA GOGALA[2]

[1]*Instituut voor Systematiek en Populatie Biologie (Zoölogisch Museum), Universiteit van Amsterdam, The Netherlands*
[2]*Prirodoslovni muzej Slovenije, Ljubljana, Slovenia*

THE CICADAS OF THE *PURANA NEBULILINEA* GROUP (HOMOPTERA, CICADIDAE) WITH A NOTE ON THEIR SONGS

Kos, M & M. Gogala, 2000. The cicadas of the *Purana nebulilinea* group (Homoptera, Cicadidae) with a note on their songs. – Tijdschrift voor Entomologie 143: 1-25, figs. 1-44, tables 1-2 [ISSN 0040-7496]. Published 5 July 2000.
The *Purana nebulilinea* group is erected for six species, distributed in Borneo, Sumatra and mainland Southeast Asia. *P. nebulilinea* and *P. pryeri* are redescribed. *P. pryeri* is taken out of the synonymy with *P. nebulilinea.* Four species are described as new (*P. capricornis*, *P. montana, P. niasica* and *P. parvituberculata*). The song of *P. nebulilinea* is described and some notes about the ecology and distribution of the group are given. A phylogeny of the group is presented and some remarks are made on the phylogenetic relationships between the species of *Purana* and the taxonomic status of the genus. A key to males and distribution maps for the species are provided.
Correspondence: Martijn Kos, Instituut voor Systematiek en Populatie Biologie (Zoölogisch Museum), University of Amsterdam, P.O. Box 94766, 1090 GT Amsterdam, The Netherlands.
Key words. – *Purana*; *nebulilinea* group; phylogeny; taxonomy; new species; sound, song, bioacoustics; Southeast Asia.

This paper aims to contribute to the taxonomy and biogeography of Southeast Asian cicadas. It also provides a basis for biodiversity studies in cicadas of Southeast Asia, like those executed in Malaysia by Zaidi and co-workers (Zaidi 1996, 1997, Zaidi & Hamid 1996, Zaidi & Ruslan 1995).

Since almost all male cicadas sing, assessment of biodiversity would be greatly enhanced if identification by sound, like is normal for birds, would be possible also in tropical rainforests and similar habitats despite of high biodiversity. During day-time, observation of tropical rainforest cicadas in their natural habitat, the canopy for most species, is very difficult and catching them is hardly feasible. Also samples collected at light are rather small and thought to be unrepresentative for the whole cicada fauna at a certain locality. For a quick and easy assessment of cicada biodiversity sound would be most suitable but first we should know the song patterns of the different cicada species. This paper is the first of a series of planned to integrate data from our research groups in the Zoological Museum, Amsterdam and the Prirodoslovni muzej Slovenije, Ljubljana, concerning cicada taxonomy and bioacoustics.

MATERIAL AND METHODS

The material for this study is deposited in the following collections:

BMNH	Natural History Museum, London (formerly British Museum (Natural History))
BPBM	Bernice P. Bishop Museum, Honolulu
PSS	Pusat Sistematik Serangga, Universiti Kebangsaan Malaysia, Bangi, Selangor
RMNH	Nationaal Natuurhistorisch Museum (formerly Rijksmuseum van Natuurlijke Historie)
TMB	Természettudomány Muzeum, Budapest
UMS	University of Malaysia Sabah, Kota Kinabalu
ZMA	Instituut voor Systematiek en Populatie Biologie (Zoölogisch Museum), Amsterdam

The following sources have been consulted for tracing localities: 'Adolf Stieler's Hand-Atlas' (Anonymous, 1872), 'Andrees allgemeiner Handatlas' (Anonymous, 1906), 'Nelles road atlas Indonesia' (Anonymous, 1992a), 'Nelles road atlas Southeast Asia excluding Indonesia' (Anonymous, 1992b), 'The Times atlas of the world' (Anonymous, 1994), 'Insight Guides: Southeast Asia Wildlife' (Bernard, 1994), 'Aardrijkskundig woordenboek van Neder-

landsch Oost-Indië' (Dumont, 1917), 'Malaysia, Singapore & Brunei - a travel survival kit' (Finlay & Turner, 1994), 'A field guide to the mammals of Borneo' (Payne, Francis & Phillipps, 1985) and GEOnet Names Server of the U.S. Defence Mapping Agency (WWW URL: http://164.214.2.59/gns/html/index.html).

PAUP 3.1.1 was used to perform the cladistic analysis to study the relationships between the species of the *P. nebulilinea* group.

Among this group of cicadas only song of *Purana nebulilinea* was recorded; the recording and identification undertaken by M. K. in Bangi, Kuala Lompat and Pasoh (November 1996 - March 1997). M. G. recorded similar song in Bangi (May - June 1996), in the Temengor forest reserve, Hulu Perak (Belum Expedition March - April 1994) and recently in Taman Negara (Kuala Juram, 1999). Some other recordings used in this investigation were made in Bangi also by Dr. Tomi Trilar, Ljubljana.

The recordings of songs were made using a TELINGA STEREO PRO 3 microphone and a TELINGA MONO PRO 3 mike in connection with DAT recorders SONY TCD-D3, TCD-D7, TCD-D8 or TCD-D10.

In the laboratory, DAT recordings were transferred through the digital interface of an AUDIOMEDIA III card to the Hard Disk of a MACINTOSH POWERPC 8500/120, or more recently to a POWER MACINTOSH G3/233 computer. Software used for viewing, editing and analyzing song signals were DIGIDESIGN PROTOOLS 4.0, and CANARY 1.2. Altogether 25 recordings of different individuals were used for analyses. For statistic evaluations of data we used the software STATVIEW 4.5.

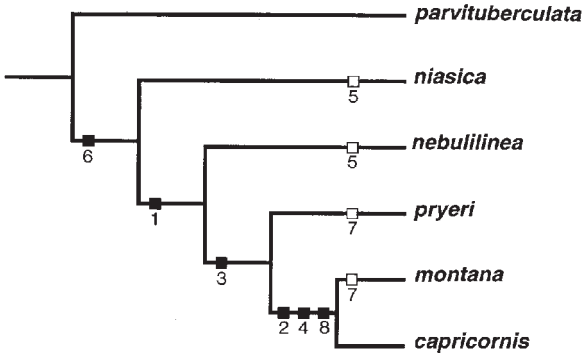
For description of songs we use the terminology of Gogala et al. (1996).

PHYLOGENY

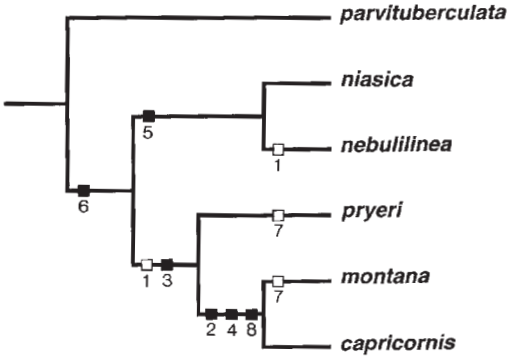
The genus *Purana* Distant, 1905

Purana Distant, 1905 was attributed by Moulton (1923) to the subtribe Leptopsaltriaria of the tribe Dundubiini. This subtribe includes *Leptopsaltria* Stål, *Maua* Distant, *Nabalua* Moulton, *Purana* Distant and *Tanna* Distant, and is characterized by ventral tubercles in the male.

1



2



Figs. 1-2.
Alternative phylogenies of the *Purana nebulilinea* group. – Numbers refer to characters discussed in the text. Squares represent character state 1. Closed squares represent synapomorphous character states, open squares represent homoplasious character states.

Table 1. Character state matrix for the species of the *Purana nebulilinea* group.

	1	2	3	4	5	6	7	8
P. capricornis	1	1	1	1	0	1	0	1
P. montana	1	1	1	1	0	1	1	1
P. pryeri	1	0	1	0	0	1	1	0
P. nebulilinea	1	0	0	0	1	1	0	0
P. niasica	0	0	0	0	1	1	0	0
P. parvituberculata	0	0	0	0	0	0	0	0

Distant (1905) erected the genus *Purana* by dividing *Leptopsaltria* into *Leptopsaltria*, *Purana* and *Maua*. A preliminary study of the morphology of the male genitalia of several species of *Purana* and *Maua*, shows that Distant's genera, as based on morphometric characters as relative lengths of head and abdomen, do not reflect the phylogenetic relations of the species included. The genus *Purana* is probably paraphyletic. Several species of *Purana,* such as *P. celebensis* Breddin and *P. ubina* Moulton, share morphological characters with species of *Maua.*

The *Purana nebulilinea* group

The *nebulilinea* group is erected for six species of *Purana.* The group is regarded as monophyletic on account of the following assumed apomorphous characters: anterior longitudinal vein of 5th apical area about three quarts as long as anterior longitudinal vein of 7th apical area (in other species of *Purana* these are near equal in length), the presence of a pair of conical basal protrusions of the uncus, the absence of a small dorsolaterally bent hook on the lateral proces of the pygofer (in all other species of Leptopsaltriaria this hook is more or less prominent), and widely separated uncus lobes.

Relationships of the *Purana nebulilinea* group

The sister group of the *nebulilinea* group is a supposedly monophyletic group consisting of the species centered around *Maua quadrituberculata* (Signoret) (such as *M. affinis* Distant) and the species centered around *Purana ubina* (such as *P. celebensis* and *P. guttularis* Walker). This sister group relationship is suggested by the following assumed apomorphous characters: fifth apical area of tegmen about three times as long as wide (about one and a half to two times as long as wide in other species of *Purana*), basal vein of first apical area parallel with the longitudinal vein of the first apical area, basal vein of 2nd apical area of tegmen outwardly convex, and a fold in lateroventral part of pygofer beside basal pygofer lobes.

Maua quadrituberculata and its relatives and *Purana ubina* and its relatives are regarded to form one monophyletic group on account of the following apomorphous characters: the sidewards rather than downwards pointed abdominal tubercles of the male, the simple short and undivided uncus, and the position of the basal pygofer lobes relative to the lateroventral part of the pygofer which is intermediate between the species of the *nebulilinea* group and other species of *Purana.*

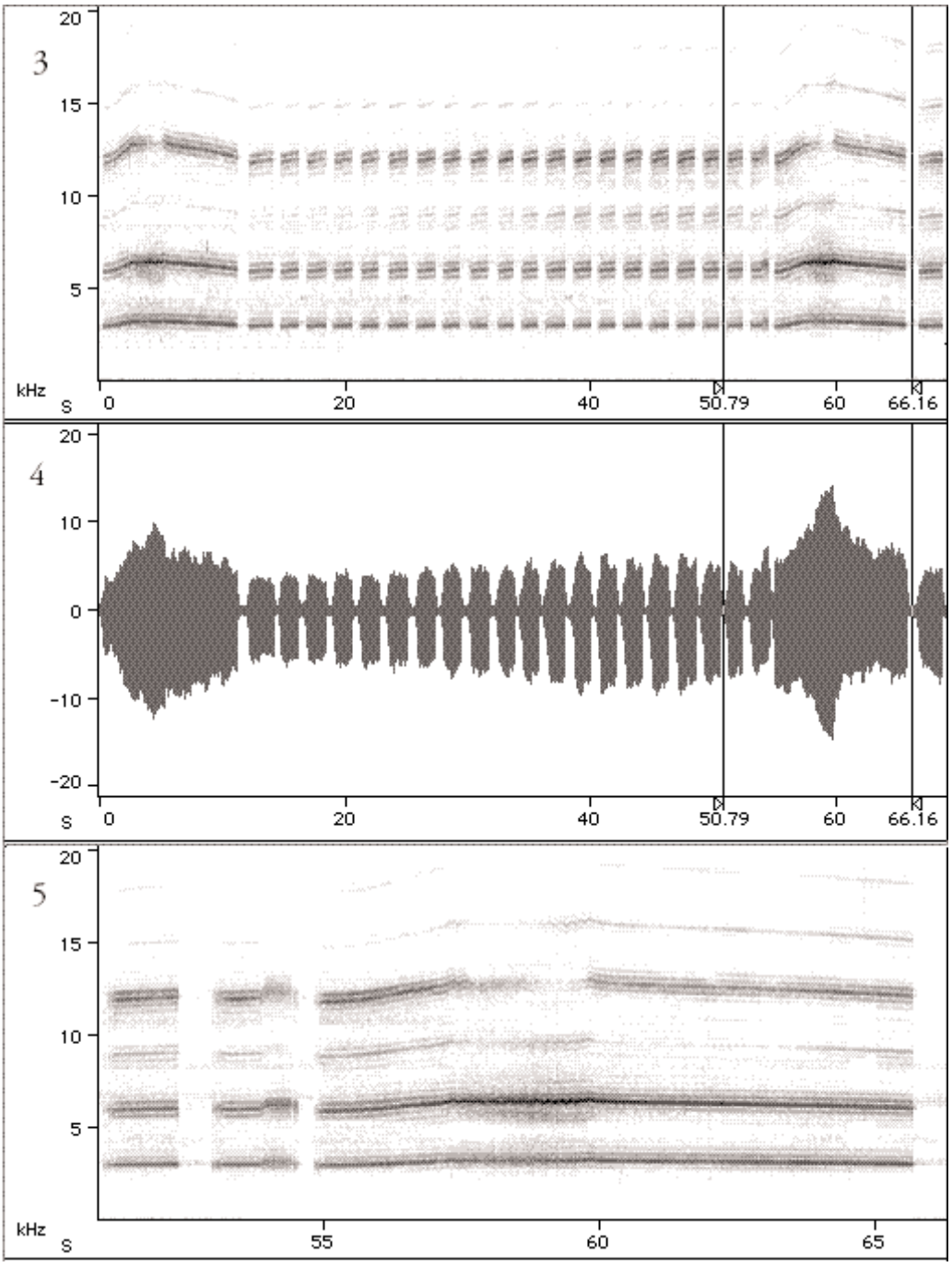
The conclusion is that *Purana* is paraphyletic with regard to *Maua*, which should be synonymized with *Purana* to obtain a taxonomy that reflects the phylogenetic relationships.

However, pending a revision of *Purana* and *Maua* no attempt is made here to use these preliminary findings to classify the discussed groups in a more natural way.

Phylogenetic analysis

A phylogenetic analysis was carried out to investigate the relationships within the *P. nebulilinea* group. The characters used are discussed below and the matrix is given in table 1.

1. Dark band at margin operculum narrow or absent (0) (figs. 33, 37); broad (1) (figs. 19, 23, 26, 30).
2. Distance between opercula at point of closest approximation 0.4-0.6 times as wide as distance at basal constrictions (0) (figs. 19, 23, 33, 37); distance between opercula at point of closest approximation 0.1-0.3 times as wide as distance at basal constrictions (1) (figs. 26, 30).
3. Mesonotum unicolorous (0) (figs. 18, 32, 36); bicolorous, castaneous between cruciform elevation and obconical areas, remaining parts ochraceous (1) (figs. 22, 25, 29).
4. Medial V-mark on pronotum in front of pronotal collar reduced or absent (0) (figs. 18, 22, 32, 36); distinctly present (1) (figs. 25, 29).
5. Dark band on anterior arms of cruciform elevation present (0); absent (1).
   Comment. – Absent is intended to mean that there really is no trace of such a band. Those species with a dark band show considerable variation among individuals, with a distinct or a hardly visible dark band usually only on posterior sides and undersides of anterior arms of cruciform elevation and not visible in dorsal view.
6. Position of basal pygofer lobes relative to lateroventral part of pygofer: basal pygofer lobes not pressed



Figs. 3-5. Song of *Purana nebulilinea* from Temengor Forest Reserve, Hulu Perak. – Oscillogram (4) and sonograms (3, 5) of a typical phrase. In fig. 5 a sonogram of a selection (50.79 - 66.16 s) from the same phrase with the last two long echemes and a very long echeme in a phrase is shown.

against sides of pygofer (0); basal pygofer lobes pressed against sides of pygofer (1).
Comment. – In *P. tigrina* the lobes are completely separated from the pygofer, in *M. quadrituberculata* and *P. ubina* the lobes are clearly connected with the lateroventral part of the pygofer but there is still space between lobes and pygofer (0); in the *P. nebulilinea* group, except for *P. parvituberculata*, the basal pygofer lobes are laterally pressed against the pygofer (1).
7. Basal pygofer lobes straight or gradually bent (0) (figs. 39, 40, 43, 44); apex abruptly bent dorsomedially (1) (figs. 41, 42).
8. Caudodorsal beak short or long, gradually narrowing towards pointed tip (0); long but equally wide along its length except for pointed tip (1).

The analysis (exhaustive search) resulted in two most parsimonous trees that differ in the position of *P. nebulilinea* and *P. niasica*. This is caused by the conflicting characters 1 and 5, which respectively make *P. nebulilinea* the sister-species of *P. pryeri*, *P. montana* and *P. capricornis* (fig. 1) or the sister species of *P. niasica* (fig. 2).

Biogeography and ecology

The distribution of the genus *Purana* includes the greater Sunda islands, Philippines, Peninsular Malaysia, Thailand, India, Indo-China, China and Japan, with just one species, *P. celebensis* from Sulawesi, recorded east of Wallace's line.

The *nebulilinea* group is found in North Laos, Peninsular Malaysia, Sumatra and Borneo. *P. capricornis*, *P. montana* and *P. pryeri* are endemic to Borneo. *P. nebulilinea* occurs in Borneo, Sumatra and Peninsular Malaysia, *P. niasica* is endemic to Pulau Nias, and *P. parvituberculata* is described from North Laos.

P. nebulilinea has a wide ecological amplitude and is found in habitats as different as virgin lowland tropical rainforest and public parks in downtown Kuala Lumpur. The endemic Bornean species show some separation in the altitudinal range they occupy: *P. pryeri* is confined to lowland, *P. montana* to hills and mountains (only one specimen taken below 900 m) and *P. capricornis* occurs over a wide range of altitudes (table 2). In Borneo all possible species pairs, except *P. montana* and *P. pryeri*, are recorded from the same collecting event. In the Long Pa Sia area , three species, *P. nebulilinea*, *P. capricornis* and *P. montana*, were collected together at 1000 m.

Table 2. Altitudinal ranges of the Bornean species of the *Purana nebulilinea* group.

P. pryeri	50-150 m
P. nebulilinea	150-1220 m
P. montana	300-1790 m
P. capricornis	50-1790 m

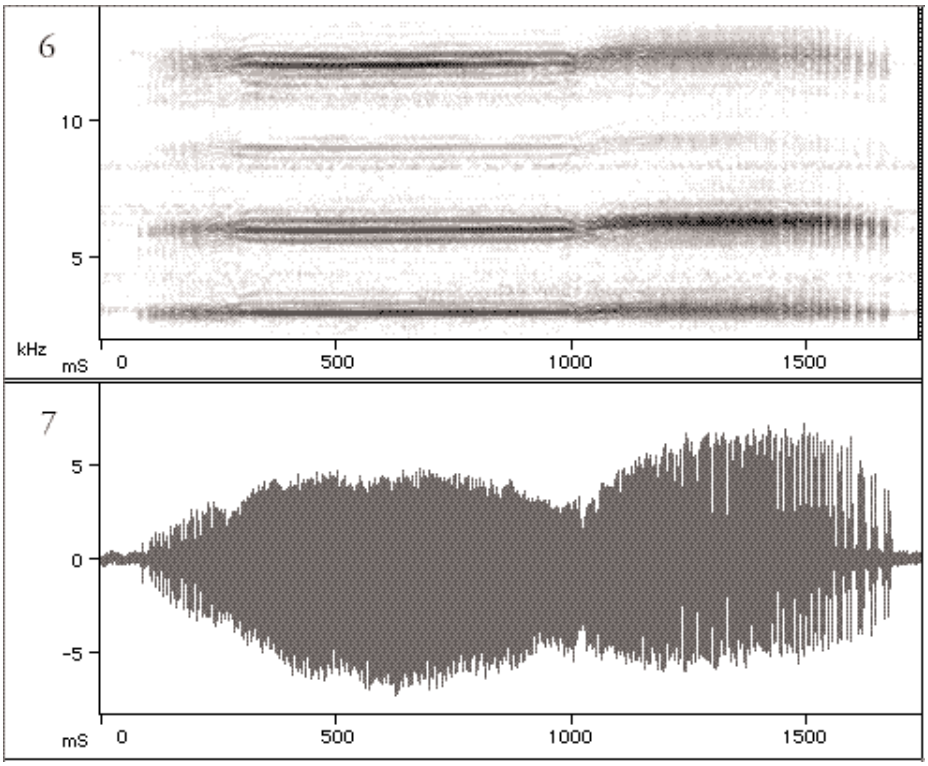
Bioacoustics

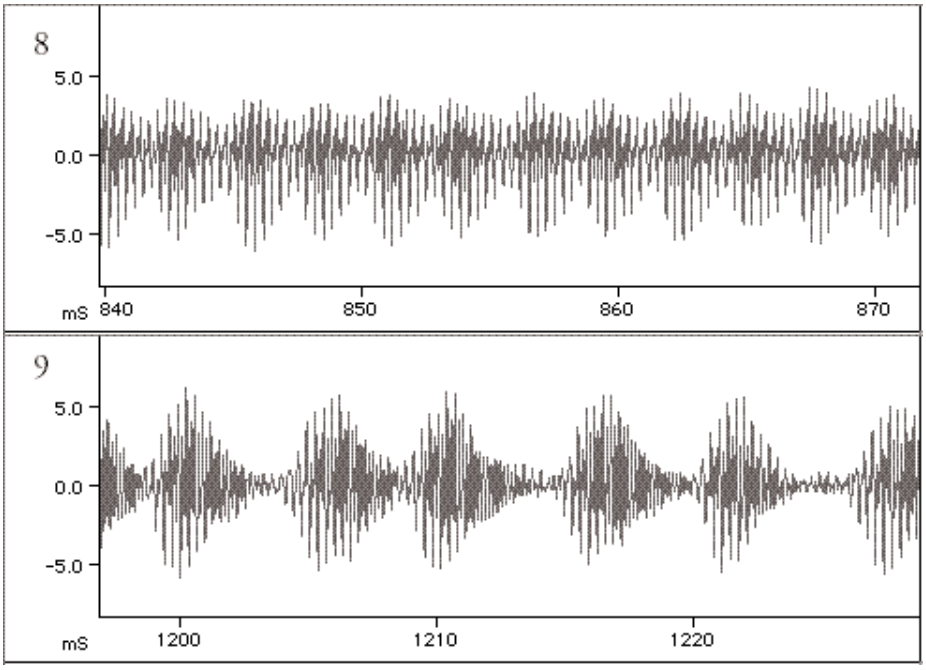
The only species of this group for which we are able to describe the song is *P. nebulilinea*. The high pitched calling song of this species consists of long repeated phrases (duration 47.7 ± 9.7 s). In each phrase there are 6-26 long echemes (LE) (duration 1.7 ± 0.5 s) separated by pauses of 0.9 ± 0.3 s duration. The first and the last LE in a phrase are longer (2.4 ± 0.7 s and 2.3 ± 0.6 s respectively) and the second half of the last one has different structure and spectrum ('distorted part', see below). Each phrase ends with a very long echeme (VLE) (duration 13 ± 2 s) and the middle part of it has again a different 'distorted' spectrum, similar to the second part of the last LE (figs. 3-5, 6-7, 10-15).

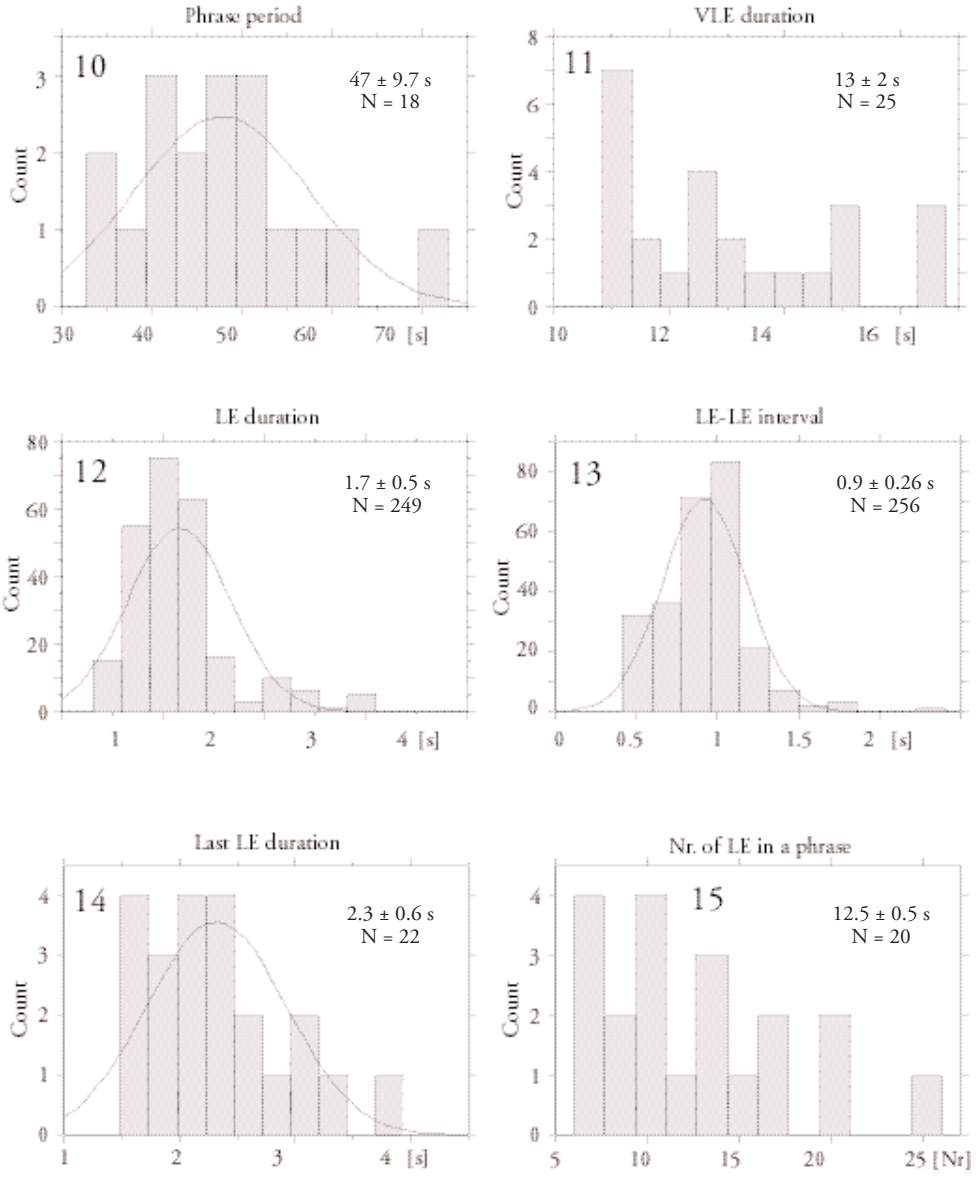
Spectral properties of these sounds are very characteristic. The spectrum shows basic and usually dominant frequency at 2.8 ± 0.3 kHz and 3 prominent higher harmonics, of which the first and third harmonics have in most parts of the song the second highest amplitudes. In so called 'distorted' parts of the song the first harmonic is usually dominant (fig. 5). The spectrum is, with the exception of these distorted parts, very narrow banded such as in songs of some other *Purana* species (Gogala 1995) with side bands caused by a pulsed structure of the song (Gerhardt 1998). The repetition frequency of pulses is around 380 Hz and so is the distance of side bands in sonograms (figs. 3, 5, 6). In 'distorted' parts of the song the pulse repetition is irregular and therefore the frequency peak is broader and less defined in these parts of sonograms (figs. 6, 8, 9).

Another characteristic of the song are slow frequency sweeps to higher frequencies in every LE, starting always with the same initial basic frequency around 3 kHz and rising to approximately 1% higher value at the end of each LE. The first part of the VLE starts also with the same initial frequency and a glissando up to an about 10% higher value, then follows the 'distorted' part with the more or less unchanged broad frequency band. In the last part of the VLE with the sharply peaked spectrum the frequency decreases from the highest value to the lower frequency, which remains somewhat higher compared to the initial one (figs. 3, 5). The glissandos and the presence of 'distorted' parts in the last LE and in the VLE are very characteristic and easily recognizable features of the *P. nebulilinea* song, which can even be heard easily in the field.

We recorded these songs in Bangi (University campus), Kuala Lompat, Pasoh, in Temengor Forest re-

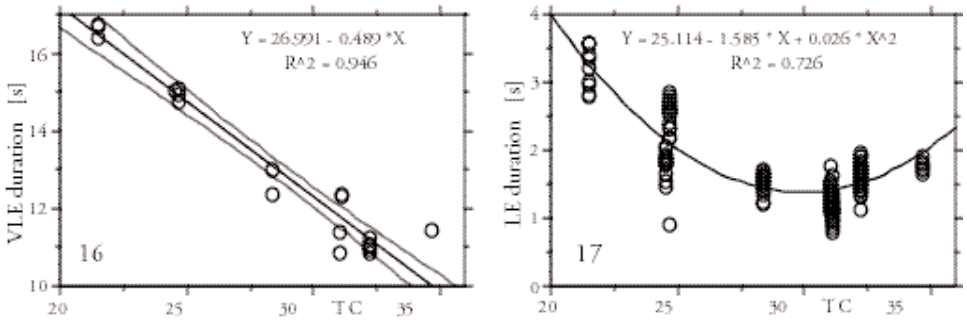

6
10
5
kHz
mS
0
500
1000
1500
7
5
0
-5
mS
0
500
1000
1500


8
5.0
0.0
-5.0
mS
840
850
860
870
9
5.0
0.0
-5.0
mS
1200
1210
1220



Figs. 6-9. Song of *Purana nebulilinea* – Oscillogram (7) and sonogram (6) of a last long echeme in a phrase, with different structure and spectrum in the first and the second part of echeme. The second 'distorted' part starts at the 1000 ms mark. – 8-9, Oscillograms of selected parts of a last long echeme in a phrase shown in fig. 7. – Song pulses of the first part (8) are repeating regularly, and in the second 'distorted' part (9) irregularly. The carrier frequency of pulses is in both parts of echeme more or less the same.

Figs. 10-15. *Purana nebulilinea* - time parameters of the calling song. – Histograms of 10) phrase period duration, 11) very long echeme duration, 12) long echeme duration, 13) interval between long echemes, 14) duration of last long echeme and 15) number of long echemes in a phrase. Sample sizes, means, and standard deviations are shown in figs. 10-15.



Figs. 16-17. Temperature dependence of very long echeme (16) and long echeme duration (17). – A linear regression line represents best the relation between VLE and a temperature and a polynomial regression the dependence of long echemes LE and the ambient temperature (STATVIEW 4.5).

serve near the Base Camp of the Belum Expedition in 1994 and in the site Kuala Juram in Taman Negara near Merapoh. *P. nebulilinea* began to sing early in the morning around 7.20 and remained acoustically active during the day till late afternoon around 17.00. Dependent on locality and the time of the day, ambient temperature can vary greatly and some of the time parameters of the song (e.g. LE and VLE duration) vary in relation to this factor. The duration of LE and VLE in relation to temperature are shown in figs. 16-17.

Unfortunately, we do not know yet, how other species of the *P. nebulilinea* group sing. Recently (1999), T. Trilar from Slovenian Natural History Museum in Ljubljana collected and recorded some species of *Purana* in Sabah (Borneo), but the material has not been studied yet. Therefore we can compare the described song only with songs of a few other related species of cicadas. The most similar, but nevertheless clearly distinct song, we recorded in April 1993 in Tale Ban national park in Thailand. It also consists of series of LE's followed by one VLE, with similar frequency spectrum, similar phrase duration and other time parameters. Nevertheless, the frequency sweeps in LE's following the initial rising phase are directed downwards, from higher to lower frequencies, and there are no 'distorted' parts to the song. We were not able to catch and identify these cicadas. Despite the suitable time, we did not find any typical songs of *P. nebulilinea* in our recordings from Thailand (Ko Tarutao, Tale Ban, Ta Mode and Northern Thailand).

The only species of *Purana,* for which the song has been previously described, is *P.* aff. *tigrina* from Ko Tarutao (Gogala, 1995). It has very long, complicated phrases which do not resemble the *P. nebulilinea* song in rhythmic pattern. Nevertheless, the spectrum shows similar narrow frequency bands, similar basic frequency and again a slow frequency sweep or glissando to higher frequencies in the first part of a sequence. Also, the sudden change to broad band spectrum in some parts of the song both species have in common. We have unpublished data about some other species of *Purana*, and most of these share some characteristics with the described songs of *P.* aff. *tigrina* and *P. nebulilinea.* These characteristics are very long song phrases, general spectral properties and sudden changes to broad band signals in certain parts of the song. Nevertheless, all investigated *Purana* species have definite species-specific song patterns.

TAXONOMY

Characterisation of the *Purana nebulilinea* group

The species of the *nebulilinea* group are small to medium-sized cicadas: ♂: 19.8-33.5 mm, ♀: 19.6-25.4 mm. Body generally ochraceous to reddish brown, sometimes with a greenish tinge on parts of thorax especially in fresh specimens; my own observations of *P. nebulilinea* in the field confirmed that specimens keep their natural colours after preservation. Markings on head and thorax present but often faint; in the species endemic to Borneo markings on mesonotum usually fused with castaneous coloration. Head with rather complex pattern of thin lines, and ocelli surrounded by black. Anterior margin of pronotum medially with narrow black band. Posterior margin of pronotal collar with narrow black band. Mesonotum markings usually consisting of a median fascia, paramedian fasciae and a variable number of lateral spots of different shapes and sizes. Mesonotum with long, bristly, golden setae laterally of and between anterior angles of cruciform elevation. Tegmina hyaline, slightly bronzed especially in apical part, infuscations at the basal veins of second, third and fifth apical areas and at

the apices of longitudinal veins of the apical areas. Venation in basal half ochraceous with some black parts, in apical part brownish to black. Male opercula short, not reaching beyond anterior pair of tubercles, about as long as broad, not touching medially. Posterior margin of tergites always with narrow black band. Dorsal parts of tergites are covered with small golden setae, densest at posterior margin and getting less dense anteriorly. All species have two pairs of dark ventral abdominal tubercles, on third and fourth sternites. Eighth sternite rather flat, not (sharply) folded as in other species of *Purana.* Uncus of male genitalia with a pair of small conical basal protrusions. Separated, parallel uncus lobes, not widening towards the rounded apices, are found in all species except *P. capricornis.*

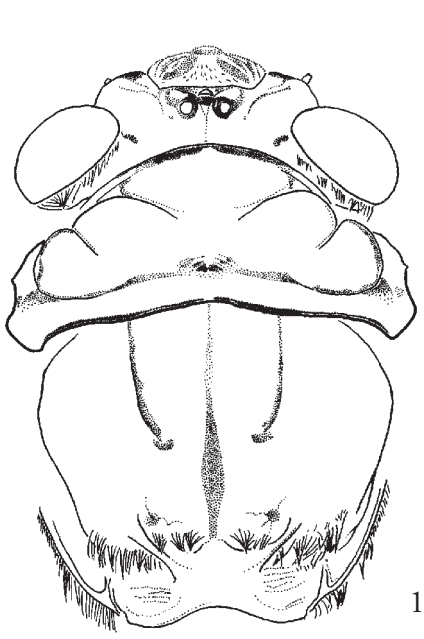
Key to the males of the *Purana nebulilinea* group

1. Operculum unicolorous (fig. 37) ....*P. parvituberculata*
– Operculum with dark band at medial margin (figs. 19, 23, 26, 30, 33) 2
2. Mesonotum ochraceous (figs. 18, 32, 36) 3
– Mesonotum ochraceous, but medial area castaneous (figs. 22, 25, 29) 4
3. Operculum with fairly narrow to broad dark band along whole median margin (fig. 19). Tegmen length 33.2-36.7 mm ..... *P. nebulilinea*
– Operculum with very narrow dark band along proximal part of median margin (fig. 33). Tegmen length 28.2-29.7 mm ..... *P. niasica*
4. Shortest distance between opercula 0.4-0.6 times as wide as maximum distance between opercula at basal constrictions. Operculum as long as or longer than broad (fig. 23). Pronotal disc with black band in front of pronotal collar (fig. 22) ... .*P. pryeri*
– Shortest distance between opercula 0.1-0.3 times as wide as maximum distance between opercula at basal constrictions. Operculum as long as or shorter than broad (figs. 26, 30). Pronotal disc with V-shaped mark in front of pronotal collar (figs. 25, 29) 5
5. Whole margin of operculum with broad to narrow black band (fig. 26). Base of 7th apical area of tegmen not infuscated. Tegmen length 38.2-42.8 mm. Uncus lobes long with pointed apices .....*P. capricornis*
– Lateral margin of operculum only distally with black band (fig. 30). Base of 7th apical area of tegmen usually infuscated. Tegmen length 42.4-47.0 mm. Uncus lobes short with rounded apices .....*P. montana*

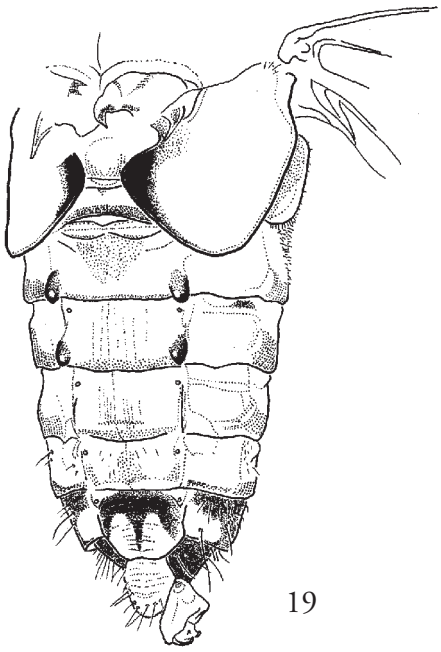
Purana nebulilinea (Walker, 1868)
(figs. 18-20, 24, 39)

Dundubia nebulilinea Walker, 1868: 84. – Holotype ♀: '*nebulilinea*' [Walker's handwriting], 'Sumat / Wallace' ['Sumat' handwritten, 'Wallace' printed], 'Type' [printed on round label with green margin] (BMNH) [examined].
Leptopsaltria nebulinea [sic!]; Distant 1889: 33; Distant 1891: pl. VIII, figs. 17, 17a-b; Distant 1892: xi.
Purana nebulilinea; Distant 1906: 51; Moulton 1911: 132; Distant 1912: 41; Schumacher 1915: 110; Moulton 1923: 120, 123; Moulton 1929: 120; Kato 1932: 161; Metcalf 1963: 468; Zaidi & Ruslan 1995: 68; Zaidi 1997: 109, 112, 113; Zaidi & Ruslan 1997: 222.

Other material examined. – MALAY PENINSULA: PENINSULAR MALAYSIA: Bangi, Selangor, 11.xi.1988, Ismail & Md. Nor, 1♂ (PSS); Gombak Valley, Selangor, 25.xi.1921, light, 1♂ (BMNH); Gunung Jerai [Kedah Peak], 3000', xi-xii.1915, H. C. R. & C. B. H., 1♀ (BMNH); Jor Camp Iapoh, Batang Padang, Perak, 25.ii.1925, H. M. Pendlebury, 1 ♂ (BMNH), same data, 1500 ft., 26.v.1923, 1♂ (BMNH); Kuala Lumpur, 19.xi.1922, 1♀ (BMNH); Kuala Lumpur, 27.x.1924, H. M. Pendlebury, 1♀ (BMNH), same data, 3.i.1925, 1♂ 1♀ (BMNH), same data, 8.ix.1934, 1♂ (BMNH); Kuala Lumpur, near L. Gardens, 19.ix.1934, H. M. Pendlebury, 1♂ (BMNH), same data, 11.viii.1938, 1♀ (BMNH); Kuala Seku, Pahang, 550', iii.1921, E. Seimund, 1♂ (BMNH); Kuala Tahan, Pahang, 10.ii.1921, E. Seimund, 1♂ (BMNH); Melaka [Malacca], Fry, 1 ♂, 4 ♀ (BMNH); Pasoh, Negeri Sembilan, 28.x.1991, Zaidi, Ruslan & Abin, 2 ♀ (PSS); Pasoh Forest Reserve, 0.9km ENE station quarters,10 km W. Ayer Hitam, N. Sembilan, 350 m, 8.xii.1996, M. Kos & S. Azman, trail between primary forest and buffer zone, at light, 1♀ (ZMA), same data, 9.ii.1997, M. Kos, 1♀ (ZMA), same data, 0.3 km ESE station quarters, 12.ii.1997, M. Kos, buffer zone of regenerating forest (selectively logged), 1♂ (ZMA), same data, 2.2 km NNE station quarters, 300 m, 10.iii.1997, M.Y. Ruslan & S. Azman, Primary forest. Old tree tower W-side 50 ha plot. 1♀ (ZMA); Railway Track, 50 km, Rompin Mining Co., S. E. Pahang, 7.iv.1961, T. C. Maa, 1♀ (BPBM), same data, 28.v.1961, 1♀ (BPBM); Selangor, 1♂ (BMNH); Tasik Cini [Tasik Chini], Pahang, 12-14.v.1993, Zaidi, Ruslan, Kudin, 1♀ (PSS); Tasik Cini, Pahang, 26.ii.1992, Badrol & Absan, 4♂ (PSS). – SINGAPORE: Singapore, Atkinson?, 1♀ (BMNH); Singapore, 1♂, 1♀ (BMNH). – BORNEO: MALAYSIA, SABAH: confluence Sg Pa Sia - Matang, Long Pa Sia area, 105 km S of Beaufort, 1000 m, 1.iv.1987, J. van Tol & J. Huisman, 1 ♂ (RMNH); Lembah Danum, 3.iv.1989, Salleh, Ismail & Nor, 2♀ (PSS); MALAYSIA, SARAWAK: Mt. Dulit, 4000 ft., 14.ix.1932, B.M. Hobby & A. W. Moore, Oxford University Expedition, Moss forest, 1♂ (BMNH); Mt. Penrissen, 2000 ft., v.1910, C.J. Brooks, 1♀ (BMNH); Sarawak, 1865, G. Doria, 1♀ (BMNH); Semenggok [Semongok], 1.iii.1937, G. H. L. Rothschild, Light Trap, 1 ♀ (BMNH); W. Melinau Gorge, Gunong Mulu Nat. Park, 150 m, iii-iv.1978, J. D. Holloway, 1♂ (BMNH); INDONESIA, KALIMANTAN: Pulau Serasan [Pulau Serassan], Kepulauan Natuna [South Natuna], 18.viii.1931, P.H. de Fontain, 1 ♂ (BMNH), same data, 24.viii.1931, 1♂ (BMNH); Borneo: Borneo, 1♀ (BMNH); Borneo, Muller, 1♂ (RMNH); Borneo, Schwaner, 1♂ (RMNH); Borneo, Xánthus, 1♀ (TMB). – INDONESIA, SUMATERA: Aur Kumanis , iii.1914, E. Jacobson, 1♂, 1♀ (RMNH), same data, 1♂ (ZMA); Bivouac One, Mt Bandahara, N Sumatra, 3°43' N - 97°41' E, ca 810 m, 25.vi-5.vii.1972, J. Krikken, 1♂ (RMNH); Kuala Simpang,



18



19

Figs. 18-19. *Purana nebulilinea*, male, Peninsular Malaysia, Pasoh Forest Reserve. – 18, head and thorax in dorsal view; 19, abdomen in lateroventral view.

N.E. Sumatra, vi.1953, lowland forest, A. Sollaart, 1♂, 1♀ (RMNH), same data, 1♂ (ZMA), same data, iv.1954, 1♂ (RMNH); Sumatra, Muller, 1♂ (RMNH); Pulau Tello, West Sumatra, xi.1924, C. B. K. & N. S., 1♀ (BMNH); Tanahmasa [Tanah Massa], Pulau Pulau Batu [Batoe eilanden], ix.1896, I. Z. Kannegieter, 1♀ (RMNH).

The pattern of markings on head and thorax in this species is rather variable but usually most markings are very faint, and some, like the median fascia, can be completely absent. The males of this species can be separated from the males of other species of the *nebulilinea* group by their triangular, instead of rounded, opercula, leaving uncovered a relatively large part of the timbal cavity in lateroventral view (fig. 19).

In the shape of the male opercula *P. nebulilinea* is somewhat akin to *P. pryeri*, though the latter species has more elongated opercula.

Description

Head (fig. 18). – Olivaceous to ochraceous. A small tongue-shaped brown spot at median corner of eye often absent or very vague. Ocelli surrounded by black. Black areas at lateral sides of paired ocelli extending forwards in two slightly diverging narrow, brown lines, inwardly curved just before clypeal suture and connected to black area lateral of median ocellus; parallel to posterior part of these lines a pair of Y-shaped figures with outer arms longer than inner arms, the latter sometimes connected with brown to black upper sides of supra-antennal plates. Postclypeus with series of 9-10 short, transverse brown streaks on both sides. Genae usually with faint dark spot or streak just below antennae, bordering lateral clypeal cleft. Inner margin of mandibular plate black around clypeal suture. Anteclypeus with a pair of large brown spots. Rostrum ochraceous, gradually darkening to brown towards apex, apex black and reaching beyond hind coxae.

Thorax: Pronotum (fig. 18). – Olivaceous to ochraceous, pronotal collar paler than rest of pronotum and mesonotum. Two narrow brown fasciae diverging and fading from posterior ends of anterior oblique fissures towards anterior margin of pronotum, but fasciae sometimes absent. Pair of small, crescent-shaped to oval or round, black to brown, spots in front of pronotal collar often fused and sometimes extending onto pronotal collar. Anterior margin of pronotal disc entirely or only medially black; anterior side of posterior part of pronotal fissure black, black coloration sometimes absent lateral of spots in front of pronotal collar, distally this black coloration turns brown, and extends on pronotal collar in a small, triangular, brown spot at posterolateral corner of lateral lobe of pronotal disc. Anterolateral of this spot a smaller brown spot. A very

narrow brown line, running along lateral margin of lateral lobe of pronotal disc from anterior end of posterior oblique fissure and either ended just before pronotal suture or continued to spot at posterolateral corner of lateral lobe of pronotal disc. Posterior margin of pronotal collar narrowly black. Lateral tooth short and sharply pointed; this tooth and margin of lateral part of anterior corner of pronotal collar rarely dark brown on dorsal and ventral side.

Mesonotum (fig. 18). – Olivaceous to ochraceous. Median fascia dark brown and narrow to very narrow along its whole length, occasionally broader at cruciform elevation, widening to two times its posterior width just below posterior ends of paramedian fasciae and than gradually narrowing towards pronotal collar; the fascia is sometimes absent. Paramedian fasciae very narrow, inwardly curved and dark brown. Lateral fasciae absent or consisting of one or two pairs of lateral spots. A pair of small round blackish brown spots in front of anterior angles of cruciform elevation.

Tegmina and wings. – Hyaline, basal cell ochraceous, apical part of tegmina lightly bronzed. Venation in basal half ochraceous with some black parts, in apical part brownish to black. Tegmina with infuscations at basal veins of second, third and fifth apical areas, infuscation at base of fifth apical area usually faint or absent. Longitudinal veins of the apical areas of tegmina with faint apical spots.

Legs. – Fore femora olivaceous to ochraceous, with three anteroventral spines, proximal spine, at about two fifths from base, strongest, long and needle-shaped; middle spine at about four-fifths from base more triangular, shorter than proximal spine; distal spine immediately adjacent to middle spine, one third to half as long as middle spine, apex blunt to pointed. Spines and areas between spines and around distal spine dark brown to black. Fore tibiae brown, distally darkened; fore tarsi brown, darkening distally. Mid femora olivaceous to ochraceous; mid tibiae dorsally light to dark brown, ventrally ochraceous with light band from one fourth of length from base to about half length where it gradually darkens to brown; mid tarsi dark brown, olivaceous to ochraceous at extreme basal part. Hind legs ochraceous, hind femora sometimes with three thin dark longitudinal stripes, hind tibiae darkened at base.

Male operculum (fig. 19). – Short, triangular, 1.0-1.2 times as long as broad (n = 8), apex subacutely rounded and reaching to one third of third abdominal segment. Lateral and median margins straight to slightly convex; timbal cavity clearly visible in lateroventral view. Distance between opercula at point of closest approximation 0.45-0.57 (n = 8) times as wide as distance at basal constrictions. Olivaceous to ochraceous; medial margin with rather narrow to broad black to brown band, which is sometimes partly covered with white wax (fresh specimens); dark coloration not reaching apex.

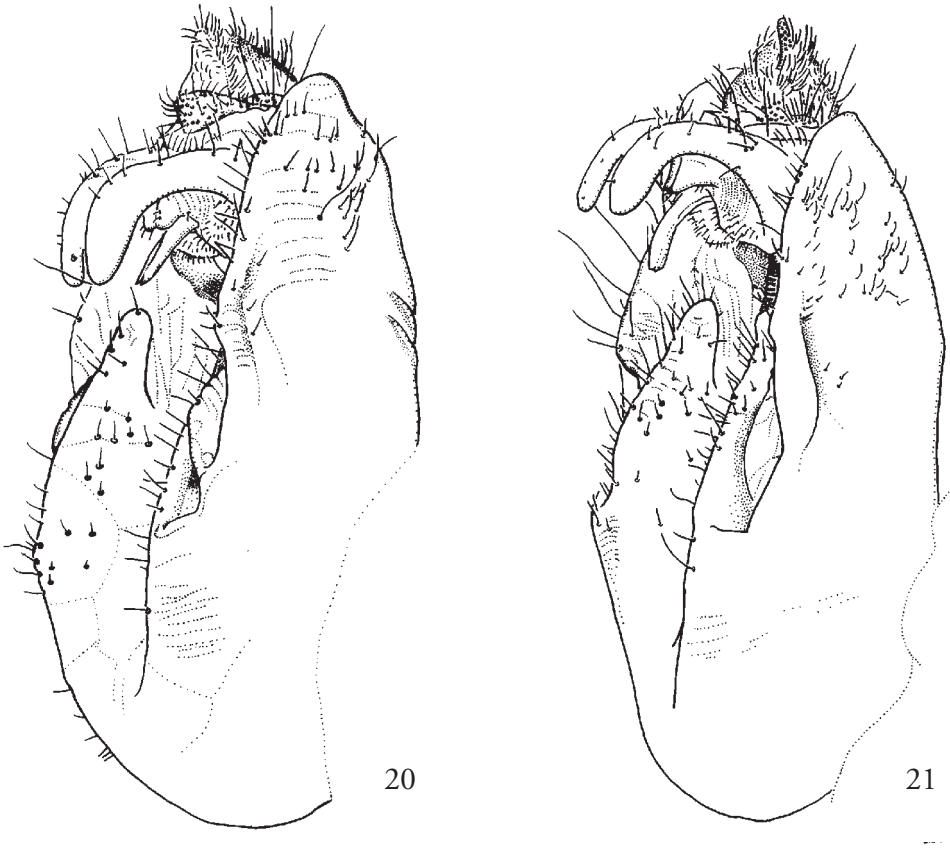
Male abdomen. – 0.9-1.0 times (n = 5) as long as head and thorax together. Upper side olivaceous, ochraceous in old specimens, posterior margins of tergites narrowly black. Underside (fig. 19) light ochraceous. Third sternite with central dark brown, triangular spot. Third and fourth sternites with pair of well developed, glossy, black tubercles. Seventh sternite entirely darkened or with only anterior third black and paler two-third with median stripe narrowing to the posterior.

Male genitalia (figs. 20, 39). – Basal lobes of pygofer narrow and long, slightly widened and bent inwards at rounded apices, reaching to two thirds of total pygofer length. Uncus with a pair of short lobes that remain equally wide to the rounded apices, and a pair of basal conical protrusions with apices rounded in lateral view and anterior and posterior margins convex.

Female operculum. – Very short, reaching posterior margin of second abdominal segment. Hind margin concave, lateral margin convex; laterodistal corner angularly rounded. Light to dark olivaceous to ochraceous, mediodistal corner darkened, dark coloration often extended around meracanthus; anterior margin and proximal part of lateral margin often with narrow dark band as well. Surface covered with minute golden setae, lateroproximal corner with tuft of long setae and some long setae scattered along proximal half of lateral margin, setae on medial and anterior margins often covered with powdery white wax.

Female abdomen. – (0.6) 0.8-1.0 times (n = 13) as long as head and thorax together. Ground colour ochraceous. Upper side with posterior margins of tergites narrowly black, and sometimes with a lateral row of small triangular black spots at anterior margins of tergites. Basic pattern on sternites consisting of dark brown coloration along posterior and lateral margins, a central longitudinal stripe on fourth to seventh sternites, and a triangular spot at anterior margin on third sternite, but usually the sternites are dark with only a pair of ochraceous spots at anterior margin. Scattered long, dark spine-like setae on sternites, eighth tergite and ventral part of seventh tergite. Eighth tergite in fresh specimens entirely covered with powdery white wax, ventral parts of seventh tergite sometimes also completely covered with wax.

Margins of lateral sides of pygofer and distal (visible) part of ovipositor sheath dark brown. Central part of lateral side of pygofer ochraceous to olivaceous, with some dark streaks from ventral margin. Dorsodistal part of pygofer covered with powdery white wax. Dorsal margin of pygofer in lateral view slightly concave, ventral margin slightly convex. Ovipositor sheath and anal valve not reaching apex of medial dorsal spine. Pygofer scattered with very long



Figs. 20-21. Male pygofer and uncus in lateroventral view. – 20, *Purana nebulilinea*, Peninsular Malaysia, Pasoh Forest Reserve; 21, *Purana pryeri*, Sarawak, West Melinau Gorge.

dark setae and apex of ovipositor sheath with a bundle of similar setae.

Measurements in mm (17 ♂, 13 ♀). – Body length ♂: 24.0-26.5 (25.2 ± 0.8), ♀: 22.0-25.6 (23.8 ± 1.4); head width ♂: 8.1-8.9 (8.6 ± 0.3), ♀: 8.0-9.2 (8.6 ± 0.4); pronotum width ♂: 8.7-9.8 (9.4 ± 0.3), ♀: 8.5-10.2 (9.3 ± 0.6); mesonotum width ♂: 7.6-8.6 (8.1 ± 0.3), ♀: 7.3-8.9 (8.1 ± 0.5); tegmen length ♂: 33.2-36.7 (35.4 ± 1.0), ♀: 32.5-38.1 (35.0 ± 1.8).

Distribution (fig. 24)

Peninsular Malaysia, Sumatra, Borneo and nearby smaller islands.

Purana pryeri (Distant, 1881) **sp. rev.**
(figs. 21-23, 24, 41)

Leptopsaltria pryeri Distant, 1881: 633. – Holotype ♂: 'N. Borneo / Pryer.' [handwritten]; 'Type' [printed on round label with red margin]; '*pryeri* / Dist.' [Distant's handwriting]; 'Distant - Coll / 1911 - 383' [printed] (BMNH) [examined].

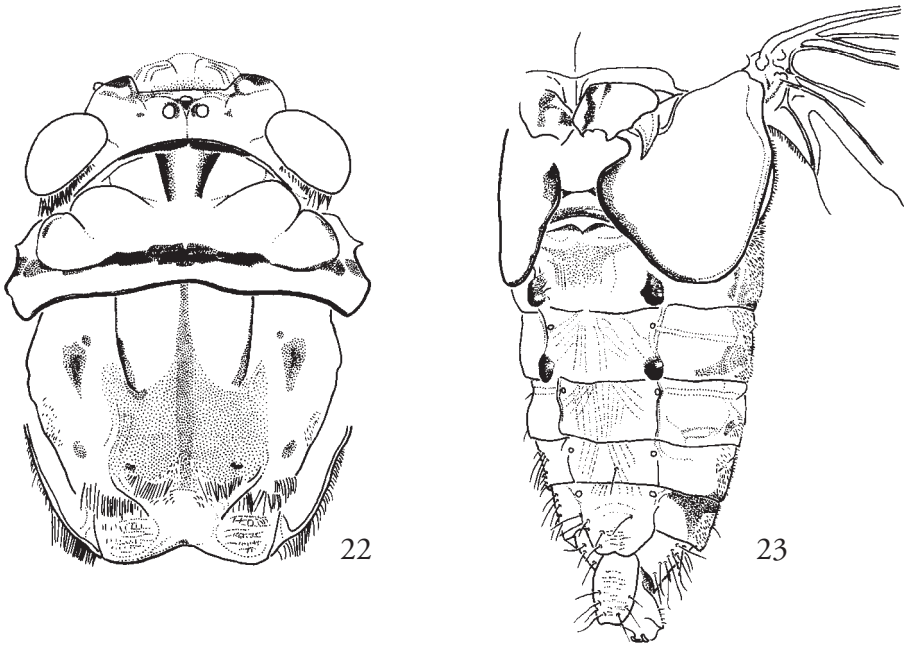
Leptopsaltria pryeri; Distant 1889: 35; Distant 1891: pl. VIII, figs. 12, 12a-b; Distant 1892: xi; Kirkaldy 1913: 9.

Purana pryeri; Distant 1906: 51; Moulton 1911: 131; Distant 1912: 40; Moulton 1923 (as synonym of *P. nebulilinea*); Kato 1932: 161; Metcalf 1963: 469; Duffels & van der Laan 1985: 107; Zaidi & Ruslan 1995: 64, 68; Zaidi & Ruslan 1997: 217, 218, 222, 223.

Paruna [sic!] *pryeri*; Orian 1963: 327, fig. 4c,d.

The holotype is from Sandakan, Sabah (Distant 1889). The abdomen (but not the opercula) and genitalia of the holotype are missing. Moulton (1923) synonymized *P. pryeri* with *P. nebulilinea* and since then the status of both species had been unclear. *P. pryeri* is here taken out of synonymy with *P. nebulilinea*.

Other material examined. – BORNEO: MALAYSIA, SABAH:



Figs. 22-23. *Purana pryeri*, male, Sarawak, West Melinau Gorge. – 22, head and thorax in dorsal view; 23, abdomen in lateroventral view.

Bukit Padang, Kota Kinabalu, 27.viii.1988, Bahiah, 1♀ (PSS), same data, 50 m, 8.viii.1988, Zul. D, 1♂, (PSS), same data, 50 m, 15.x.1988, Lee Lay Wee, 1♂, (PSS); MALAYSIA: SARAWAK: Kuching, N.W. Borneo, 24.vii.1899, Dyak Collector, presented by R. Shelford, 1♀ (BMNH); same data but 25.v.1900, 1♀ (BMNH); same data but 27.vii.1900, 3♀ (BMNH); Kuching, iii.1911, J. C. Moulton, 1♂ (BMNH); Lanjak Entimau, 28-29.ii.1992, Zaidi, 2♂ (PSS); Sarawak, Moulton, 2♀ (BMNH); Sarawak, Wallace, 1♀ (BMNH); W. Melinau Gorge, Gunung Mulu National park, 150 m, iii-iv.1978, J. D. Holloway, 2♂, 2♀ (BMNH), same data, 1♂ (ZMA); BRUNEI: Brunei, N. Borneo, Waterstradt, 2♂, 4♀ (BMNH); Brunei?, N. Borneo, Waterstracht, 1♀ (BMNH); INDONESIA: KALIMANTAN: Pontianak, 15.ix.1922, J. H. Jurriaanse, 1♂ (RMNH), same data, 3.vii.1923, 1♂ (RMNH), same data, 1.x.1923, 1♂ (RMNH); Pontianak, Max Weber, Borneo Exp., 1♂ (RMNH); Mt. Tibau [Mt. Tibang], 1925, Mjöberg, 1♂ (ZMA); Tiong Buu (= Nahabuan), 18 km N.W. of Long Kay, S. Mahakam, Kalimantan Timur, 15.iv.1996, R. Sözer, 1♂ (ZMA); Borneo: S.E. Borneo, Malay Archipelago, W. Doherty, 1 ♂, 1 ♀ (BMNH).

P. pryeri is more colourful than *P. nebulilinea*. The most striking character separating *P. pryeri* from the other species of the *nebulilinea* group is the posterior black band on the pronotal disc in front of the pronotal collar, which is medially about 1 mm broad and is narrowing laterally. Area between cruciform elevation and obconical fields dark castaneous, as in *P. capricornis* and *P. montana*. Opercula, which are the longest of all species in the *nebulilinea* group, reach from half to two-thirds the length of third abdominal segment, and almost to or just beyond the first pair of tubercles. Tubercles slightly smaller and more pointed compared to those of *P. capricornis*.

Description

Head. – Pattern of markings on head as in *P. nebulilinea*. Markings more distinct.

Thorax: Pronotum (fig. 22). – Ochraceous sometimes with a greenish tinge, pronotal collar paler than rest of pronotum and mesonotum. Two prominent, short, black fascia diverging from posterior ends of anterior oblique fissures, slightly widen anteriorly and either considerably widen at anterior margin of pronotum or abruptly end just before this margin. Anterior margin of pronotal disc entirely or only medially black, posterior margin bordering pronotal collar with black band, which is widest medially (about 1 mm), narrows laterally, and ends on pronotal collar in brown spot at posterolateral corner of pronotal disc; this spot is usually fused with a smaller anterolateral spot, but these spots are sometimes separated like in *P. nebulilinea*. A short brown line runs along lateral margin of lateral lobe of pronotal disc from anterior end of posterior oblique fissure to shortly before pronotal suture. Posterior margin of pronotal collar narrowly black. Ante-

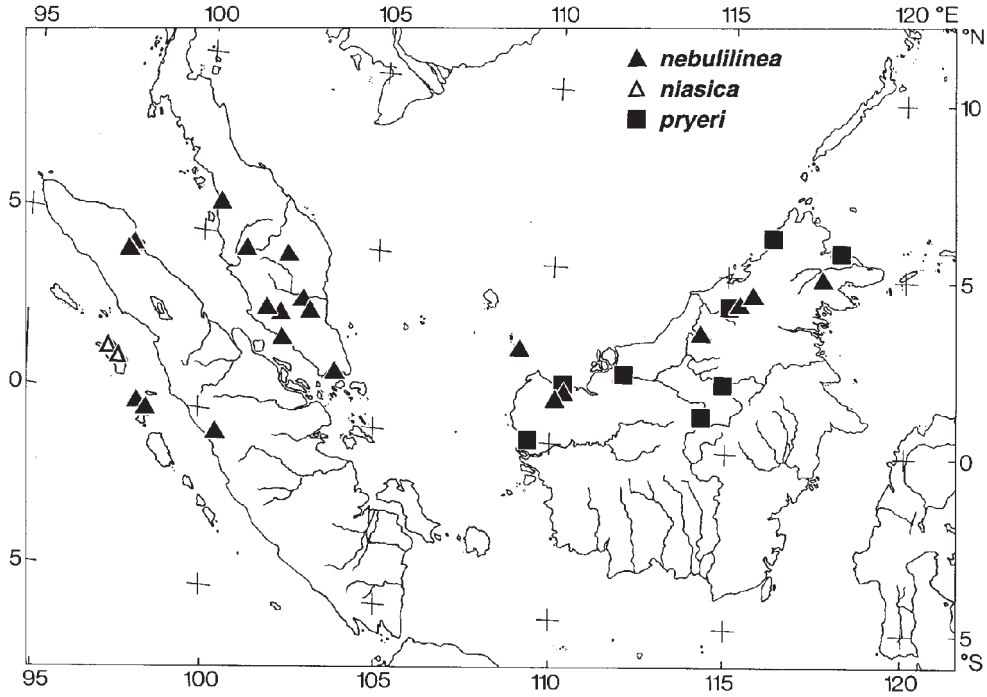


Fig. 24. Localities of *Purana nebulilinea, P. niasica* and *P. pryeri.*

rior corner of pronotal collar slightly angular and rather broad; lateral tooth short and pointed; posterior corner broad and angular. Margin of lateral part of anterior corner of pronotal collar and lateral tooth sometimes dark brown on dorsal and ventral side.

Mesonotum (fig. 22). – Olivaceous to ochraceous sometimes with a greenish tinge; central part castaneous brown from cruciform elevation to obconical areas. Median fascia narrow and dark brown. Paramedian fasciae very narrow, inwardly curved and dark brown. Lateral fascia reduced to one to three pairs of castaneous to reddish brown spots, pair of anterior spots just behind pronotal collar usually absent; pair of middle spots at one third of mesonotum length, large, triangle- or lozenge-shaped; pair of posterior spots at three fifths of mesonotum length usually absent. A pair of small round blackish brown spots in front of anterior angles of cruciform elevation. Anterior arms of cruciform elevation with dark band.

Tegmina and wings. – As in *P. nebulilinea,* but infuscations slightly darker and infuscation at basal vein of fifth apical area more often present and as dark as infuscations at basal veins of second and third apical areas.

Legs. – As in *P. nebulilinea,* but spines and adjacent areas light brown (except for the dark brown to black area around distal spine). Apices of spines sometimes darkened.

Male operculum (fig. 23). – Short, triangular, 1.0-1.1 times as long as broad (n = 5), apex broadly rounded and reaching to half length or two-thirds of third abdominal segment, almost reaching or just passing first pair of tubercles. Lateral margin straight and medial margin slightly convex; timbal cavity hardly visible in lateroventral view. Distance between opercula at point of closest approximation 0.36-0.46 times (n = 5) as wide as distance at basal constrictions. Olivaceous to ochraceous, medial margin with fairly narrow to broad, black to brown band, often passing apex and continuing on distal part of lateral margin.

Male abdomen. – 0.9-1.0 times (n = 5) as long as head and thorax together. Upper side of abdomen castaneous brown, but anterolateral parts of tergites ochraceous and posterior margins narrowly black. Underside (fig. 23) paler, ochraceous to brown, but darker than in *P. nebulilinea.* Third sternite with central dark brown triangular spot. Third and fourth sternites with pair of relatively small glossy, black to brown, somewhat pointed tubercles. Anterior half of seventh sternite brown, distal part paler, sometimes with vague blackish median stripe narrowing to the posterior.

Male genitalia (fig. 21, 41). – As in *P. nebulilinea,* but apices of basal lobes of pygofer abruptly bent in dorsomedial direction and basal protrusions of uncus pointed and with anterior and posterior margins concave in lateral view.

Female operculum. – Very short, reaching posterior margin of second abdominal segment. Hind margin straight in lateroventral view, lateral margin slightly convex. Laterodistal corner angular. Ochraceous to brown. Pattern of dark markings as in *P. nebulilinea*, but dark band on distal instead of proximal part of lateral margin. Surface covered with minute golden setae, lateroproximal corner with tuft of long setae and some long setae scattered along proximal half of lateral margin, setae on medial and anterior margins often covered with powdery white wax.

Female abdomen. – Length 0.8-0.9 times (n = 4) that of head and thorax together. Ground colour castaneous brown. Posterior margins of tergites narrowly black. Usually the whole abdomen is coloured the same shade of castaneous brown, rarely the centres of the sternites are paler with a dark spot in the middle. Pygofer as in *P. nebulilinea* , but the areas covered with powdery white wax in *P. nebulilinea* are here more densely covered with small golden setae than the rest of the pygofer.

Measurements in mm (12 ♂, 10 ♀). – Body length ♂: 25.4-29.8 (27.4 ± 1.4), ♀: 23.2-26.4 (24.6 ± 1.2); head width ♂: 8.5-9.4 (9.0 ± 0.3), ♀: 8.4-9.1 (8.8 ± 0.2); pronotum width ♂: 9.4-10.6 (10.0 ± 0.4), ♀: 9.1-10.7 (9.8 ± 0.5); mesonotum width ♂: 8.0-9.9 (8.8 ± 0.5), ♀: 8.0-8.8 (8.4 ± 0.3); tegmen length ♂:35.7-40.5 (37.8 ± 1.5), ♀: 34.9-37.6 (36.2 ± 1.2).

Distribution (fig. 24)

Borneo. The records for Peninsular Malaysia and Singapore by Zaidi & Ruslan (1995) and Zaidi & Ruslan (1997) have yet to be confirmed and probably can be ascribed to *P. nebulilinea.*

Purana capricornis sp. n.
(figs. 25-27, 31, 40)

Type material. – Holotype ♂: 'RMNH Leiden * S SABAH / Beaufort, 105 km S of: Long Pa Sia area: confluence Sg / Pa Sia - Matang. 1 Apr 1987 / J. van Tol & J. Huisman' [print]; 'At light. 4°24'N 115°43'E. / Semicultivated area. 1000 m / asl. Near disturbed / evergr.tropical rainforest' [print], (RMNH). – Paratypes: BORNEO: MALAYSIA, SABAH: Airstrip along S. Pa Sia., Long Pa Sia, 1090 m, 14.x.1986, J. Huisman et al; airstrip Long Pasia, Long Pa Sia area, 105 km S of Beaufort, 1000 m, 15.iv.1987, Van Tol & Huisman, 1♂ (RMNH), same data, 16.iv.1987, 8♂ (RMNH); confluence Sg Pa Sia - Matang, Long Pa Sia area, 105 km S of Beaufort, 1000 m, 1.iv.1987, J. van Tol & J. Huisman, 21♂ (RMNH), same data, 4♂ (ZMA), same data, 10.iv.1987, 1♂ (RMNH); Lembah Danum, 25-30.viii.1991, M. S., Zaidi, Mall, Lan, 1♂ (PSS); Maliau Basin, Tawau, 12-25.v.1996, Light Trap, 1 ♂ (UMS); MALAYSIA, SARAWAK: Batu Niah, xii.1980, A. Harmann, 1♂ (BMNH); Bintulu, 14.viii.1994, Zaidi & Talib, 1♂ (PSS); G. Api Pinnacles, Gunong Mulu Nat. Park, 1200 m, iv.1978, J. D. Holloway, 4♂ (BMNH); G. Api, Gunong Mulu Nat. Park, 1500 m, iv.1978, J. D. Holloway, 1♂ (BMNH); Julau Lanjak Entimau, 28-29.ii.1992, Zaidi, 1♂ (PSS); Long Pala (Base), Gunong Mulu Nat. Park, 70 m, iii.1978, J. D. Holloway, 1♂ (BMNH); Nr. Long Pala, Gunong Mulu Nat. Park, 50 m, v.1978, J. D. Holloway, 1♂ (BMNH); Mt. Dulit, 4000 ft., 2.ix.1932, B. M. Hobby & A. W. Moore, Oxford University Expedition, moss forest, at light in house, 8.0-9.30. P.M., rainy & cold, 1♂ (BMNH); Mt. Dulit, 4000 ft., 25.ix.1932, B. M. Hobby & A. W. Moore, Oxford University Expedition, moss forest, 1♂ (BMNH); Mt. Matang, W. Sarawak, i.1914, G.E. Bryant, 1♀ (BMNH), same data, i-ii.1914, 1♀ (BMNH); Mulu, Gunong Mulu Nat. Park, 1790 m, i.1978, J. D. Holloway, 1♂ (BMNH), same data, 150 m, ii.1978, 1♂ (BMNH), same data, 1000 m, ii.1978, 4♂ (BMNH), same data, 1♂ (ZMA); R. Kapah, of R. Tinjar, 23.ix.1932, B. M. Hobby & A. W. Moore, Oxford University Expedition, primitive forest, under damp moss and humus, 1♂ (BMNH); W. Melinau Gorge, Gunung Mulu National park, 150 m, iii-iv.1978, J. D. Holloway, 1♂ (BMNH); BRUNEI: Brunei, N. Borneo, Waterstradt, 1♂ (BMNH); ridge N.E. of Kuala Belalong, Temburong District, approximately 300 m, x.1992, J. H. Martin, 125 W mercury vapour light, 4♂, 1♀ , (BMNH), same data, 1♀ (ZMA); INDONESIA, KALIMANTAN: Doesonlanden, Wahnes, 1♂ (BMNH); Mahakam [Mahakkam], 1894, Dr. Nieuwenhuis, 1♂ (RMNH); Sintang, 1894, Borneo-Exp, 1♂ (RMNH); Tiong Buu (=Nahabuan), 18 km N.W. of Long Kay [Longkay], S. Mahakam, Kalimantan Timur, 15.iv.1996, R. Sözer, 2♂ (ZMA); Longnawan [Long Nawang], 1925, Mjöberg, 6♂ (ZMA).

The long and pointed uncus lobes of *P. capricornis* make a very distinctive character, separating this species easily from the other species that all have more or less the same genitalia with short, rounded uncus lobes. Usually the uncus hangs over the posterior margin of the eighth sternite, so that extraction of the genitalia is not necessary for identification. This is the only species of the group with a dark band along whole margin of operculum. Colour and markings are similar to *P. pryeri* but *P. capricornis* has a V-shaped mark instead of the black posterior band on pronotal disc as found in *P. pryeri*; this mark is not connected with the central fasciae as in *P. montana.* Castaneous coloration on mesonotum usually covering a larger

area than in *P. pryeri* or *P. montana*, and margins of this area more vague. Lateral tooth glossy black and rather long.

Description

Head (fig. 25). – As in *P. pryeri.*

Thorax: Pronotum (fig. 25). – Ochraceous, sometimes with a greenish tinge, pronotal collar paler than rest of pronotum and mesonotum. Two narrow, brown, sometimes faint, fasciae slightly diverge from posterior ends of anterior oblique fissures to the head. Anterior margin of pronotal disc entirely or only medially black, pronotal disc in front of pronotum collar with a medial V-shaped mark formed by two short brown fasciae that gradually widen and diverge to the anterior, and end abruptly and considerably widened at about halfway between posterior ends of anterior oblique fissures and pronotal fissure; pronotal fissure black between posterior ends of posterior oblique fissures and posterolateral corner of pronotal disc. A brown line runs along margin of lateral lobe of pronotal disc from anterior end of posterior oblique fissure to a brown spot at posterolateral corner of lateral lobe of pronotal disc. Posterior margin of pronotal collar narrowly black, lateral tooth often fairly long and pointed; lateral tooth and margin of lateral part of anterior corner of pronotal collar glossy black on dorsal and ventral side.

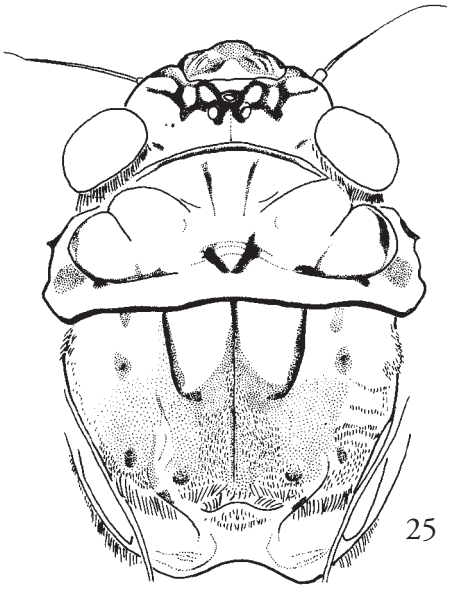
Mesonotum (fig. 25). – Largely castaneous brown, obconical fields and lateral parts olivaceous to ochraceous. Median fascia dark brown, anteriorly narrow and gradually widening posteriorly to twice its anterior width. Paramedian fasciae narrow, inwardly curved and dark brown. Lateral fasciae reduced to one to three pairs of brown spots: a pair of anterior spots just behind pronotal collar usually absent, a pair of large, ill defined middle spots at one third of mesonotum length, a pair of posterior spots at three fifths of mesonotum length usually present. A pair of small round blackish brown spots in front of anterior angles of cruciform elevation. Anterior arms of cruciform elevation with dark band.

Tegmina and wings. – As in *P. pryeri*

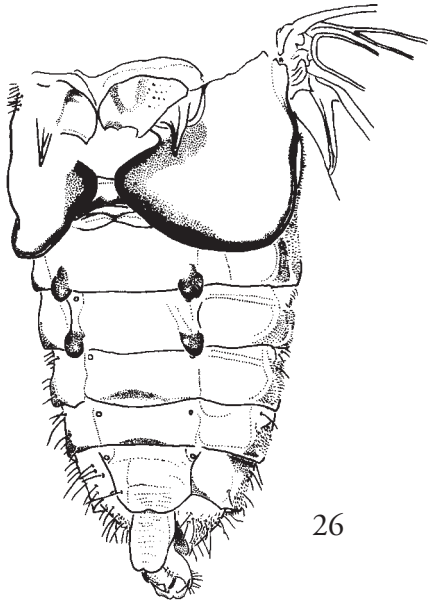
Legs. – As in *P. pryeri,* but sometimes with white wax on ventral part of mid and hind femora.

Male operculum (fig. 26). – Short, rounded, 0.91-0.97 times as long as broad (n = 5), distal half broadly rounded, almost semi-circular, reaching to half length third abdominal segment, not reaching first pair of tubercles. Lateral margin concavely sinuate at about midlength; timbal cavity almost completely covered in lateroventral view. Distance between opercula at point of closest approximation 0.21-0.32 (n = 5) times as wide as distance at basal constrictions. Surface relatively convex compared to the other species. Olivaceous to ochraceous. Whole margin with black to

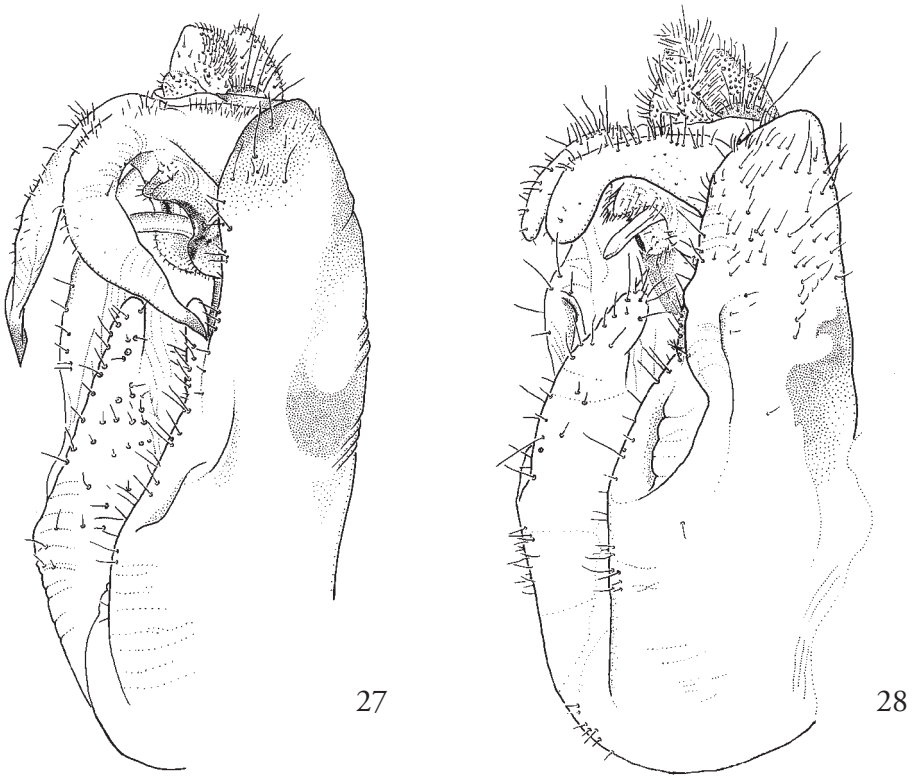
Figs. 25-26. *Purana capricornis*, holotype. – 25, head and thorax in dorsal view; 26, abdomen in lateroventral view.



25



26



Figs. 27-28. Male pygofer and uncus in lateroventral view. – 27, *Purana capricornis*, paratype, Sabah, confluence Sg Pa Sia - Matang; 28, *Purana montana*, holotype.

brown band, broad at medial margin and usually narrow at lateral margin, sometimes with white wax on black at medial margin (fresh specimens).

Male abdomen. – 0.9-1.0 times (n= 5) as long as head and thorax together. Underside of abdomen (fig. 26) castaneous brown, darkest centrally and posteriorly, sometimes almost black. Anterior half of seventh sternite castaneous brown, posterior part dark brown to black. Sternites often laterally with powdery white wax.

Male genitalia (fig. 27, 40). – Uncus with two long, outwardly bent lobes, narrowing distally to sharply pointed apices, that reach lateral margin of pygofer. Basal lobes of pygofer narrow. Basal protrusions of uncus pointed and with anterior and posterior margins concave in lateral view. In some specimens from Mulu the genitalia are larger and the angle in the uncus lobes is sharper, while the lobes are longer so that the apices often extend beyond lateral margins of pygofer.

Female operculum. – As in *P. pryeri*, but whole lateral margin with prominent dark band narrowing to the posterior.

Female abdomen. – As in *P. pryeri*, length 0.8 times (n = 4) as long as head and thorax together.

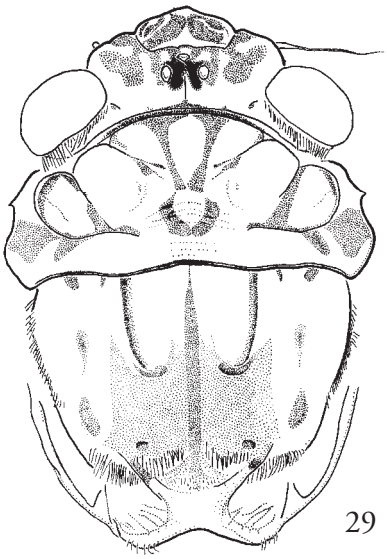
Measurements in mm (42 ♂, 4 ♀). – Body length ♂: 26.6-30.8 (28.7 ± 1.1), ♀: 24.8-26.4 (25.6 ± 0.7); head width ♂: 8.7-9.8 (9.2 ± 0.3), ♀: 8.6-9.2 (9.0 ± 0.3); pronotum width ♂: 9.4-11.4 (10.3 ± 0.4), ♀: 9.6-10.4 (10.1 ± 0.4); mesonotum width ♂: 8.2-9.7 (8.9 ± 0.4), ♀: 8.2-9.1 (8.7 ± 0.4); tegmen length ♂: 38.2-42.8 (40.8 ± 1.1), ♀: 38.4-40.3 (39.6 ± 0.8).

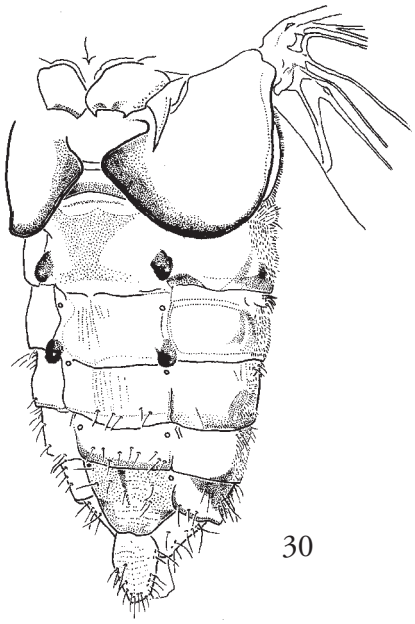
Distribution (fig. 31)

Borneo.

Etymology

Capricornis, an adjective, means like goat's horn and refers to the typically shaped uncus lobes of the male which resemble a pair of goat's horns (Lat.: capra = goat, cornus = horn).





Figs. 29-30. *Purana montana*, holotype. – 29, head and thorax in dorsal view; 30, abdomen in lateroventral view.

Purana montana sp. n.
(figs. 28-31, 42)

Type material. – Holotype ♂: 'BRUNEI: 5520' / Bukit Pagon / LP 308, upper / montane forest / 15-20.ii.1982' [print]; 'G.S. Robinson / BM 1982-156' [print] (BMNH). – Paratypes: – BORNEO: MALAYSIA, SABAH: confluence Sg Pa Sia - Matang, Long Pa Sia area, 105 km S of Beaufort, 1000 m, 1.iv.1987, J. van Tol & J. Huisman, 5 ♂ (RMNH), same data, 2 ♂ (ZMA); MALAYSIA, SARAWAK: G. Api Pinnacles, Gunong Mulu Nat. Park, 1200 m, iv.1978, J. D. Holloway, 1 ♂ (BMNH), same data, 1 ♂ (ZMA); G. Api, Gunong Mulu Nat. Park, 1500 m, iv.1978, J. D. Holloway, 3 ♂ (BMNH), same data, 900 m, 2 ♂ (BMNH); Mount Matang, W. Sarawak, i-ii.1914, G. E. Bryant, 1 ♀ (BMNH); Mulu, Gunong Mulu Nat. Park, 1790 m, i.1978, J. D. Holloway, 3 ♂ (BMNH), same data, 1000 m, ii.1978, 2 ♂ (BMNH); BRUNEI: Bukit Pagon, 5520', 15-20.ii.1982, C. S. Robinson, 2 ♂ (BMNH), same data, 1 ♂ (ZMA); ridge N.E. of Kuala Belalong, Temburong District, approximately 300 m, x.1992, J. H. Martin, 125 W mercury vapour light, 1 ♂ (BMNH).

P. montana is the largest species of the *nebulilinea* group, with the most elaborate pattern. The extensive and bold castaneous brown markings, on head and pronotum (fig. 29), especially the Y-shaped figures on the head, make it easy to distinguish from the other species of the *nebulilinea* group. The base of the seventh apical area of the tegmen is usually infuscated in *P. montana,* but not in the other species of the *nebulilinea* group.

Description

Head. (fig. 29). – As in *P. nebulilinea*, but markings distinct and bold. Pair of Y-shaped figures lateral of paired ocelli with very broad base and outer arm.

Thorax: Pronotum (fig. 29). – Ochraceous. Pronotal collar paler than rest of pronotum and mesonotum. Two narrow brown, central, fasciae diverge anteriorly from posterior ends of anterior oblique fissures and widen considerably at anterior margin of pronotum. Base of pronotal disc medially with V-shaped mark in front of pronotal collar, formed by two crescentic brown fasciae, posteriorly narrowly connected. A brown line along lateral margin of lateral lobe of pronotal disc runs from anterior end of posterior oblique fissure, along anterior side of pronotal fissure, to some distance before V-shaped mark. A fairly broad brown band along posterior oblique fissures continues to pronotal fissure; anterior oblique fissures with narrow lateral band. Pair of faint brown spots between posterior ends of oblique fissures. Pronotal collar with large square-like brown spot at posterolateral corner of lateral lobe of pronotal disc and brown triangle at pronotal suture between large spot and posterior end of posterior oblique fissure. Posterior margin of pronotal collar narrowly black; lateral tooth short and

rather blunt to sharply pointed.

Mesonotum (fig. 29). – Olivaceous to ochraceous, central part castaneous to reddish brown from cruciform elevation to obconical areas. Median fascia narrow, very narrow anteriorly, dark brown. Paramedian fasciae narrow, inwardly curved and dark brown; inner sides of paramedian fasciae sometimes broadened anteriorly. Lateral fasciae reduced to three pairs of triangular, castaneous to reddish brown spots; pair of anterior spots just behind pronotal collar, middle and posterior spots pointed to each other and sometimes touching. Anterior spots sometimes medially accompanied by another pair of very small anterior spots just lateral of paramedian fasciae. A pair of small round dark brown spots in front of anterior angles of cruciform elevation. Anterior arms of cruciform elevation with dark band.

Tegmina and wings. – As in *P. nebulilinea*, but tegmina also infuscated at the basal vein of seventh apical area. All infuscations distinct and dark, except for the one at basal vein of seventh apical area which is occasionally very faint.

Legs. – As in *P. capricornis*, but proximal spine slightly broader and angle between femur and proximal spine smaller.

Male operculum (fig. 30). – Short, rounded, 0.83-0.98 times as long as broad (n = 5), distal half broadly rounded, almost semi-circular shaped, reaching to one third of third abdominal segment. Lateral margin sinuate, weakly concave at about midlength; timbal cavity almost completely covered in lateroventral view. Distance between opercula at point of closest approximation 0.14-0.30 (n = 5) times as wide as distance at basal constrictions. Surface rather convex. Olivaceous to ochraceous, medial margin and distal part of lateral margin with rather narrow to broad, black to brown band. Medial margin sometimes with white wax (fresh specimens).

Male abdomen (fig. 30). – As in *P. pryeri,* abdomen 1.0-1.1 times (n = 5) as long as head and thorax together, but tubercles like in *P. capricornis*; sternites often laterally with powdery white wax.

Male genitalia (figs. 28, 42). – As in *P. pryeri,* but anterior and posterior margins of basal protrusions of uncus convex in lateral view.

Female operculum and abdomen. – As in *P. capricornis*.

Measurements in mm (23♂, 1♀). – Body length ♂: 29.4-33.5 (31.4 ± 1.1), ♀: 25.4; head width ♂: 8.8-10.2 (9.6 ± 0.3), ♀: 8.9 ; pronotum width ♂: 10.3-11.7 (11.2 ± 0.3), ♀: 9.9; mesonotum width ♂: 9.0-10.3 (9.7 ± 0.4), ♀: 8.4; tegmen length ♂:42.4-47.0 (44.9 ± 1.2), ♀: 38.6.

Distribution (fig. 31)

Borneo: confined to hills and mountains.

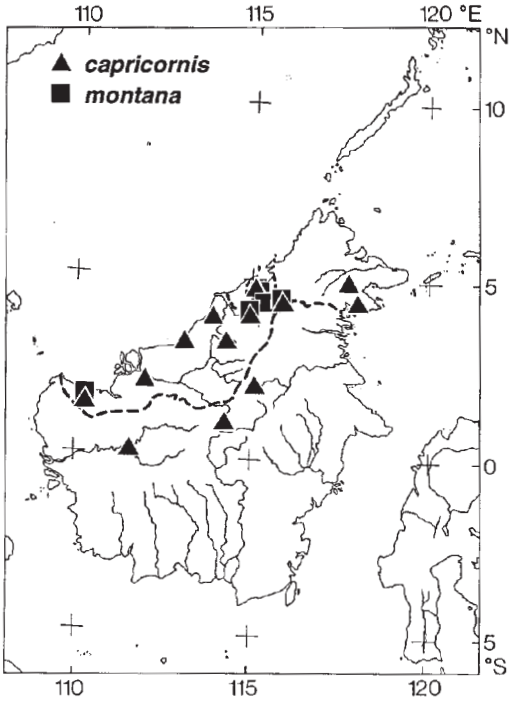


Fig. 31. Localities of *Purana capricornis* and *P. montana.*

Etymology

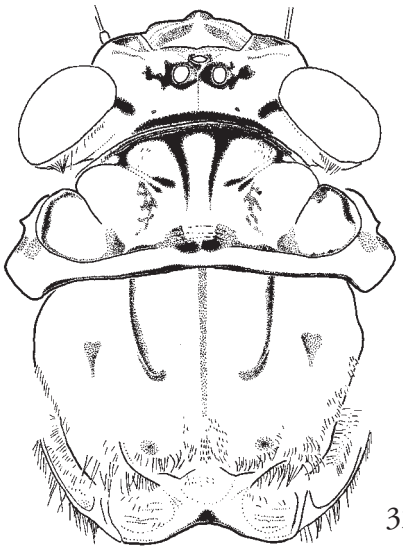
Montana (Latin), an adjective, means of the mountains and refers to the mountainous habitat of the species.

Purana niasica sp. n.
(figs. 24, 32-34, 43)

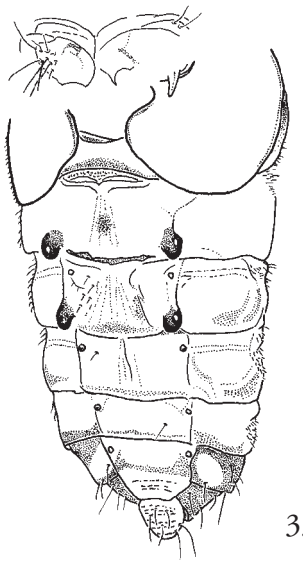
Type material. – Holotype ♂: 'Hili Madjedja / Noord Nias / Mitschke 4de trim. '95' [print] (BMNH). – Paratypes: INDONESIA: SUMATERA BARAT: Pulau Nias: same data as holotype 2 ♂ (BMNH), same data 1 ♂ (ZMA); Hili Zabobo, viii.1886, Modigliani, 1 ♂ (BMNH); Kalim Bungo, central Nias [M. Nias], 1896, R. Mitschke, 1 ♀ (BMNH).

P. niasica is most easily separated from the other species of the *nebulilinea* group by its small size, by the markings being black, by the presence of a black band on posterior margin of head, and the black base of cruciform elevation.

Closely related to *P. nebulilinea*. Both species lack the dark bands on anterior arms of cruciform elevation. Besides the differences mentioned above the two species differ from each other in the male operculum



32



33

Figs. 32-33. *Purana niasica*, holotype. – 32, head and thorax in dorsal view; 33, abdomen in lateroventral view.

which has a very narrow dark band along proximal part of medial margin in *P. niasica* instead of a fairly narrow to broad band along whole median margin in *P. nebulilinea*.

Description

Head (fig. 32). – As in *P. nebulilinea*, but posterior margin of head with rather broad black band between tongue-shaped spots, which are black, large and always present. Lines extending forwards from black areas at lateral sides of paired ocelli connected with medial part of brown to black upper side of supra-antennal plates. Usually only extreme posterior part of base and outer arms of Y-shaped figures visible. Anteclypeus with small dark strike on both sides or without markings.

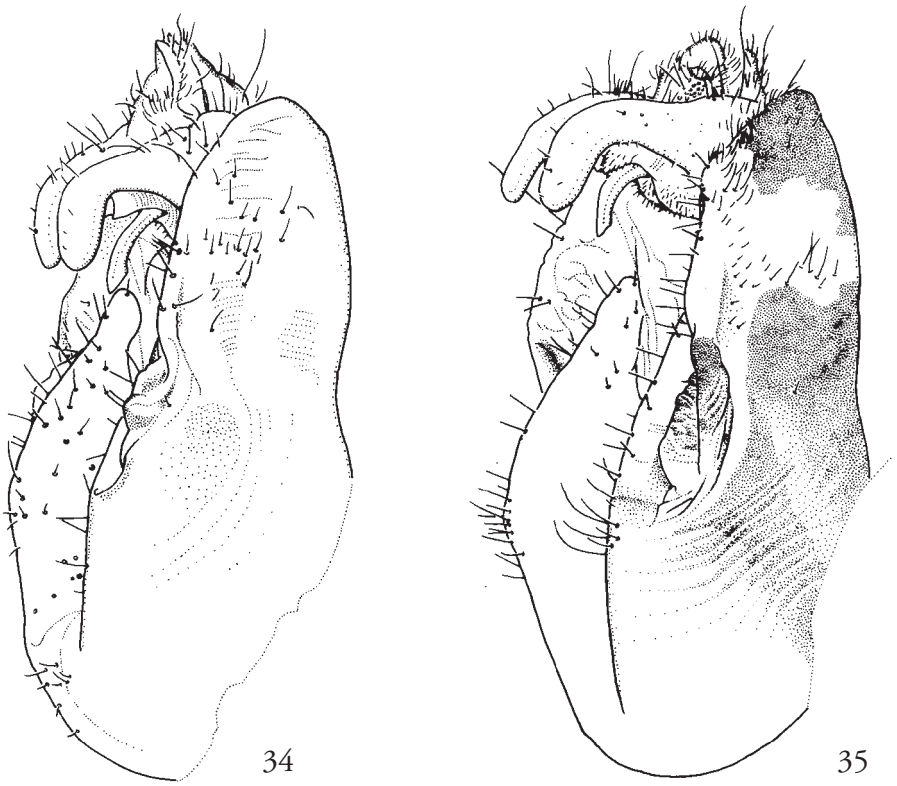
Thorax: Pronotum (fig. 32). – Ochraceous. Two narrow, dark brown fasciae diverge from somewhat below posterior ends of anterior oblique fissures, and widen considerably at anterior margin of pronotum, which is black between anterior ends of anterior oblique fissures. Pair of triangle-shaped medial black spots or one large crescent-shaped medial black spot in front of pronotal collar. Posterior ends of anterior oblique fissures with short black fasciae on both sides of fissure. A dark brown line along lateral margin of lateral lobe of pronotal disc continues in the dark brown anterior side of pronotal fissure. Posteromedian corner of lateral lobe of pronotal disc dark brown. Pair of irregular crescent-shaped fuscous spots between posterior ends of oblique fissures. Pronotal collar with narrowly black posterior margin, a pair of squarish brown spots at posterolateral corner of lateral lobe of pronotal disc, and another pair of smaller spots at lateral margin pronotal collar just below lateral tooth; spots on one lobe often fused. Lateral tooth short and bluntly pointed.

Mesonotum (fig. 32). – Dark ochraceous. Median fascia very narrow and dark brown. Paramedian fasciae narrow, inwardly curved and dark brown. A pair of triangle-shaped dark brown lateral spots, at about one third of mesonotum length. A pair of small round blackish spots in front of anterior angles of cruciform elevation. Posterior margin of cruciform elevation black between posterior arms.

Tegmina and wings. – As in *P. nebulilinea*, but infuscations more complete and dark, and infuscation at the base of the fifth apical area always present though slightly paler in colour than infuscations second and third apical areas.

Legs. – As in *P. nebulilinea*

Male operculum (fig. 33). – Short, round, 1.0-1.2 times as long as broad (n = 5), distal half semicircular, usually reaching to less than one third of third abdominal segment. Lateral margin convex, timbal cavity almost completely covered in lateroventral view. Distance between opercula at point of closest approximation 0.49-0.56 (n = 5) times as wide as distance at basal constrictions. Pale ochraceous, proximal part of medial margin with very narrow dark brown band.



Figs. 34-35. Male pygofer and uncus in lateroventral view. – 34, *Purana niasica*, holotype; 35, *Purana parvituberculata*, paratype, Laos, Sien Tor Du.

Male abdomen. – 1.1-1.3 times (n = 4) as long as head and thorax together. Upper side dark ochraceous, posterior margins of tergites narrowly black. Underside (fig. 33) pale ochraceous. Posterior margin of ventral part of sixth tergite with narrow dark brown band. Seventh and eighth tergites black. Third sternite with central dark brown rounded spot at posterior margin. Third and fourth sternites with pair of well developed, rounded, glossy dark brown to black tubercles. Third to sixth sternites with brown band at posterior margin. Seventh sternite sometimes with dark median fascia and with often black lateral margins.

Male genitalia (fig. 34, 43). – Very similar to *P. nebulilinea*, but lateroventral part of pygofer at the level of the basal pygofer lobe with more complex folds, basal protrusions of uncus pointed in lateral view, and with anterior and posterior margins straight to concave.

Female operculum. – As in *P. nebulilinea* but pale ochraceous without dark markings or wax, not reaching posterior margin of second abdominal segment.

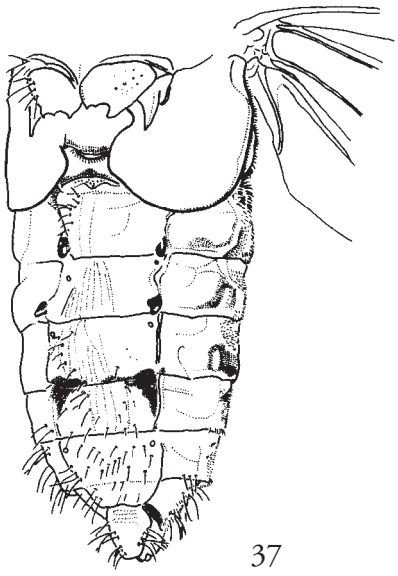
Female abdomen. – 0.8 times as long as head and thorax together. Ground colour ochraceous, posterior margins of tergites and sternites with very narrow black band, only interrupted in middle of sternite. No other markings. Setae as in *P. nebulilinea*, no wax. Pygofer ochraceous. Distal part of ovipositor sheath darkened. Dorsal parts of pygofer darker than ventral parts. Shape and hairs as in *P. nebulilinea*, but without wax, dorsodistal part of pygofer where *P. nebulilinea* has white wax more densely covered with small golden setae than rest of pygofer.

Measurements in mm (5 =♂, 1♀). – Body length ♂: 19.8-22.8 (21.7 ± 1.2), ♀: 19.6; head width ♂: 6.7-7.2 (7.0 ± 0.2), ♀: 7.1; pronotum width ♂: 7.5-7.8 (7.7 ± 0.11), ♀: 7.4; mesonotum width ♂: 6.6-6.7 (6.6 ± 0.1), ♀: 6.2; tegmen length ♂: 28.2-29.7 (28.6 ± 0.8), ♀: 28.5.

Distribution (fig. 24)

Pulau Nias.

36



37

Figs. 36-37. *Purana parvituberculata*, paratype, Laos, Sien Tor Du. – 36, head and thorax in dorsal view; 37, abdomen in lateroventral view.

Etymology

The species is named after the locality of the type specimens, to date the only known locality, Pulau Nias.

Purana parvituberculata sp. n.
(figs. 35-37, 38, 44)

Type material. – Holotype ♂:'Luang Prabang: / Muong Houoc. / 10. V. 1920. / R.V.de Salvaza.' [print]; 'Indo-China. / R.V.de Salvaza. / 1920-280' [print], (BMNH). Paratype : LAOS: 'Chapa, Tonkin. / V.- - VI.1916. / R.V deSalvaza / 1916-208' [print]; 'Vientiane / 26 Mai 191[last number illegible] / Sien Tor Du' [handwritten, pencil], 1♂ (BMNH).

The most conspicuous characters separating *P. parvituberculata* from the other species of the *nebulilinea* group are the much smaller ventral tubercles and the monocolorous male opercula. The abdomen of *P. parvituberculata* is more elongated than in the other species of the group.

Description

Head (fig. 36). As in *P. nebulilinea*, but underside of the postclypeus with transverse brown streaks longer and darker, extending to lateral margin of postclypeus. No spots on sides of anteclypeus.

Thorax: Pronotum. (fig. 36). – Dark ochraceous, pronotal collar paler than rest of pronotum and mesonotum. Two narrow dark brown fasciae diverge and widen from posterior ends of anterior oblique fissures and widen considerably at anterior margin of pronotum. Crescent shaped dark brown medial spot in front of pronotal collar fused with dark brown band in pronotal fissure. This band extends to a small triangular to semicircular spot situated proximally of lateral lobe of pronotal disc. Lateral of this spot a larger lanceolate spot at lateral lobe of pronotal disc. Anterior margin of pronotal disc medially black. A very narrow brown line along lateral margin of lateral lobe of pronotal disc. Posterior margin of pronotal collar with narrow black band. Lateral tooth short but prominent and sharply pointed.

Mesonotum (fig. 36). – Dark ochraceous. Median fasciae absent. Paramedian fasciae inwardly curved, narrow, slightly widening posteriorly. No lateral fasciae or spots. A pair of small round dark brown spots in front of anterior angles of cruciform elevation. Anterior arms cruciform elevation with distinct dark band.

Tegmina and wings. – As in *P. nebulilinea*, but infuscations darker and with clearly defined margins.

Legs. – Largely ochraceous, without dark markings except darkened tarsi and claws.

Male operculum (fig. 37). – Short, as long as broad,

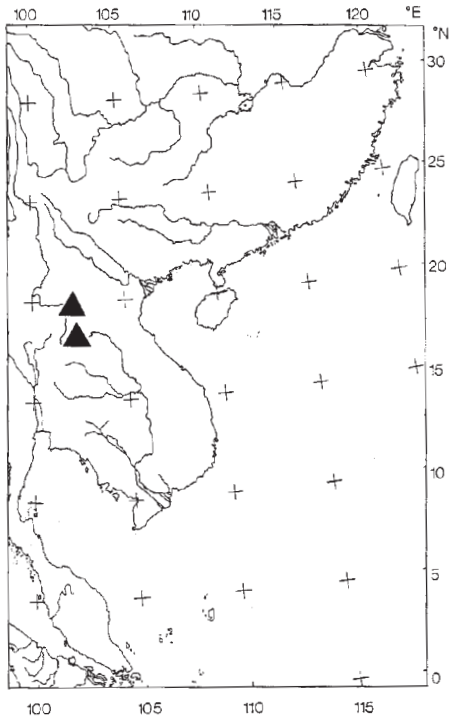


Fig. 38. Localities of *Purana parvituberculata.*

distal half broadly rounded, almost semicircular, reaching to one third of third abdominal segment. Lateral margin straight, mediodistal corner straightened, timbal cavity almost completely covered in lateroventral view. Distance between opercula at point of closest approximation 0.52-0.53 times (n = 2) as wide as distance at basal constrictions. Pale ochraceous.

Male abdomen. – 1.2-1.4 times (n = 2) as long as head and thorax together. Upper side castaneous to reddish brown, but lateral parts of tergites ochraceous and posterior margins with narrow black band. Underside (fig. 37) dark ochraceous. Third and fourth sternites with pair of small, rather pointed, mat dark brown, tubercles. Posterior margin fifth sternite with discontinuous dark band. Anterolateral corners sixth sternite darkened.

Male genitalia (fig. 35, 44). – Basal lobes of pygofer straight, not adjacent to lateroventral part of pygofer as in other species of *nebulilinea* group. Basal protrusions of uncus pointed and with anterior and posterior margins convex in lateral view.

Measurements in mm (2♂). – Body length ♂: 28.7 & 27.6; head width ♂:8.6 & 8.4; maximum pronotum width ♂: 9.7 & 9.8; maximum mesonotum width ♂: 8.3 & 8.9; tegmen length ♂:36.4 & 37.0.

Distribution (fig. 38)

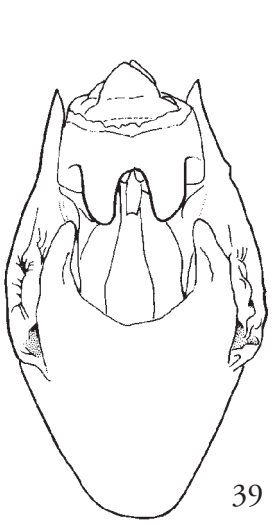
North Laos. Vientiane and Luang Prabang, both in North Laos, were plotted on the distribution map since the more precise collecting places of the types could not be traced. The paratype bears a printed locality label 'Chapa, Tonkin', which lies in North Vietnam, and a written locality label 'Sien Tor Du, Vientiane', which lies in North Laos. The latter label is assumed to be the correct one.

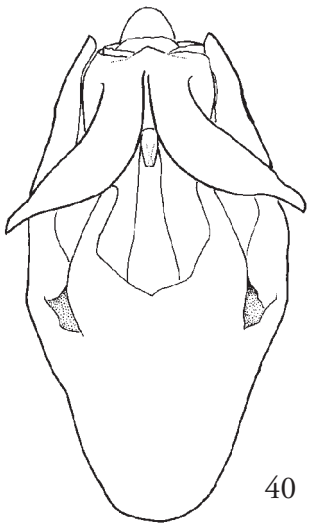
Etymology

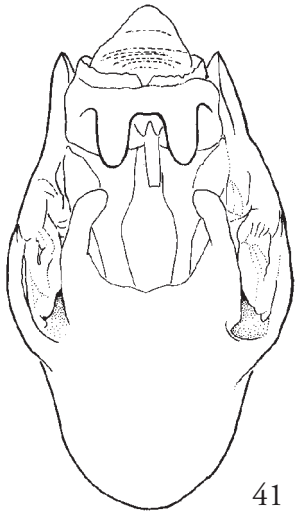
Parvituberculata, an adjective, refers to the small ventral tubercles of the male relative to the other species of the *P. nebulilinea* group (Lat.: parvus = small, tuberculum = tubercle).

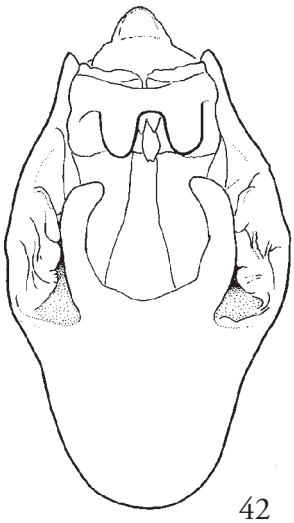
ACKNOWLEDGEMENTS

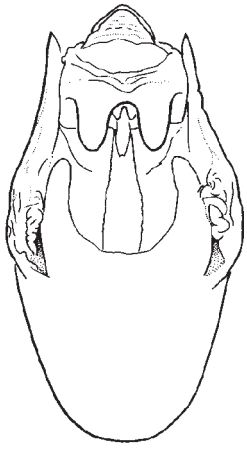
For the loan of material the first author is indebted to Mr. M. D. Webb and Mrs. W. J. Margerison-Knight (BMNH); Mr. J. van Tol (RMNH); Dr. M. I. Zaidi and Mr. M. Y. Ruslan (PSS); Mr. K. Arakaki (BPBM)); Dr. Maryati Mohamed (UMS) and Dr T. Vasarhelyi (TMB). He would like to thank Mr. M. D. Webb, Mrs. W. J. Margerison-Knight and Mr. J. H. Martin for being most helpful during his visit to the Natural History Museum in London, Mr. G. Verlaan for technical assistance and Mr. D. A. Langerak for preparing the maps; the advice and remarks of Mr. P. L. Th. Beuk and Dr. A. J. de Boer were much appreciated. Dr. M. I. Zaidi is greatly thanked for providing the opportunity to do fieldwork in Peninsular Malaysia, arranging facilities, material and transport and abling us to study the collection of the Centre for Insect Systematics (PSS). Mr. M. Y. Ruslan is thanked for his continuous invaluable help in both the field and the PSS collection. Sound recordings were partially made during the first Belum Expedition organized by Malaysian Nature Society in 1994. One of us (M.G.) took part in this expedition and would like to thank all the members for local support during our investigations. For some sound recordings of *P. nebulilinea,* used in this study the second author is indebted to Dr. Tomi Trilar from Prirodoslovni muzej Slovenije in Ljubljana. We would especially like to thank Dr. J. P. Duffels. He initiated this cooperative study and his enthusiasm, stimulating discussion and constructive remarks have made it what it is now.

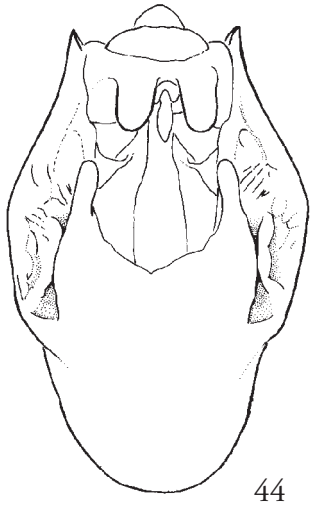












Figs. 39-44. Male pygofer and uncus in ventral view. – 39, *Purana nebulilinea*, Peninsular Malaysia, Pasoh Forest Reserve; 40, *Purana capricornis*, paratype, Sabah, confluence Sg Pa Sia - Matang; 41, *Purana pryeri*, Sarawak, West Melinau Gorge; 42, *Purana montana*, holotype; 43, *Purana niasica*, holotype; 44, *Purana parvituberculata*, paratype, Laos, Sien Tor Du.

References

Anonymous, 1872. Adolf Stieler's Hand-Atlas, Vollständige Ausgabe in 84 Karten. – Adolf Stieler, Gotha.

Anonymous, 1906. Andrees allgemeiner Handatlas. Fünfte Auflage: [i-ii], 1-186, pls. 1-207. – Velhagen & Klasing, Bielefeld / Leipzig.

Anonymous, 1992a. Nelles road atlas Indonesia: 1-127. – Nelles Verlag GmbH, München.

Anonymous, 1992b. Nelles road atlas Southeast Asia excluding Indonesia: 1-128. – Neles Verlag GmbH, München.

Anonymous, 1994. The Times atlas of the world (9th comprehensive ed.): i-xlvii, pls. 1-123, 1-218. – Times Books Ltd., London.

Bernard, H. ed. with M. Brooke, 1994. Insight Guides: Southeast Asia Wildlife, first edition (2nd reprint). – APA Publications (HK) LTD, Höfer Press Pte. Ltd, Singapore.

Distant, W.L., 1881. Descriptions of new species belonging to the homopterous family Cicadidae. – Transactions of the Royal Entomological Society of London 1881: 627-648.

Distant, W.L., 1889. A monograph of Oriental Cicadidae 2: 25-48, pls. III-IV. – West, Newman & Co., London.

Distant, W.L., 1891. A monograph of Oriental Cicadidae 4: 73-96, pls. VII-IX. – West, Newman & Co., London.

Distant, W.L., 1892. A monograph of Oriental Cicadidae 5: 97-120, pls. X-XII. – West, Newman & Co., London.

Distant, W.L., 1905. Rhynchotal Notes XXIX. – Annals and Magazine of Natural History (7) 15: 58-70.

Distant, W.L., 1906. A synonymic catalogue of Homoptera. Part 1. Cicadidae: 1-207. – Trustees British Museum, London.

Distant, W.L., 1912. Homoptera, fam. Cicadidae, subfam. Cicadinae. – Genera Insectorum 142: 1-64, pls. 1-7.

Duffels, J.P. & P.A. van der Laan, 1985. Catalogue of the Cicadoidea (Homoptera, Auchenorhyncha) 1956-1980. – Series Entomologica 31: i-xiv, 1-414.

Dumont, CH.F.H., 1917. Aardrijkskundig woordenboek van Nederlandsch Oost-Indië. Met overzichtskaart. – Nijgh & van Ditmar, Rotterdam: i-viii, 1-654.

Finlay, H. & P. Turner, 1994. Malaysia, Singapore & Brunei - a travel survival kit, 5th edition. – Lonely Planet Publications, Victoria, Australia.

Gerhardt H.C., 1998. Acoustic signals of animals: recording, field measurements, analysis and description. – In: S.L. Hopp, M.J. Owren and C.S. Evans (eds.) - Animal Acoustic Communication: Sound Analysis and Research Methods, pp. 1-25. – Springer Verlag, Berlin / Heidelberg / New York.

Gogala M., 1995. Songs of four cicada species from Thailand. – Bioacoustics 6: 101-116.

Gogala, M., A.V. Popov & D. Ribarič, 1996. Bioacoustics of singing cicadas of the western Palaearctic: *Cicadetta tibialis* (Panzer) (Homoptera: Cicadidae). – Acta entomologica Slovenica 4(2): 45-62.

Kato, M., 1932. Monograph of Cicadidae: 1-450, pls. 1-4 & 1-32.

Kirkaldy, G.W., 1913. On some new species of leaf-hoppers. Part I. – Bulletin of the Hawaiian Sugar Planters' Association Experiment Station 12: 7-27.

Metcalf, Z.P., 1963. General catalogue of the Homoptera. Fascicle VIII. Cicadoidea. Part 1. Cicadidae. Section I Tibiceninae: i-vii, 1-585. – North Carolina State College, Raleigh, North Carolina.

Moulton, J.C., 1911. Material for a Fauna Borneensis: a list of Bornean Cicadidae. – Journal of the Straits Branch of the Royal Asiatic Society 57: 123-155.

Moulton, J.C., 1923. Cicadas of Malaysia. – Journal of the Federal Malay States Museum 11: 69-177, pls. 2-5.

Moulton, J.C., 1929. Spolia Mentawiensa. Cicadidae. – Bulletin of the Raffles Museum 2: 118-122.

Orian, A.J.E., 1963. A new genus of Cicadidae (Homoptera) from the island of Rodrigues with notes on nomenclature of the family. – Annals and Magazine of Natural History (13) 6: 321-328, pls. XII, XIII.

Payne, J., C.M. Francis & K. Phillipps, 1985. A field guide to the mammals of Borneo. – The Sabah Society with World Wildlife Fund Malaysia, Kota Kinabalu / Kuala Lumpur.

Schumacher, F., 1915. H. Sauter's Formosa-Ausbeute. Homoptera – Supplementa Entomologica 4: 108-142.

Walker, F., 1868. Catalogue of the homopterous insects collected in the Indian Archipelago by Mr. A.R. Wallace, with descriptions of new species. – Proceedings of the Linnean Society of London (Zoology) 10: 82-193.

Zaidi, M. I., 1996. Preliminary survey of cicadas within the campus area of the Science Teachers Training College, Bintulu, Sarawak. – Serangga 1: 97-107.

Zaidi, M. I., 1997. Cicadas within the town centre area of Bintulu, Sarawak: an additional survey. – Serangga 2: 109-118.

Zaidi, M. I. & A. A. Hamid, 1996. Preliminary survey of cicadas in Lanjak Entimau Wildlife Sanctuary, Sarawak. – Serangga 1: 48-58

Zaidi, M. I. & M. Y. Ruslan, 1995. Cicadas (Homoptera: Cicadoidea) in the Kuala Lompat Sector of Krau Wildlife Reserve, Pahang. – The Journal of Wildlife and Parks XIV: 62-70.

Zaidi, M. I. & M. Y. Ruslan, 1997. Notes on cicadas (Homoptera: Cicadoidea) in the zoological reference collection, National University of Singapore. – Serangga 2: 217-233.

Received: 6 October 1999
Accepted: 22 February 2000