

DESCRIPTION OF THE SONG OF
PURANA SAGITTATA SCHOUTEN & DUFFELS
 (HOMOPTERA, CICADIDAE) FROM
 PENINSULAR MALAYSIA

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Songs of the cicada *Purana sagittata* were investigated. The sound emission analysis is based on 25 recordings of different individuals from four localities in Malaysia. Described are two similar but clearly different song patterns, one from Belum and Gombak and a second from Endau Rompin.

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The *Purana sagittata* was described as a member of the *Purana carmentis* group by Schouten & Duffels, 2002 (this issue) and is known from Peninsular Malaysia, Borneo and Sumatra.

From the genus *Purana* only the songs of *Purana aff. tigrina* from Ko Tarutao, Thailand (Gogala 1995) and *Purana nebulilinea* (Walker, 1868) from Peninsular Malaysia (Kos & Gogala 2000) have been described until now.

MATERIAL AND METHODS

Songs of *Purana sagittata* were recorded in the field using a TELINGA PRO III and PRO V parabolic microphones (parabola diameter 57 cm) connected to SONY DAT-recorders TCD-D3 and TCD-D10 (sampling rate 48 kHz, 16 Bit dynamic range). In the lab, DAT recordings were transferred to the hard disk of a POWER MACINTOSH G3/233 MHz computer through an AUDIOMEDIA III sound card. For viewing, editing and analyzing the song signals we used DIGIDESIGN PROTOOLS 4.1, and CANARY 1.2. Altogether 25 recordings of different individuals were used for analyses. For statistical evaluation we used the MICROSOFT EXCEL 97 and STATVIEW 4.5.

Voucher specimens of cicadas from Gombak are preserved in the collection of the Slovenian Museum of Natural History (PMSL) in Ljubljana. A single male, which was first recorded and then collected in the sec-

ondary forest of Gombak Field Station (Selangor, Kuala Lumpur, Ulu Gombak, Gombak Field Station) on 25. May 1996, is used as the holotype (Schouten & Duffels 2002).

RESULTS

The analysis of the sound emission of *Purana sagittata* is based on 25 recordings of different individuals from four localities: six recordings from Perak, Belum (5°30'07"N, 101°26'21"E) on 23. March, 1. April and 5. April 1994, seven recordings from Selangor, Gombak Field Station (3°19'47"N, 101°45'15"E) made on 17, 18, 19, 21 and 25 May 1996 and eleven recordings from Johor, Endau Rompin, Kuala Jasin (2°31'38"N, 103°22'25"E) made on 11 June 1996 and one recording from the same locality on 24 March 1999.

We can distinguish two similar but clearly different song patterns: *P. sagittata* from Belum and Gombak and *P. sagittata* from Endau Rompin. The samples of both types of the song could be found at home page: <http://www2.pms-lj.si/staff/bioacoustics/asiaw.html>

Purana sagittata from Belum and Gombak

The high pitched song of *Purana sagittata* from Belum and Gombak is composed of two distinctly different phrases (PH) (fig. 1a), which follow each other without a pause. Duration of the song is 55.72

Table 1. Time parameters of the second phrase (PH2) of the song of *Purana sagittata* from Belum and Gombak (S1, pulsed segment; S2, narrow band segment; S3, wide banded segment; BS3, beginning of S3; FS3, end of S3; LS, last segment).

	S1[ms]	S2[ms]	S3[s]	BS3[s]	FS[s]	LS[s]
N	124	124	110	38	38	14
MEAN	49	516	3.28	1.71	1.62	5.13
STDEV	13	83	0.43	0.39	0.34	1.34
Xmin	21	362	2.58	1.26	1.19	2.19
Xmax	87	697	4.39	2.56	2.83	6.99

± 9.07 s (range 46.65-68.32 s) (fig. 2a).

Duration of the first phrase is 11.7 ± 3.2 s (range 6.50-14.59 s) (fig. 2c). The first phrase consists of a continuous sound, which rises in amplitude as the call proceeds. The second half of the first phrase consists of a series of quickly repeated wide band short pulses (fig. 1b).

The second and much longer phrase (duration 44.0 ± 8.2 s, range 37.19-56.81 s) (fig. 2d) is composed of 8 to 14 (10.7 ± 2.1) (fig. 2e) repeated sequences comprising three segments (fig. 1c). Each sequence consists of a short wide band pulse segment (S1) (fig. 3a), a very narrow banded segment (S2) (fig. 3b), followed by another wide band segment (S3) (fig. 3c), and the sequence repeats again without a pause (fig. 1c). The wide banded segment (S3) consists of a rhythmically modulated first part, which has a pulsed structure with a repetition frequency between 32 and 20 pulses per second (BS3), followed by a continuous second part (FS3). Both parts are of approximately equal duration (table 1). The last sequence ends with a longer last segment (LS) of slowly decreasing amplitude (fig. 3d). This takes place at the end of the second phrase and the whole song. The time parameters are listed in table 1.

Spectral properties of these sounds are distinct. In very narrow banded segments (S2), spectral analysis reveals a fundamental frequency at 2.6 ± 0.05 kHz (fig. 2b) and three prominent higher harmonics. The first and third harmonics have the highest amplitudes and the second harmonic is much lower. All other parts of the song show wide band spectrum without strong harmonics. In the pulse structured portion (BS3), the peak frequency was 2.65 kHz with most of the rest of the energy contained in a broad band from 1.9 to 6.1 kHz at -20 dB. In all other wide band portions of the song the fundamental frequency (maximum intensity around 2.7 kHz) and the first harmonic contain most of the energy, the third harmonic has a significantly lower amplitude and the second harmonics is almost undetectable.

Purana sagittata from Endau Rompin

The high pitched song of *Purana sagittata* from Endau Rompin consists of three distinctly different phrases (PH0, PH1, PH2) (fig. 4a) without a pause between them. The duration of the song averages 40.47 ± 7.06 s (range 26.91-53.09 s) (fig. 5a). Each song was followed by a pause (duration 1.4, 10.9 or 22.2 s). However, only for three songs we have measurements for this parameter.

The introductory phrase (PH0 duration 6.7 ± 2.6 s, range 3.1-12.2 s) (fig. 5f) is composed of 3 to 7 segments (5.6 ± 1.8), which represent a continuous, but pulsating sound (fig. 4b). Pulsation is the result of fluctuation of wide band segment of sound emission with slight changes of frequency characteristics.

Duration of PH1 is 12.58 ± 2.87 s (range 7.06-18.08 s) (fig. 5c). The phrase consists of rapidly repeated short, wide band pulses, which decrease in length in time, and during the last third transform into a continuous sound (fig. 4b).

The third phrase or PH2 (duration 21.95 ± 5.54 s, range 12.8-32.32 s) (fig. 5d) is composed of 3 to 7 (4.8 ± 1.4) (fig. 5e) repeated sequences, comprising three segments (fig. 4c). Each sequence consists of a short wide band pulsed segment (S1) (fig. 6a), a very narrow band segment (S2) (fig. 6b), followed by a wide banded segment (S3) (fig. 6c), which continues into the next sequence without a pause (fig. 4c). The wide band segment (S3) consists of an amplitude modulated first part, which is pulse structured changing from 18 and 10 pulses per second, followed by a shorter continuous second part. This second part represents approximately 15 % of the S3 duration. The last sequence ends with a longer last segment (LS) (fig. 6d) of slowly decreasing amplitude. This is also coincident with the end of the second phrase and the whole song. The time parameters are listed in table 2.

Spectral properties of these sounds are quite well conserved and represent an easily recognized pattern. In very narrow band segments (S2) the spectrum shows a basic frequency at 3.0 ± 0.05 kHz (fig. 5b) and three harmonics. The third harmonic has the highest amplitude, while the fundamental frequency and first harmonic are of slightly lower amplitude. The second harmonic is almost undetectable. All other parts of the song contain wider energy bands occurring between 2.2 and 6.5 kHz at -20 dB, with a prominent band within this range of 3.0 and 4.8 kHz.

DISCUSSION

The songs of *Purana sagittata* from Belum and Gombak are very similar to the songs of the same species from Endau Rompin. They consisted from the same elements, which contain both very narrow

Table 2. Time parameters of the third phrase (PH2) of the song of *Purana sagittata* from Endau Rompin (S1, pulsed segment; S2, narrow band segment; S3, wide banded segment; LS, last segment).

	S1 [ms]	S2 [ms]	S3 [s]	LS [s]
N	100	99	79	24
MEAN	63	776	3.19	5.40
STDEV	11	12	0.53	1.34
Xmin	35	538	1.95	2.16
Xmax	93	1052	3.99	8.54

banded segments and wide banded components. Both songs contain pulse structured and continuous parts. However, they differ in the number and duration of phrases, in number of repeated elements, and in spectral peaks of very narrow banded segments.

Despite the absence of an introductory phrase (PH0) in the song of *P. sagittata* from Belum and Gombak, the song duration is, on average, 15 s or 27 % longer than in individuals from Endau Rompin. The second phrase (PH2) is also 50% longer; songs from Belum and Gombak contain 10-14 sequences and in Endau Rompin only 3-7. In contrast, in Belum and Gombak, the very narrow band segment (S2) lasts for 260 ms or 33 % shorter than this same element in songs from Endau Rompin. The first phrase (PH1) is equal in duration in both populations. Both songs are similar in general spectral properties, but in Belum and Gombak the fundamental frequency is 0.3 kHz or 10 % lower than in Endau Rompin.

Despite these differences in songs, Duffels (personal communication) did not find any differences in morphology between the populations, nor did he in additional material from Borneo and Sumatra (Schouten & Duffels 2002). There are many known examples of morphologically very similar species groups, which are known to be acoustically significantly different (e.g. the *Cicadetta montana* complex, Gogala & Trilar 1999, Puissant & Boulard 2000). For this reason the songs from Borneo and Sumatra as well as populations in intermediate areas in Peninsular Malaysia should be carried out in order to find out whether cline variation exists in song structure or there are two taxa with clearly different songs.

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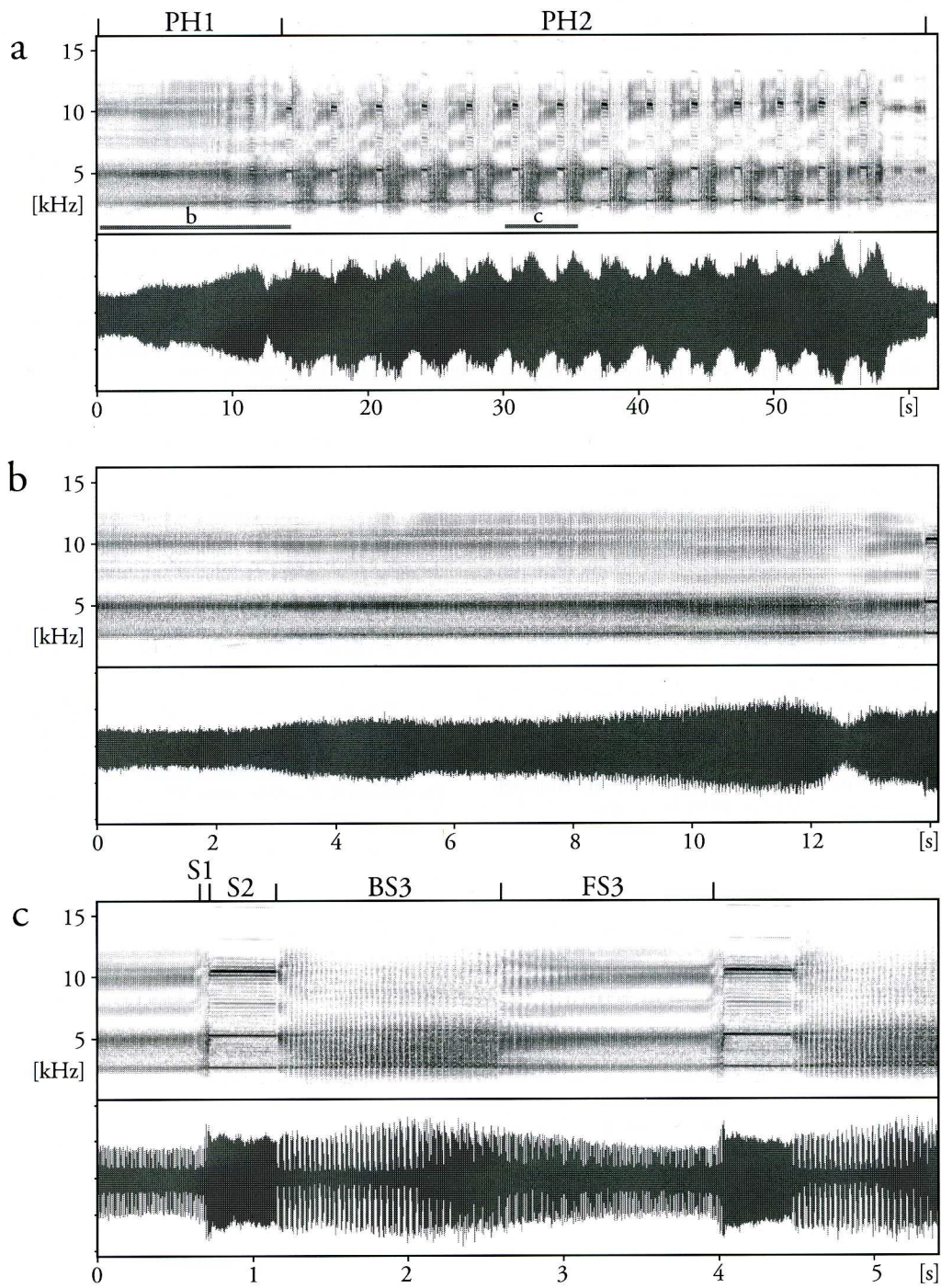


Fig. 1. Song of *Purana sagittata* from Belum and Gombak. – a) Spectrogram and oscillogram of a typical song (PH1, first phrase; PH2, second phrase; b, expanded part from fig. 1b; c, expanded part from fig. 1c). b) Spectrogram and oscillogram of the first phrase (PH1). c) Spectrogram and oscillogram of the selected part of second phrase (PH2) (S1, pulsed segment; S2, narrow band segment; BS3, beginning of the wide banded segment; FS3, end of the wide banded segment).

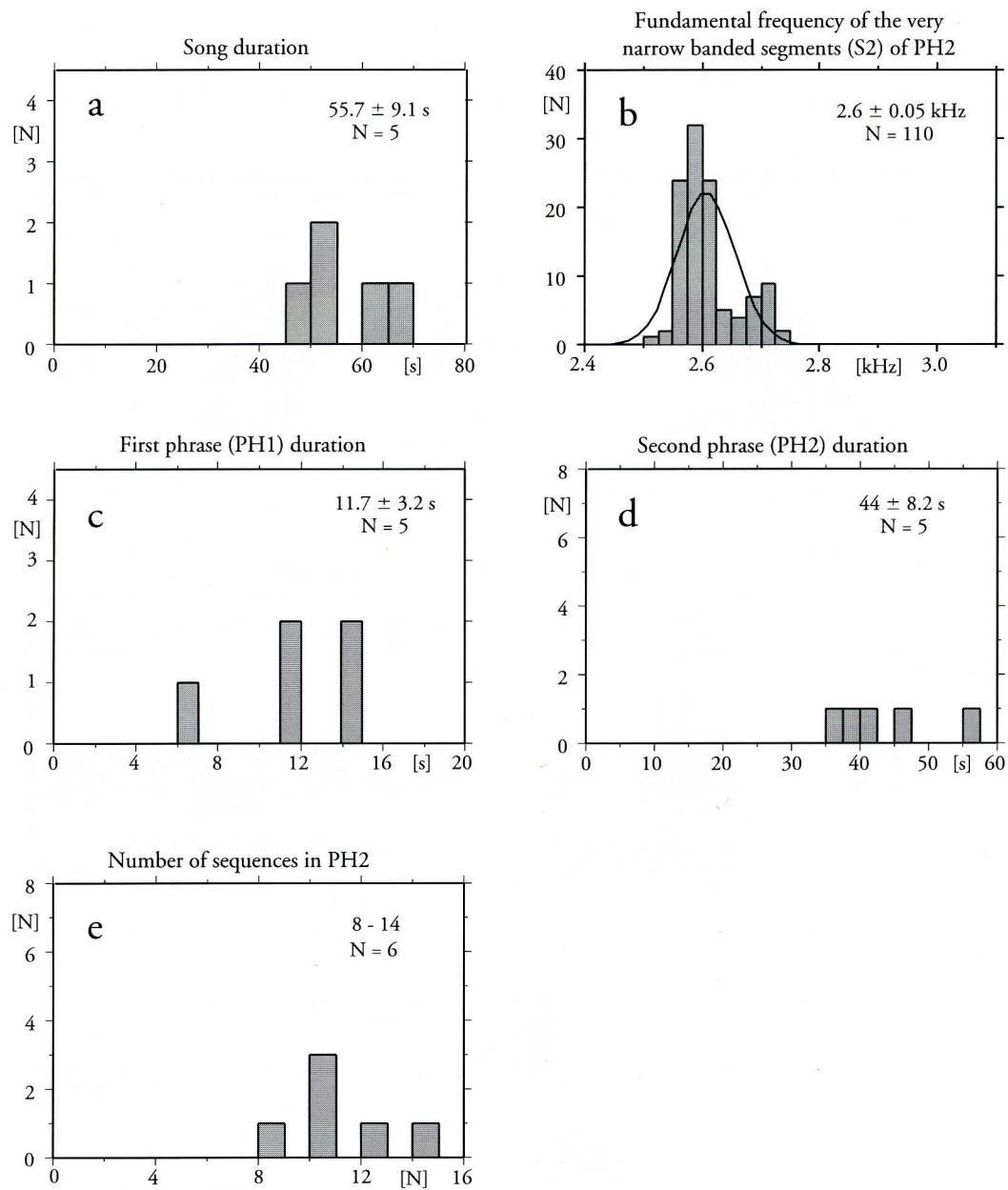


Fig. 2. *Purana sagittata* from Belum and Gombak, time parameters of the song. – Histograms of a) song duration, b) fundamental frequency of very narrow banded segments (S2) of PH2, c) first phrase (PH1) duration, d) second phrase (PH2) duration and e) number of sequences in PH2. Means, standard deviations, and sample size are shown.

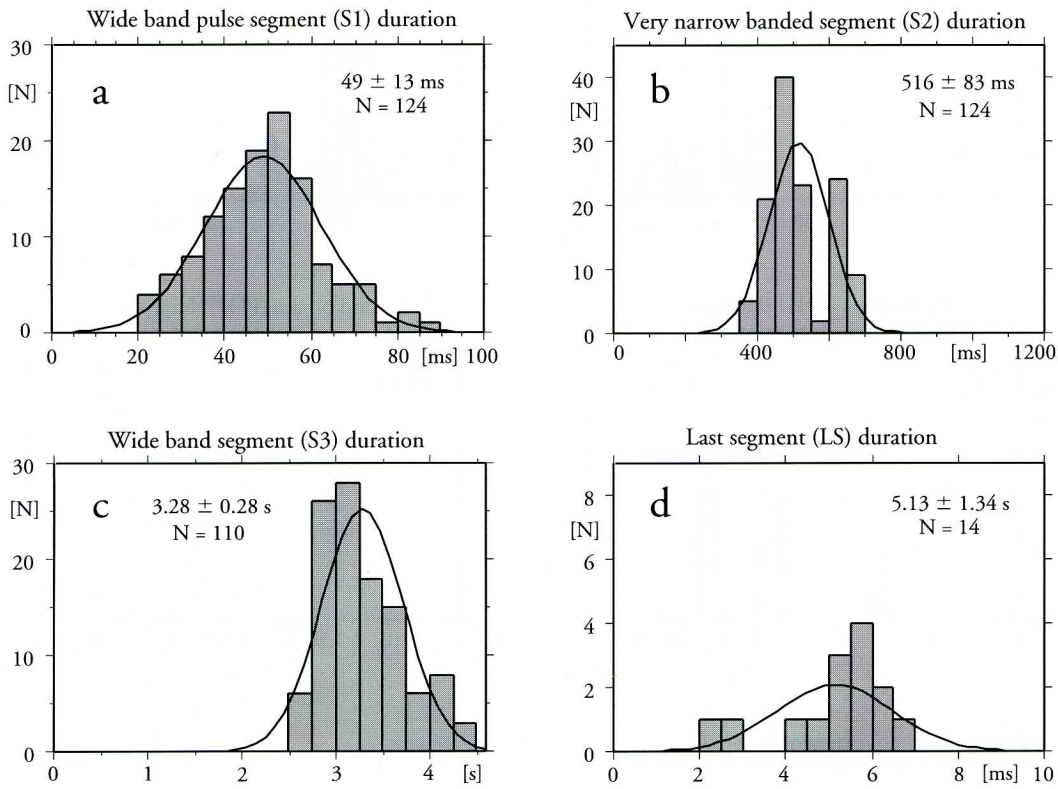


Fig. 3. *Purana sagittata* from Belum and Gombak, time parameters of the song. – Histograms of a) wide band pulse segment (S1) duration, b) very narrow banded segment (S2) duration, c) wide band segment (S3) duration, d) last segment (LS) duration. Means, standard deviations, and sample size are shown.

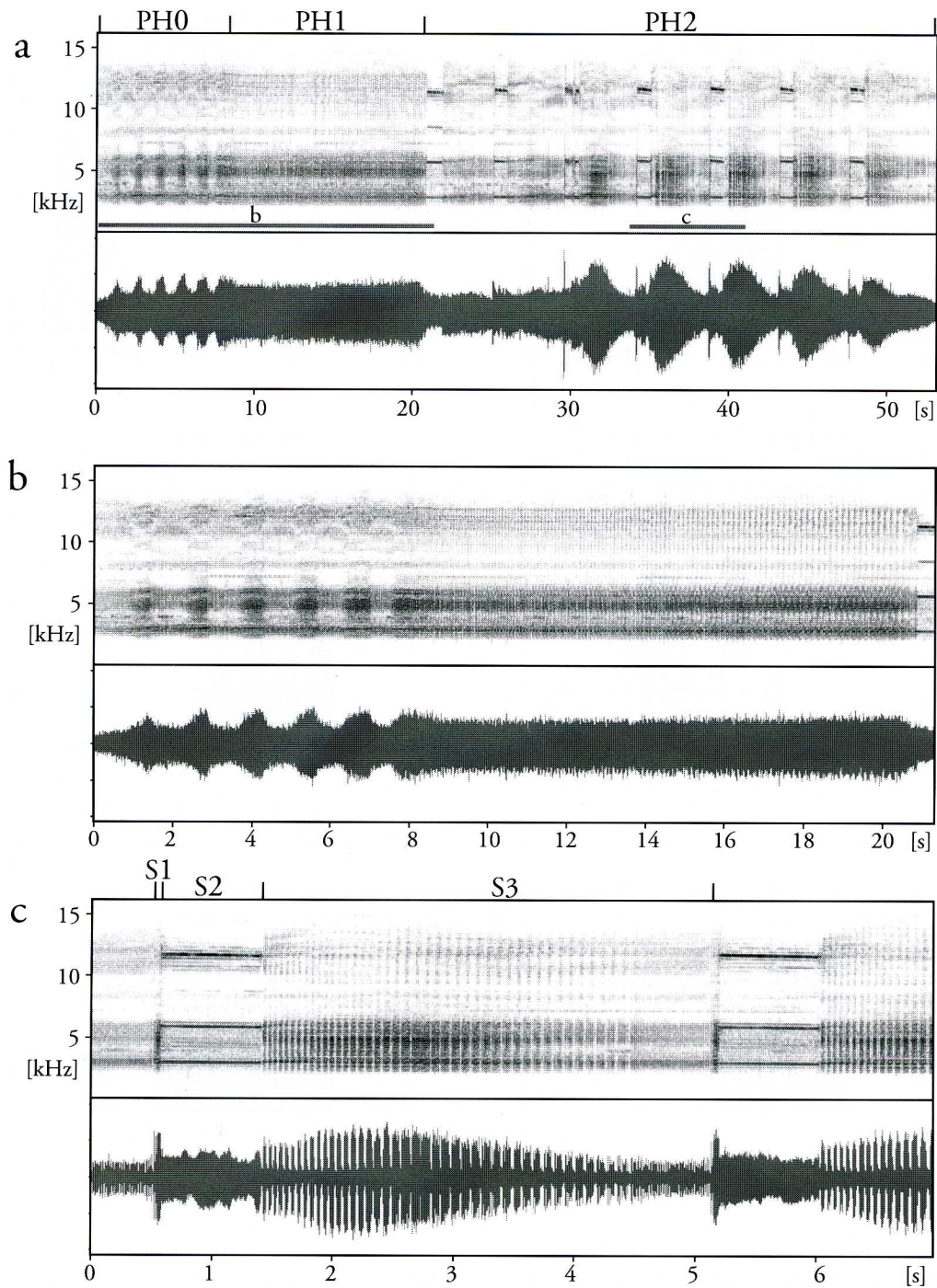


Fig. 4. Song of *Purana sagittata* from Endau Rompin. – a) Spectrogram and oscillogram of a typical song (PH0, introductory phrase; PH1, first phrase; PH2, second phrase; b, expanded part from fig. 4b; c, expanded part from fig. 4c). b) Spectrogram and oscillogram of the introductory (PH0) and first phrase (PH1). c) Spectrogram and oscillogram of the selected part of second phrase (PH2) (S1, pulsed segment; S2, narrow band segment; S3, wide banded segment).

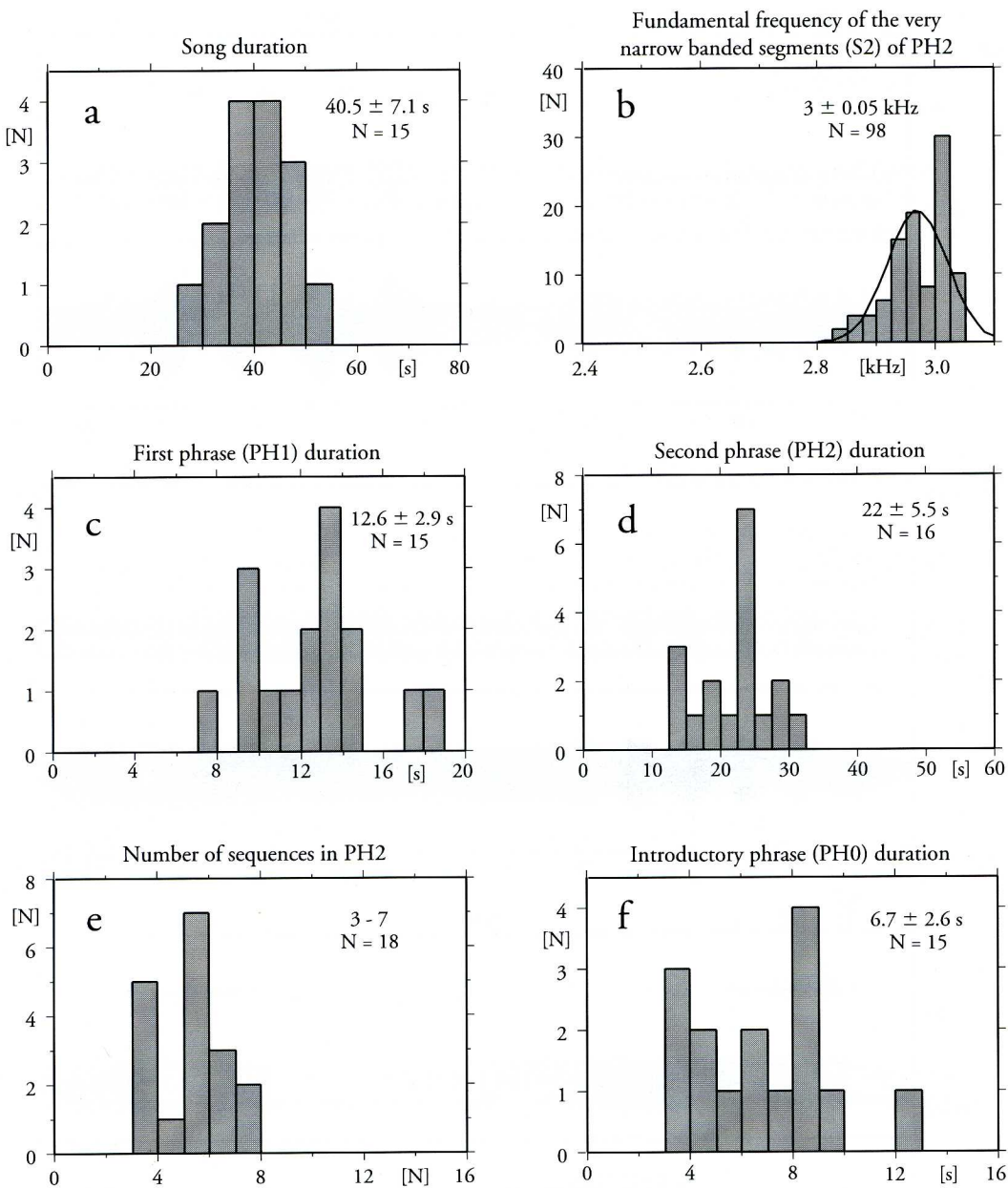


Fig. 5. *Purana sagittata* from Endau Rompin, time parameters of the song. – Histograms of a) song duration, b) fundamental frequency of a very narrow banded segments (S2) of PH2, c) first phrase (PH1) duration, d) second phrase (PH2) duration, e) number of sequences in PH2 and f) introductory phrase (PH0) duration. Means, standard deviations, and sample size are shown.

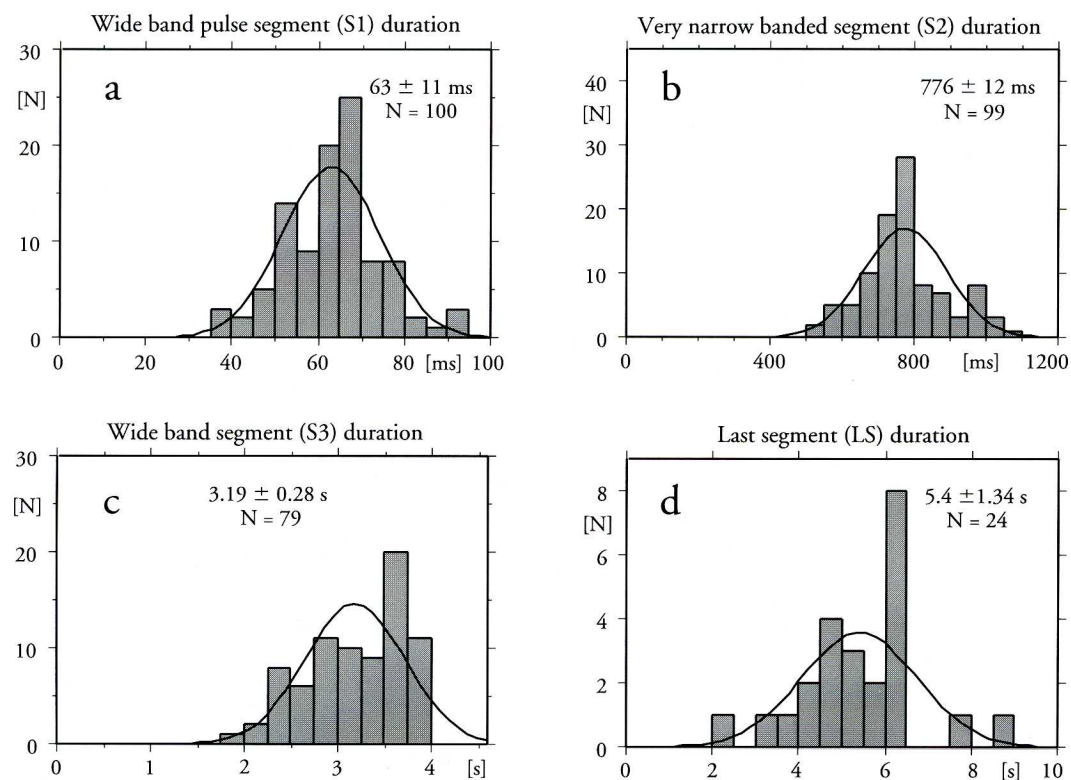


Fig. 6. *Purana sagittata* from Endau Rompin, time parameters of the song. – Histograms of a) wide band pulse segment (S1) duration, b) very narrow banded segment (S2) duration, c) wide band segment (S3) duration, d) last segment (LS) duration. Means, standard deviations, and sample size are shown.