# A survey method for the speckled bushcricket *Leptophyes punctatissima* (Orthoptera: Tettigoniidae) based on its sound emission

A. M. Boonman

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*Abstract*: The calling-activity of *Leptophyes punctatissima* during the nightcycle in summer and autumn was measured and taken as an index of abundance to establish year and day- periods for reliable population surveys. Furthermore chirp-structure, -loudness and -emission rate were analyzed. The author argues the possibility of a survey method for *Leptophyes* using an ultrasound detector.

I.B.B.-laan 143-2, 3582 XW Utrecht, The Netherlands.

## Introduction

The song of *Leptophyes punctatissima* (Bosc) (Orthoptera: Tettigoniidae) was first described by Hansson (1902). Faber (1953) describes the song as a very short and faint sound that is repeated every three or four seconds when the air temperature is 19°C. Ahlén & Degn (1980) subjected the sound of *Leptophyes* recorded outdoors with an ultrasound detector, to a thorough analysis revealing that most of its sound energy is in the range of 40 kHz (twice the upper limit of human hearing) and consists of 5-7 toothstrikes every single syllable. Most articles concerning *Leptophyes* have only paid attention to aspects of male-female communication and hearing characteristics (Hartley & Robinson, 1976; Robinson et al., 1986; Rheinländer et al., 1986; Robinson, 1990).

When occurrence or even population densities of a particular orthopteran species have to be measured it would seem convenient to develop some kind of survey method that requires little effort but gives a reliable impression of the actual population. Methods using population indices can yield information about local densities and yearly differences in abundance. When showing little short-term variation the number of visits can be kept small while several populations can be monitored this way. The aim of this study was to develop a method based on population indices for monitoring the numbers of *Leptophyes punctatissima*. This was not only done by surveying a population as a whole, but also by measuring some sound emission-characteristics of individuals.

## Material and methods

The study was conducted in the northeastern part of the city of Utrecht (The Netherlands) in summer and autumn 1993. A street of approximately 260 m length was monitored five times a night (table 1) during six periods from the end of July till the beginning of October (table 2). Additional visits were paid during the day. The number of these visits, however, is too small for reliable statistical analyses.

As weather can have an influence on the activity of *Leptophyes* the visits were all paid during periods with low wind speeds, relatively high temperatures and no precipitation. Both sides of the street were scanned for calling speckled bush crickets using an ultrasound detector (see below). The observer walked at a calm pace (± 1.5 m/s) and only stopped when notes had to be made. Individuals as well as clumped groups of *Leptophyes* were mapped in the same way because estimations of group

Table 1. Abundance of *Leptophyes punctatissima* at several times during the night. P = period of the night, A = mean absolute number, SD = standard deviation, R = relative abundance (%).

| P | A | SD | R |
|---|---|---|---|
| 1: 30 minutes before sunset | 9.5 | 8.1 | 32.5 |
| 2: 30 minutes after sunset | 21 | 8.5 | 78.1 |
| 3: 2-3 hours after sunset | 25.8 | 9.7 | 98.3 |
| 4: midnight | 23.4 | 8.7 | 89.3 |
| 5: 2 hours before sunrise | 13 | 9.2 | 50.0 |

Table 2. Abundance of *Leptophyes punctatissima* at several times of the year. P = period of the year, A = mean absolute number, SD = standard deviation, R = relative abundance (%).

| P | A | SD | R |
|---|---|---|---|
| 1: 29-31 vii | 5.8 | 3.96 | 16.6 |
| 2: 1 viii | 15.5 | 9.75 | 44.3 |
| 3: 16-18 viii | 24.4 | 11.08 | 69.7 |
| 4: 26-29 viii | 23.6 | 10.85 | 67.4 |
| 5: 11-15 ix | 24.0 | 3.92 | 68.6 |
| 6: 2 x | 22.0 | 3.74 | 62.9 |

sizes will be very rough in general and demand a lot of the time in which a transect has to be finished. This method, therefore, was based on the counting of calling-sites. During this study both an S-25 Detector (Ultra Sound Advice) and a Pettersson D960 Detector (Pettersson Elektronik) were used for monitoring the ultrasonic chirps of *Leptophyes*. One could argue that an influence on the results must somehow have been caused by differences in overall and/or directive sensitivity between these two detectors (Forbes & Newhook, 1990). However, by adjusting the detector's gain the major differences have been minimized. Furthermore, the microphones of the different detectors are both of the condensator type. Both detectors were set to the 'heterodyning mode' with the tuning dial on 40 kHz. This technique combines sensitivity with a good signal to noise ratio. For further details on the heterodyning process see Pettersson (1993). Though many sound parameters are rejected during the heterodyning-process enough sound information is preserved for recognition of *Leptophyes punctatissima* (see also Ahlén & Degn, 1980). The precise structures of the emitted sounds of *Leptophyes* under different circumstances were also a subject of investigation during this study. For this aim the 'time expansion system' of the D960 was used. In this technique the ultrasonic signal is digitally expanded 10 times, thus slowed down by this factor, as with high-speed tape-recording. For details see Pettersson (1993). These converted sounds were recorded with an analogue recorder (adjustable recording level) and then fed into a computer for analysis with an LP900 Signal Analyzer ver.2 (Pettersson Elektronik). The technical specifications of this programme are the same or slightly better than those of the former digitizing process. Chirp-durations could be measured accurately with the use of cursorbars in the oscillogram.

The chirp-emission rate was also investigated during this study. To this end some individuals of *Leptophyes* were counted on the number of chirps per minute (heard on the detector) ten times. The specific conditions (e.g. time, temperature) under which the countings were made, were noted. The countings were executed under seven different temperature conditions, varying from 7°C to 19°C.

To measure differences in loudness under various circumstances a number of observations were done on the furthest detectable distance of *Leptophyes*. In this way extreme variations due to reverberation caused by scattering or multiple reflections from vegetation could be smoothed out.

All statistical calculations were done with Number Cruncher Statistical System (NCSS), according to Mead et al. (1993).

## Results

### *Best time of the night*

If a great number of visits is paid several times during the night, a period with consistent high numbers of calling places can be called a suitable time for surveying *Leptophyes*. The investigated 'nighttimes' are presented in table 1 with their relative number of *Leptophyes* calling sites (abundance). The relative abundance of *Leptophyes* was calculated by setting the highest number counted on a particular night at 100%. The abundance at other periods of the same night is related to this 100%.

The only periods that differ significantly are periods 1 and 2 (Student's T, p=0.037, df=10). This indicates that a survey on *Leptophyes* is started preferably 30 minutes after sunset and can carry on for the whole further night. However, as period 1 and 5 do not differ significantly from each other (Student's T, p=0.575, df=7) period 5 is apparently not very well suited if reliable results are to be obtained.

*Best time of the year*

In 1993 the first calling speckled bush crickets were heard on July 28; a few individuals remained till the middle of October. It can be said that there is some sort of seasonal optimum for *Leptophyes* during which the survey is to be carried out. Table 2 shows the relative abundance of *Leptophyes* during the times of the season when the population was counted. The abundance given is relative to the highest number ever found. A steep increase, although not significant, can be noted between period 1 and 2 with just one single day in between. Period 1 and 3 are the only periods that differ significantly (Student's T, p=0.008, df=8). Despite the high numbers in September and October their standard deviations have become quite small. This is mainly due to the fact that the number of animals calling 30 minutes before sunset was almost equal to the number of calling animals during the rest of the evening, in contrast to the significant difference found during the other seasons (table 1).

*Structure of the emitted sounds*

According to Ahlén & Degn (1980) the sounds of *Leptophyes* consist of 5-7 toothstrikes a chirp, one chirp lasting just 30 milliseconds. The 'closing' of the chirp by a single toothstrike as described by Ahlén & Degn (1980), probably originates from an answering female *Leptophyes* (Hartley and Robinson, 1976). For male *Leptophyes* Hartley & Robinson (1976) mention 5-8 toothstrikes a chirp.

All recorded sounds during the research were similar to the male sounds as described by Hartley and Robinson (1976), which suggests that the results of this research on *Leptophyes* should be interpreted as outcomes concerning *Leptophyes*-males (fig. 1). Three of the analyzed sounds do only show 4 toothstrikes a chirp; 8 toothstrikes a chirp also occurred. On average, the entire chirp lasted for 35.9 milliseconds (SD=15.7, n=8). The high standard deviation is due to influences of tem-

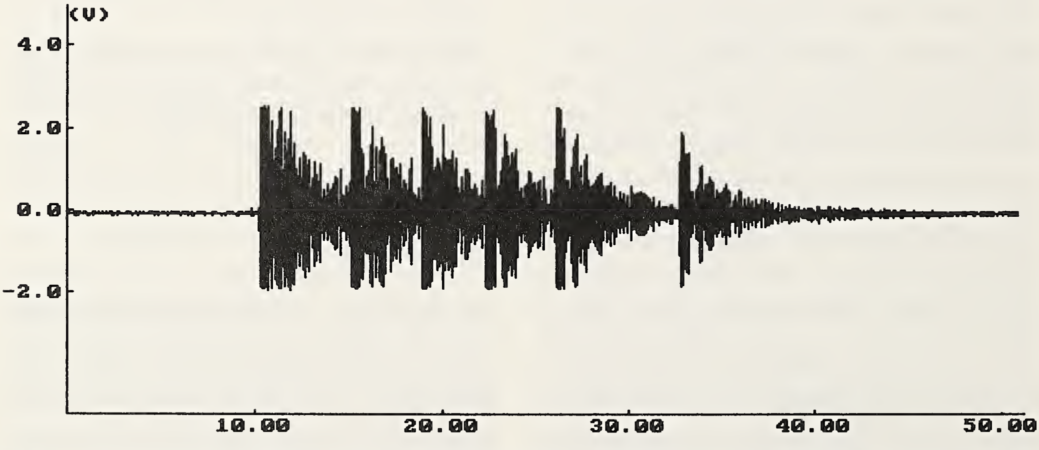


Fig. 1. A single chirp of *Leptophyes punctatissima* consisting of 6 toothstrikes, partially masked by echo-clutter caused by multiple reflections from vegetation. Scale of x-axis: time in milliseconds; scale of y-axis: amplitude in volts.

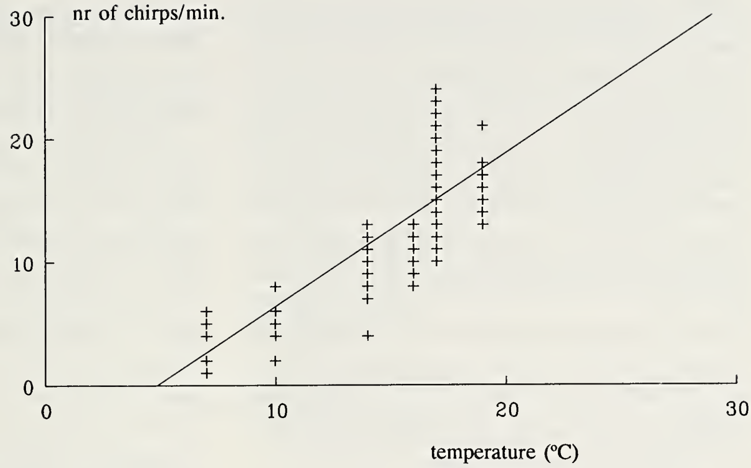


Fig. 2. The influence of temperature on the chirp emission-rate

perature. At all times of the year chirps become short in duration (± 20 milliseconds) during high temperatures (> 15°C) and long in duration (± 50 milliseconds) during low temperatures (5°C-7°C). Other authors (e.g. Ahlén & Degn, 1980; Hartley & Robinson, 1976) report chirp durations around 20 milliseconds, but neither of them considers the influence of temperature on this value.

Single toothstrikes were found to be highly frequency modulated and their duration averaged 0.315 milliseconds (SD=0.079, n=13), irrespective of temperature or number of toothstrikes. Considerable variations in toothstrike duration were found within a single chirp. Echo-clutter in recordings can be one of the major sources of variance in this duration because it makes a reliable measurement in the oscillogram more difficult. Diurnal recordings aroused suspicion as to a deviant chirp-structure; instead of a slowly diminishing amplitude, the chirps suddenly ceased. It is possible that chirps produced during the day also contain fewer toothstrikes and have a relative short duration on average. This question is still to be clarified in a more systematic way.

*Chirp emission-rate*

The number of chirps produced per minute was highly correlated with temperature (r=0.81): the higher the temperature, the more chirps per minute (fig. 2). For temperatures within the range of 7°C to 19°C the following relationship was obtained: $N=-5.96+1.24T$, where N stands for the number of chirps a minute and T stands for temperature in °C. The model was highly significant ($F(1,115) = 213.8$, $p<0.001$). However, it might be that such a linear relationship does not account for influences on the chirp emission-rate that work in a nonlinear way. The Sum of Squares-nonlinear part of the data, obtained by a One Way Anova of the data was therefore tested on significance. This nonlinear part turned out to be insignificant ($F(106,9)=1.77$, $p>0.10$).

The model can only be used in summer because countings in autumn showed a higher chirp emission rate than can be predicted by the formulated model. For this reason only countings executed during summer were used for the calculation of the model. The counted values ranged from 1 to 24 chirps per minute.

*Differences in loudness*

The greatest distance over which a calling *Leptophyes* could be heard averaged 17.8 metres in summer with a D960 bat-detector. This value differed significantly ($T = 5.79$, $p = 0.0002$, $df = 10$) from the mean value recorded on October 13 (11.7 m). During the course of October an increasing number of bushcrickets switched to a sound production of lower amplitude, while a few remained to emit loud sounds. During the October-count only animals emitting low-amplitude sounds were taken into account. The difference in maximum hearable distance does indeed stand for an actual diminishing of loudness as influences on sound amplitude other than spherical spread and atmospheric attenuation are smoothed out by the number of measurements taken. The difference in amplitude was estimated to be in the order of 10 dB. The maximum hearable distance is not a constant value. It depends on a great number of factors such as direction of the microphone, sensitivity of the detector, vegetation and even the noise within the observer's audible frequency-range.

## Conclusions and discussion

In The Netherlands the best day/night-time for surveying a population of *Leptophyes*-males by their sounds seems to be from 30 minutes after sunset to midnight as indicated by the given results. However, since there is a very steep increase of calling males from sunset to 30 minutes after, it will do no harm to start a survey only when the sky has completely darkened. Visits made during the day never resulted in an abundance of more than 60% relative to the maximum number found at night within the same seasonal period. Robinson (1980; 1990) claims that the singing activity, measured in chirps per hour, is at its highest level in the afternoon. These findings do not necessarily contradict each other since abundance and number of chirps per time unit are probably unrelated, although both are measurements of singing-activity. From September on, more bushcrickets seemed to be active during daytime. This assumption is confirmed by the greater number of calling sites found during 30 minutes before sunset, at the end of the season (see results). Most likely *Leptophyes*-males enhance the chance of mating by expanding their calling period as the mating-season is ending.

At the beginning of August the number of males more than doubled within a single day. Depending on the weather-conditions, it seems safe, therefore, to wait at least a week from the beginning of August to start a survey. When weather conditions are favourable, surveys can be carried out from August through the whole of September.

Although the numbers found at the beginning of October 1993 did not differ significantly from the preceding period, weather conditions probably have effects on the population which can differ from year to year. Furthermore, in the course of October more bushcrickets switched to a sound production of lower amplitude. This, in turn, is likely to have consequences on the results of surveys carried out during that period.

Female presence positively affects the chirp-rate of males (Hartley & Robinson, 1976; Robinson et al., 1986; Robinson, 1980; 1990). This investigation suggests that, under natural conditions, males behave as if females were present with respect to their calling-behaviour. As indicated by the results, the calling activity is mainly dependent on temperature. It can be argued that at low temperatures the chirp emission rate can indeed have effects on the measured abundance since individuals are not noticed as emitted chirps fall outside the observer's range when walking a transect. However, taking into account walking speed, maximum audible distance and directional sensitivity of the microphone, this effect only becomes apparent at temperatures of 10°C or lower (when on average 1.5 chirp has to fall within the critical time-span). For this reason, surveys can best be carried out when the temperature is above 10°C. During this investigation it was presumed that low wind speeds, high temperatures and no precipitation were weather conditions with a positive influence on the observed numbers of *Leptophyes*. The influence of weather factors, however, remains to be investigated more thoroughly.

During this research it was found that the abundance of *Leptophyes* was very constant, as were the calling-sites themselves. Many calling-sites remained restricted to the same $6m^2$ for the entire investigation-period. The development of an absolute-number method seems therefore possible. The countings of such a method can be seen as the real number of *Leptophyes*-males present in a particular area. The two main problems that have to be solved first are: 1) is it possible to estimate the number of calling bushcrickets at a calling site from the number of emitted chirps? 2) how many of the present *Leptophyes*-males do actually emit sounds? It is hoped that a more systematic approach to the survey of bushcrickets will increase our knowledge on occurrence, year to year abundance and other particularities of these interesting animals.

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Ultra Sound Advice, 23 Aberdeen Road, London N5 2UG, U.K.

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