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Authors: Cano-Santana, Zenón, Romero-Mata, Ariana, and Pérez-Escobedo, H. Marcela

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Modified Petraborg index applied to the sampling of male crickets by aural detection

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ZENÓN CANO-SANTANA, ARIANA ROMERO-MATA AND H. MARCELA PÉREZ-ESCOBEDO

Departamento de Ecología y Recursos Naturales, Facultad de Ciencias, Universidad Nacional Autónoma de México. Ciudad Universitaria. 04510 México, D. F. MEXICO. Email: zcs@fciencias.unam.mx, arianromat@yahoo.com.mx, salamandram@hotmail.com

Abstract

A modified Petraborg index is proposed to correct an underestimation error in the original formula and its use illustrated in censusing singers of *Oecanthus niveus* in Mexico. The unmodified index departs widely from observed densities; the modified index does not.

Key words

Oecanthus, census, density, acoustic, Southwood, listen

Aural detection is an indirect census method used to estimate the density of acoustically signalling animals, such as birds and insects (Gates & Smith 1972, Southwood & Henderson 2000).

In order to estimate the density of calling animals, Southwood (1978) and Southwood & Henderson (2000) proposed the "Petrabough" index. Misspelled by these authors, this should be called the 'Petraborg' index (see Petraborg *et al*. 1953).

The Petraborg Index is based upon a series of regularly spaced sampling pauses made by a listener. The density of singing animals (P.I.) is given by the following equation:

$$P.I. = \frac{\bar{h}}{L\pi r_a^2}$$

where h = the average number of songs heard per sampling pause, L = the total number of listening pauses made, and r_a = the audibility radius.

As written this equation indicates:

$$P.I. = \frac{\sum_{i=1}^{L} h_i}{L^2\pi r_a^2}$$

That is, the number of singing animals is divided twice by the number of listening pauses (L) made, which underestimates the true density of the animals producing the sounds. Therefore, we suggest a correction to the index (as originally proposed in Petraborg's paper and repeated in Southwood's book in its two editions (1978, 2000): we shall refer to this as the Modified Petraborg Index (*M.P.I.*):

$$M.P.I. = \frac{\sum_{i=1}^{L} h_i}{L\pi r_a^2} \quad \text{or} \quad M.P.I. = \frac{\bar{h}}{\pi r_a^2}$$

Our work group used both Petraborg indices, modified and unmodified, to calculate the density of male tree crickets, *Oecanthus niveus*, singing at a site in Central Mexico from January to December, 2005. The calling song of the males of this species is composed of five-pulse trains (chirps) each lasting ~0.1 s, given at a regular rate of about 3/s at 22°C, with a carrier frequency of ~2.25 kHz (Ponce-Wainer & Cueva del Castillo 2008). At the study site, singing activity takes place between 18:00 and 03:30 h, with the highest peak of activity recorded between 19:30 and 20:00 h (Pérez-Escobedo 2007).

This study was conducted in Pedregal de San Ángel Ecological Reserve (lat 19°17′ North, long 99°11′ West, 2300 m a.s.l.). Our measurements were made more comparable by employing the same single listener throughout the survey [this listener was H.M.P.-E.]: this avoided any errors arising in r_a due to different listeners. Audibility radius r_a was determined by establishing the distance at which our designated listener ceased to detect calling *O. niveus*: this distance was about 7 m. The error in r_a continues to be affected by variation in both vegetation density and chirp volume of each caller.

We obtained 25 listening-pause samples (L), each 100 m apart, over two consecutive days each month between 18:00 and 20:00 in the evening. Each listening sample lasted three minutes: 15 of these were carried out the first day at one location, and 10 the following day at another location. The listener counted only the number of calling males, not the number of chirps.

To avoid disturbance during sampling, the actual presence of cricket singers was only verified following every sampling pause, by searching for and finding the singing males. The male songsters sing spaced within an aggregation or chorus, and each songster could be individually detected within a time interval of about 3 min. We also observed silent adult (satellite?) males perched near the singing male in *ca* 5% of our observations: 1-3 nonsinging males were within 1 m of a singing male.

The Petraborg index (*P.I.*) varied from 3.5 ± 0.6 $s_{\bar{x}}$ to 10.5 ± 0.8 ind/ha, whereas *M.P.I.* varied from 87.0 ± 15.2 to 262.4 ± 20.1 ind/ha (Table 1).

The *M.P.I.* values were a much better estimate of the mean density of crickets, more congruent with the real density of callers determined in the field: up to nine callers, 2.3 on average, were detected during each sampling pause in an audibility area of 153.9 m^2. This is a mean density of males per 10,000 m^2 (hectare) of 150. It compares well with the monthly mean densities as determined by the *M.P.I.* (Table 1), but not with the monthly mean densities estimated by P.I. Estimation of male density using the *P.I.* is an unrealistic estimator.

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Table 1. Comparison of mean density (No./ha) of tree crickets (*O. niveus*) in Pedregal of San Ángel Ecological Reserve, calculated by the Petraborg index (*P.I.*) and by [recommended] modified Petraborg index (*M.P.I.*). Data from January to December, 2005. Note that *M.P.I.* is *L* times higher than *P.I.* ($L = 25$).

Months	P. I.	M.P. I.
	(Mean ± $s_{\bar{x}}$)	(Mean ± $s_{\bar{x}}$)
January	5.0 ± 0.8	123.9 ± 19.4
February	10.5 ± 0.8	262.4 ± 20.1
March	10.1 ± 1.2	252.0 ± 29.2
April	6.0 ± 0.9	150.7 ± 22.8
May	5.5 ± 0.8	137.1 ± 19.2
June	4.3 ± 0.8	106.5 ± 19.8
July	4.8 ± 0.9	120.8 ± 21.9
August	3.5 ± 0.6	87.0 ± 15.2
September	4.8 ± 0.9	120.8 ± 21.8
October	7.8 ± 1.0	194.9 ± 25.8
November	5.4 ± 1.0	135.1 ± 24.7
December	4.8 ± 0.8	120.8 ± 18.9

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