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A new species of the genus *Pterodichopetala* (Orthoptera: Tettigoniidae: Phaneropterinae) from northeastern Mexico

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Abstract

A new species of Phaneropterinae from northeastern Mexico, *Pterodichopetala alfredoi* n. sp., is described. *P. alfredoi* n. sp., may be easily separated from congeneric *P. cieloi* on morphological characters such as length of tegmen (shorter in *P. alfredoi* n. sp., leaving exposed the last abdominal tergites), male cerci composed of three processes *vs* two processes in *P. cieloi*, internal genitalia made up of two subtriangular processes, proximally and distally very produced (not so in *P. cieloi*), stridulatory file with *ca* 113 teeth (9-10 mm in length, 8-15 teeth/mm) *vs P. cieloi* stridulatory file *ca* 70 teeth (7-8 mm in length, 8-12 teeth/mm). Information on acoustic signals, ecology and distribution of *P. alfredoi* n. sp., is provided and discussed.

Key words

Phaneropterinae, biodiversity, *Pterodichopetala alfredoi*, new species, bioacoustics

Introduction

The genus *Pterodichopetala* Buzzetti *et al*., 2010 was described from material collected at El Cielo Biosphere Reserve (BR), south Tamaulipas, Mexico. The authors pointed out the similarity of *Pterodichopetala* to both *Dichopetala* Brunner von Wattenwyl, 1878, and *Marenestha* Brunner von Wattenwyl, 1878. Nevertheless, specimens collected at el Cielo BR did not fit within any of these genera and a new genus, represented by a single species, *P. cieloi*, was described.

The genus *Pterodichopetala* is characterized by having the pronotum square in cross section with lateral lobes inserted to the disc at a right angle, forming slightly out-curved lateral carinae. The pronotal disc is pentagonal in dorsal view, with fore margin straight and hind margin angulated. This combination of pronotal characters is the peculiar feature of this genus and is not found in any of the other two similar genera. *Pterodichopetala* shares characters of both *Marenestha* and *Dichopetala*, such as wing development, leg spinulation and ovipositor shape, but the pronotal shape is unique to *Pterodichopetala*.

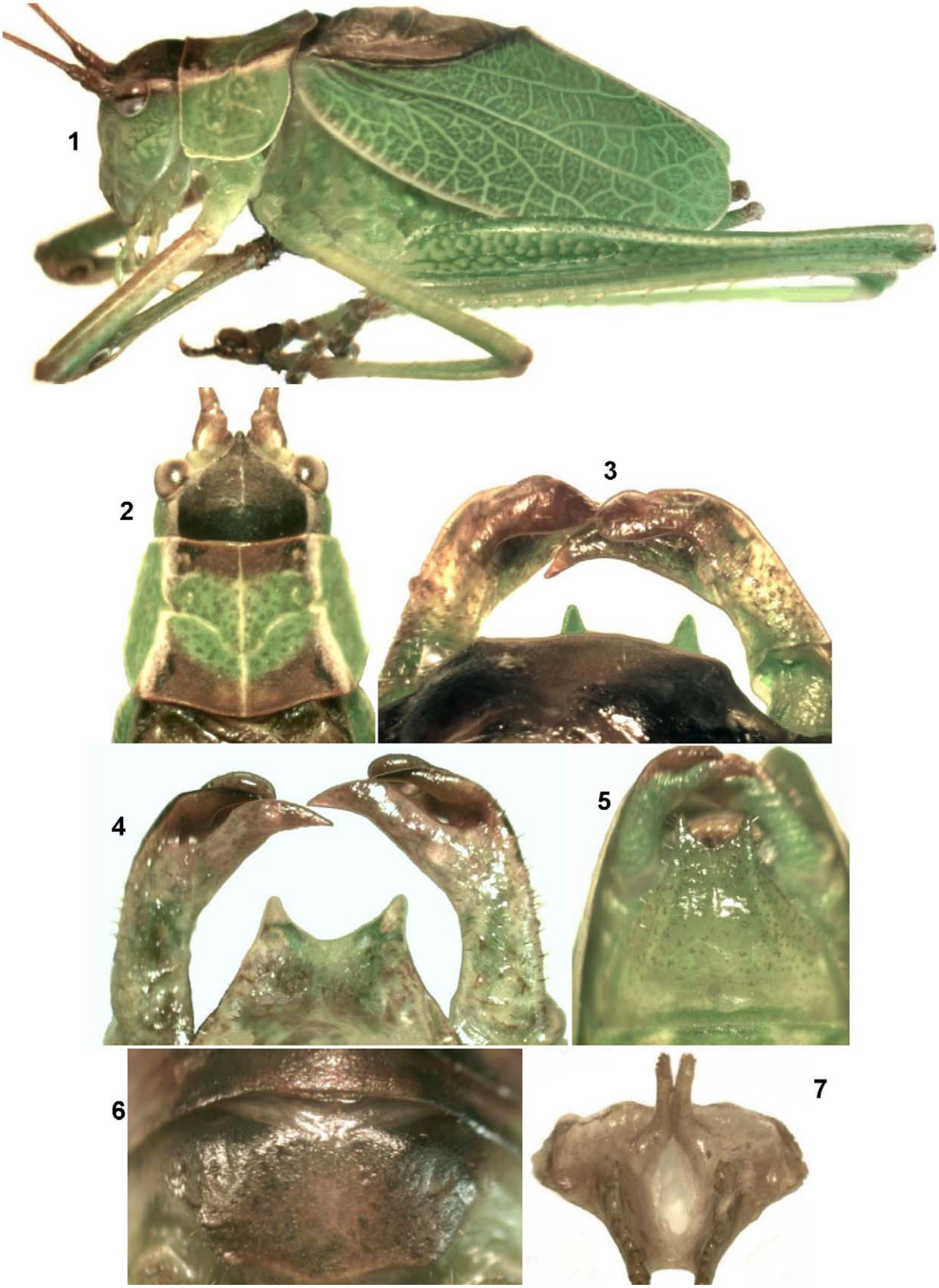
Specimens of *P. cieloi* were collected at a single locality in el Cielo Biosphere Reserve, Ejido (Ej.) La Gloria (1,630 m., lat 23°2.517'N, long 99°15.29'W), where they live on annual grasses of the family Asteraceae. Main host plants are *Stevia monardifolia* Kunth, *Tagetes lunulata* Ortega and *T. patula* L. They are considered indigenous to Mexico and Central America. The altitudinal distribution of host plants ranges from 1,400 to 3,000 m. Females of *P. cieloi* lay the eggs in the soil from September to December; the insects overwinter as eggs and hatch from May to July; the species has one generation per year.

During expeditions to Miquihuana, Tamaulipas in 2012, we collected specimens of a phaneropterine katydid that at first sight resembled *Dichopetala* and *Pterodichopetala*: careful examination confirmed they belonged to the latter genus. However, they did not fit the description of *P. cieloi*. Therefore *P. alfredoi* n. sp. is herein described. Information on ecology, distribution and calling song of *P. alfredoi* n. sp. is provided.

Materials and methods

A total of 20 adult males and 12 females were collected at Miquihuana, Tamaulipas, Mexico, from March to October 2012. In describing *Pterodichopetala alfredoi* n. sp. Barrientos & Rocha, the following morphological characters were considered: body length; shape of the fastigium verticis and fastigium frontalis; shape of the pronotal disc, carinae, and lobes; stridulatory file length and approximate number of teeth; length of tegmen; shape of femoral genicular lobes; fore tibiae spinulation; male external and internal genitalia, including terminal tergite, cerci, subgenital plate, and titillators; and in the female, shape and size of the ovipositor; basal lobe of ovipositor; subgenital plate and basal sclerites of subgenital plate. Measurements were defined as follows: *total length*, the distance between the frons and the apex of the flexed and parallel aligned to body hind femora; *length of pronotal disc*, the median length of the disc from anterior to posterior margin; *length of hind femur*, the greatest dimension of that structure as seen in lateral view; *length of tegmen*, the greatest dimension of that structure as seen in lateral view; and *length of ovipositor*, the distance from the anterior margin of ventral valvae to the apex of the ovipositor. All teeth on the stridulatory file on the left tegmen were counted, and the straight-line distance between first and last tooth on the file was measured as the length of the file. Figures (1-14) and measurements were made with a Motic Stereomicroscope, Model 43-FBGG-C, 3.0 mp. Figures and measurements of habitus and pronotal disc were taken at 10×; all others at 40×. Dissection of internal genitalia was performed on fresh material or by relaxing specimens in hot water for *ca* 1 h. After relaxation the male was positioned on a sheet of pinning surface, and the phallus slipped back using insect pins with the tip bent at a right angle. The phallic complex was placed for ~10 min in a 10% KOH solution to clear and remove the membranes and muscles. The membranes and muscles were then completely removed with insect pins with the tip bent. The structure was then washed with cold water and photographed. Phallic structures were preserved in a mixture of 70% alcohol (80% of total), glycerin (15%) and acetic acid (5%). This procedure is described by Cohn & Cantrall (1974) and Hubbell (1932). Live specimens and habitat photographs (Figs 15-18) were made with a Nikon D3000 digital camera with a resolution of 10.2 MP. Acoustic signals of five males were recorded

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Figs 1-7. Male of *Pterodichopetala alfredoi* n. sp. 1. Habitus; 2. Head and pronotum in dorsal view; 3. Cerci in dorsal view; 4. Cerci in ventral view; 5. Subgenital plate in ventral view; 6. Terminal tergite in dorsal view; 7. Titillators.

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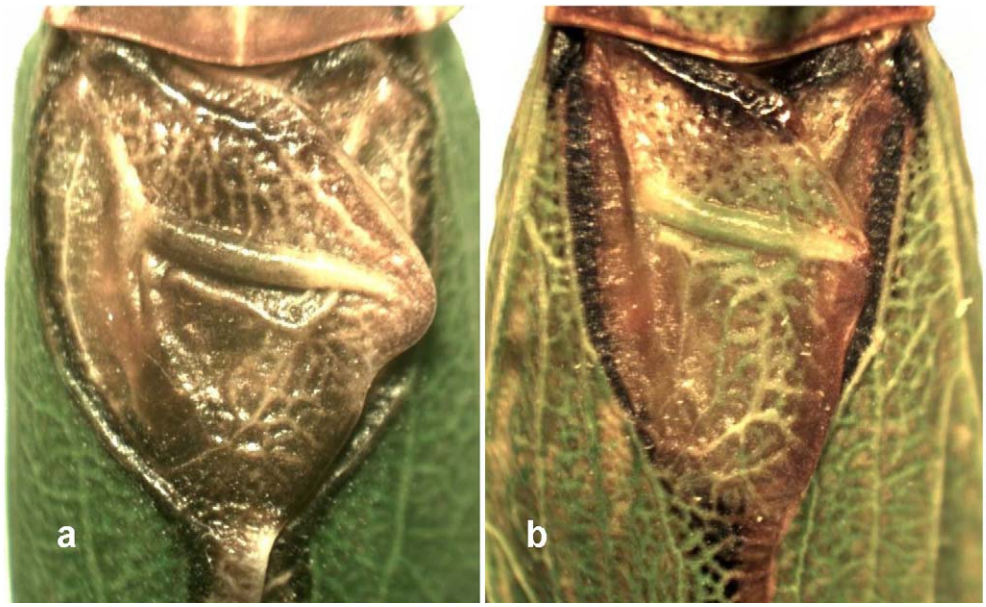


Fig. 8. Stridulatory field of left tegmen: a) *Pterodichopetala alfredoi* n. sp.; b) *P. cieloi*.

in the laboratory; males were separated from females and placed in a 30×30×30 cm net cage. To obtain better quality sound the cage was covered with foam. Acoustic signals were recorded directly into a Sony Vaio laptop using an *ativa* Omni-directional microphone, -38±3 dB sensibility and 100Hz - 10 kHz frequency response. The tracks were sampled with Cool Edit Pro 2.0 at 32.0 kHz, 16 bit, FFT size1024. Temperature was 28°C. The terminology for the description of acoustic signals follows Ragge & Reynolds (1998), Gerhardt & Huber (2002), Sevgili *et al.* (2006), and Orci *et al.* (2010). *Calling song*: song produced by a single male; *syllable group (echeme)*: an assemblage of syllables; *syllable*: sound produced during one opening and closing movement of the tegmina; *impulse*: a simple, undivided transient train of sound waves (here: the highly dampened sound impulse resulting from the impact from one tooth of the stridulatory file). Abbreviations used: s: second, ms: millisecond.

Habitat.— Photographs were taken, and samples of grasses and host plants collected during field trips. Plant species were identified with relevant literature (Rzedowski & Rzedowski 2005; Rzedowski 2006; Treviño & Banuet 2005). Coordinates and altitude measurements were taken using a Garmin-GPS 48 (12-channel).

Depositories.—University of Michigan Museum of Zoology (UMMZ): ♂ holotype and ♀ allotype. Instituto de Biología-Universidad Nacional Autónoma de Mexico (IB-UNAM): 1 ♂ and 1 ♀ paratypes. L. Barrientos-Lozano collection-Instituto Tecnológico de Cd. Victoria, Tamaulipas, Mexico. (L. Barrientos-Lozano-ITCV): all other ♂ and ♀ paratypes.

Results

***Pterodichopetala alfredoi* n. sp.**
(Figs 1-17)

Type material.—Holotype ♂ and allotype ♀. Mexico, Tamaulipas, Miquihuana, Ejido (Ej.) Aserradero, 3,044 m, lat. 23°41.465'N, long. 99°43.871'W, 17.VIII.2012, Barrientos-Lozano L., Rocha-Sánchez A.Y. & Sánchez-González A.

Paratypes.—**Mexico, Tamaulipas, Miquihuana:** 1 ♂, Ej. La Glo-

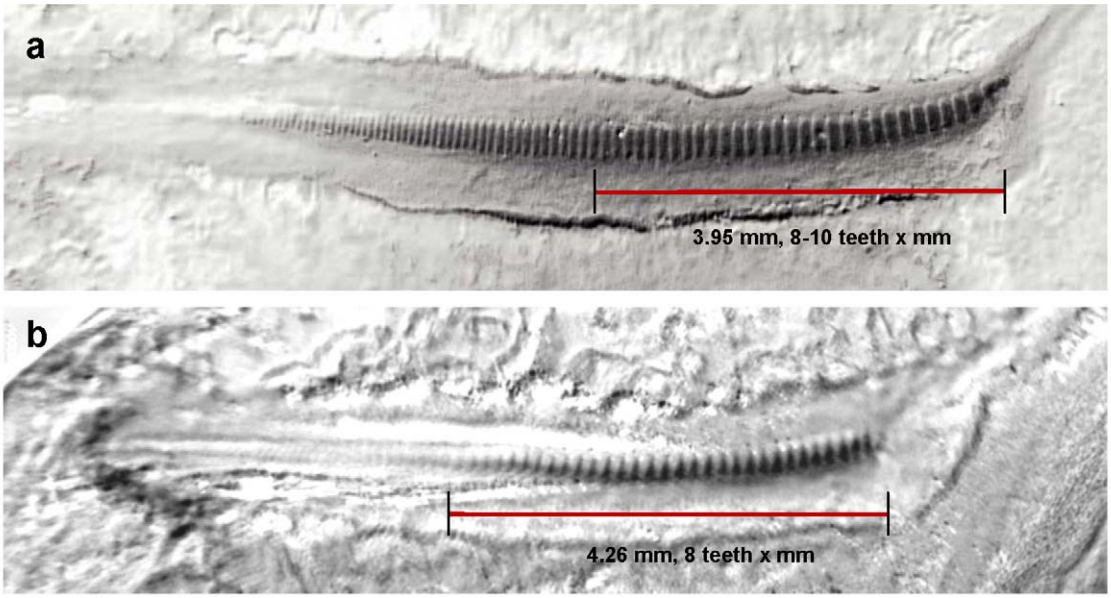
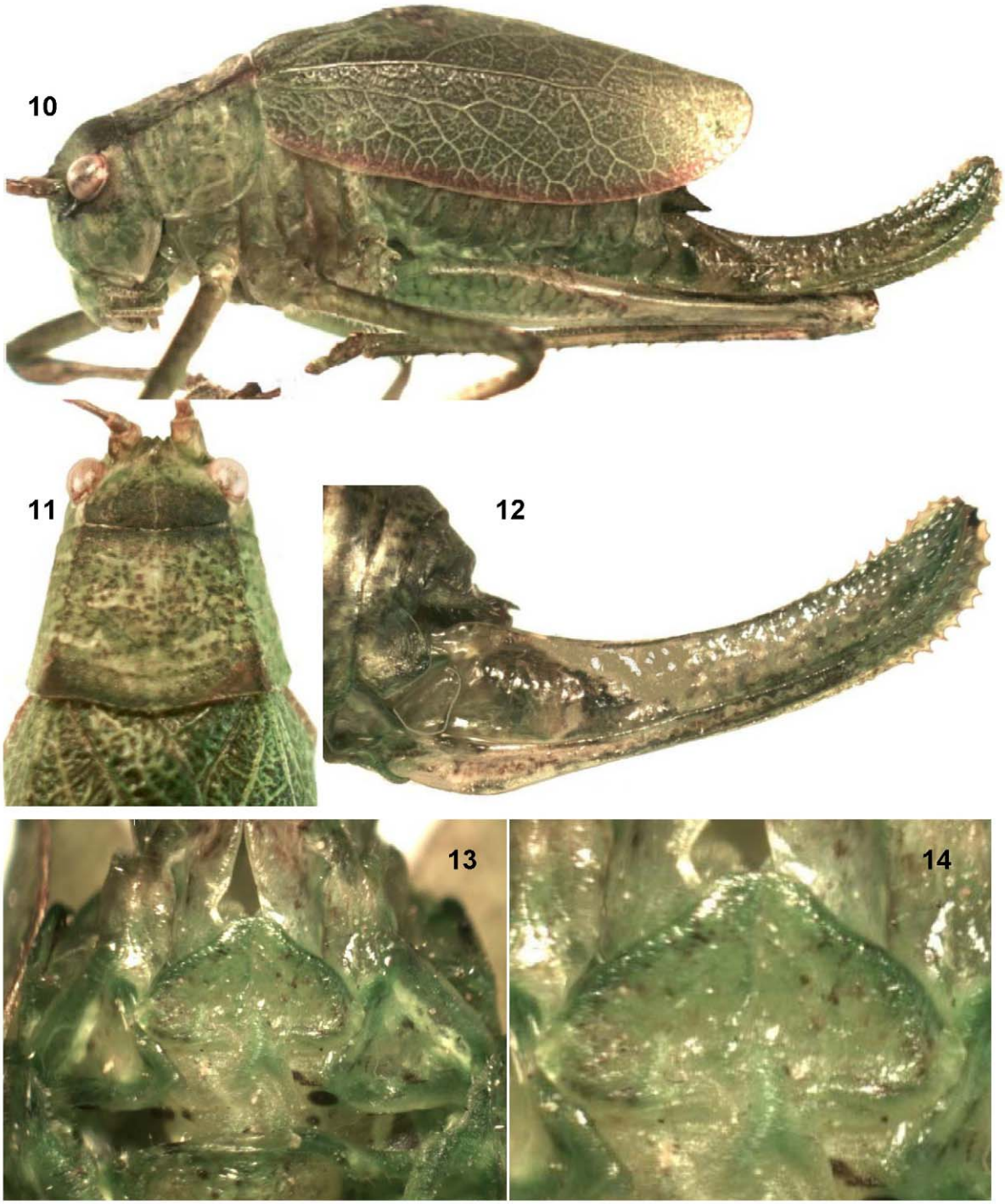


Fig. 9. Stridulatory file on underside of left tegmen: a) *Pterodichopetala alfredoi* n. sp. b) *P. cieloi*.

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Figs 10-14. Female of *Pterodichopetala alfredoi* n. sp. 10. Habitus; 11. Pronotum in dorsal view; 12. Ovipositor in lateral view and basal lobe of ovipositor; 13. Subgenital plate and basal sclerites of subgenital plate; 14. Subgenital plate.

ria, 3,240 m, lat. 23°42.336'N, long. 99°43.436'W, 18.II.2012, Sánchez-González A., coll. L. Barrientos-Lozano-ITCV; 4 ♂ and 2 ♀, same data as type material, coll. L. Barrientos-Lozano-ITCV; 5 ♂ and 3 ♀, road (rd.) Miquihuana-La Joya, km 11, 2,649 m, lat. 23°36.101'N, long. 99°42.423'W, 17.VIII.2012, Barrientos-Lozano L., Rocha-Sánchez A.Y. & Sánchez-González A., coll. L. Barrientos-Lozano-ITCV; 6 ♂ and 4 ♀, Ej. La Joya, 3,026 m, lat. 23°38.952'N, long. 99°42.482'W, 17-18.VIII.2012, Barrientos-Lozano L., Rocha-Sánchez A.Y. & Sánchez-González A., coll. L. Barrientos-Lozano-ITCV; 8 ♂ and 5 ♀, Ej. La Joya, 3,026 m, lat. 23°38.952'N, long. 99°42.482'W, 13.X.2012, Barrientos-Lozano L. & Rocha-Sánchez A.Y., coll. L. Barrientos-Lozano-ITCV.

Diagnosis.—*P. alfredoi* n. sp. may be easily distinguished from *P. cieloi* by the following characters: smaller than *P. cieloi* (males average 16.6 mm, females 16.8 *vs* 19.5 and 19.6 mm in *P. cieloi* males and females, respectively); general color green; short tegmina in both male and female (Figs 15-16) leaving uncovered abdominal tergites 8-10, in

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Fig.15. Males of *Pterodichopetala alfredoi* n. sp. on host plant *Gochnatia hypoleuca* (DC.) A. Gray. For color version, see Plate I.

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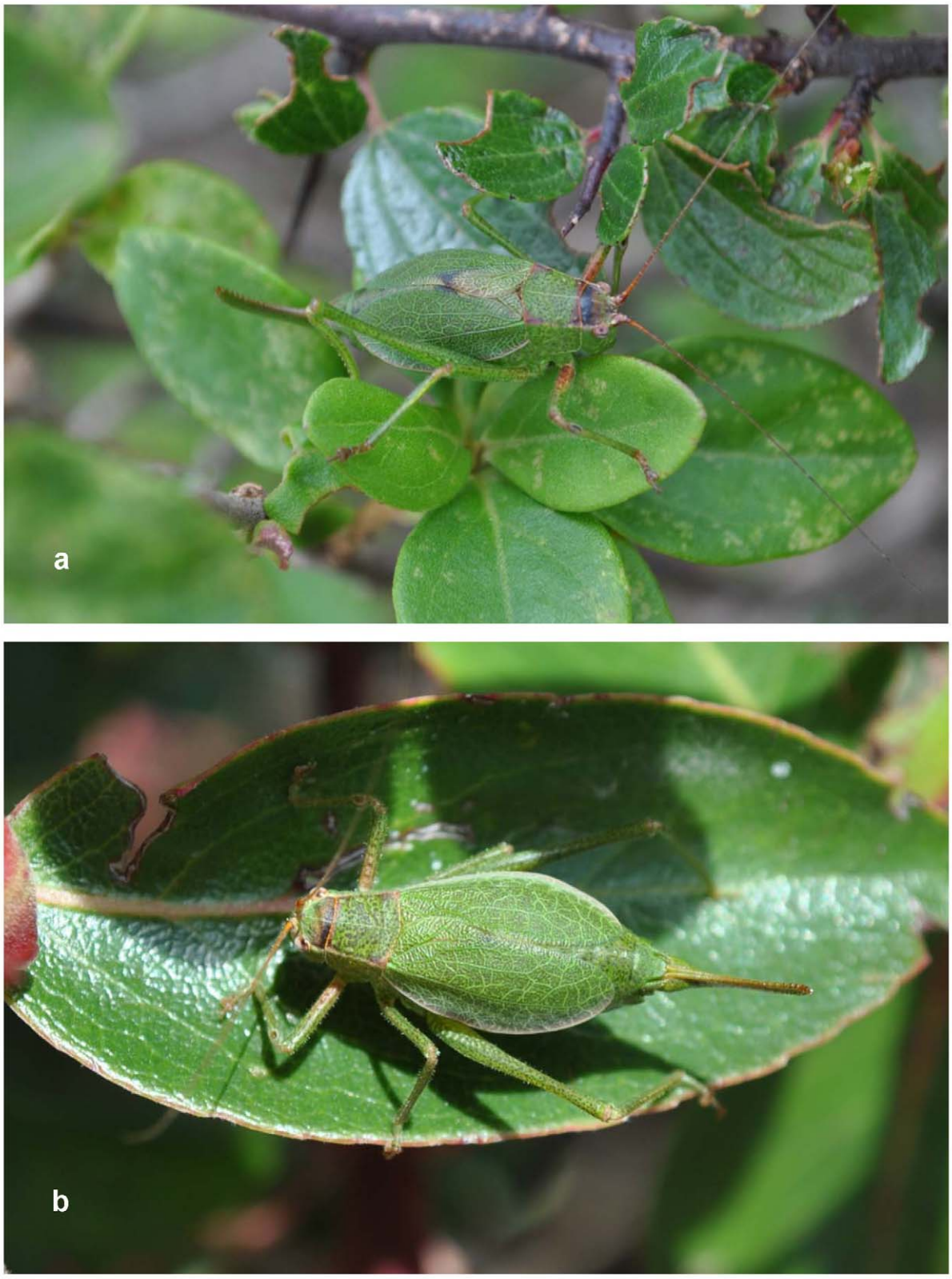


Fig. 16. Females of *Pterodichopetala alfredoi* n. sp. on host plants *Gochnatia hypoleuca* (DC.) A. Gray (a) and *Malosma laurina* (Nutt.) (b). For color version, see Plate II.

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Fig.17. Nymphs of *Pterodichopetala alfredoi* n. sp. male (a) and female (b). For color version, see Plate III.

P. cieloi tegmina are slightly longer than abdomen; male cerci (Figs 3-4) bearing three processes: a very long finger-like ventral arm with very pointed apex, a stout dorsal process which is apically expanded, concave, rounded, and curve inwards, and between the ventral and dorsal arms a third process which is basally swollen and tapering gradually towards a pointed apex; subgenital plate (Fig. 5) basally strongly concave and distally with a wide-U shaped emargination; terminal tergite (Fig. 6) subpentagonal, lateral margins distinctively undulated; internal genitalia (Fig. 7) composed of two subtriangular processes, which are anterior and distally very produced, each part bearing a crown of denticles on top of the anterior process and a row of spines on the distal process. Morphology of external and internal male genitalia is very different in *P. cieloi*. Stridulatory file of *P. alfredoi* n. sp. (Figs 8a-9a) with *ca* 113 teeth, 9-10 mm in length and 8-15 teeth/mm *vs P. cieloi* stridulatory file (Figs 8b-9b) with *ca* 70 teeth, 7-8 mm in length and 8-12 teeth/mm. Different acoustic signals as shown in Figs 20-21.

Description of males.—General color green (Figs 1, 15); antennae basally light brown, distally greenish; fastigium of vertex short, conical, tubercle-like, divided from the frontal fastigium by a distance of 0.1mm (10×), frontal fastigium of similar shape but smaller; a delicate white stripe from hind margin of eyes to pronotum; occiput anterior half light brown, posteriorly dark brown-blackish; pronotal disc (Fig. 2) pentagonal (dorsal view), anterior portion brown, slightly sinuous, posterior margin brown, carina media



Fig.18. Habitat of *Pterodichopetala alfredoi* n. sp., montane pine-oak forest. Miquihuana, Tamaulipas. Mexico. For color version, see Plate III.

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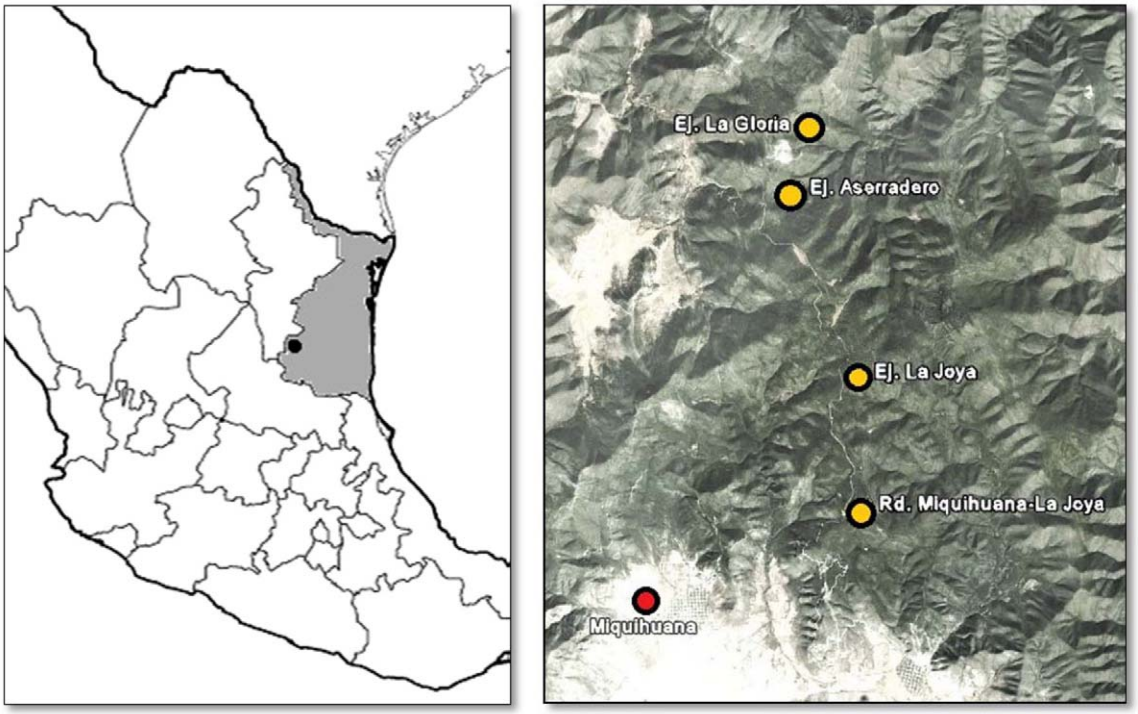


Fig. 19. Distribution of *Pterodichopetala alfredoi* n. sp.

conspicuous whitish cream; typical sulcus on pronotal disc evident, cream, shallow wide u-shaped, cutting acutely the "well-developed," white, lateral carinae and extending to middle of lateral lobes in form of a groove; lateral lobes of pronotum (Fig. 1) quadrate (lateral view), humeral sinus obsolete. Basal portion of tegmina (Fig. 8a) dark brown; stridulatory apparatus (Fig. 8a) light brown with darker brown edges. Tegmina (Figs 1, 15) are elongated, ovate, with prominent venation, upper margin slightly overlaps beneath the stridulatory apparatus, tergites 8-10 of abdomen exposed, upper margin of tegmina with a well defined white longitudinal area, lower margins whitish cream with brown spots; hind wings vestigial. Fore tibiae dorso-external margin each with 1 spine or unarmed, dorso-internal margin unarmed; ventral external and internal margins each with 1 spine; distal spines not included. Ventral femoral margins unarmed. Femoral genicular lobes distally concave (dorsal view) and unarmed. Cerci as described in diagnosis. Stridulatory file (Fig. 9a) with *ca* 113 teeth, 9-10 mm in length, 8-15 teeth/mm. As teeth size decreases, the number of teeth per mm increases.

Measurements (mm) males.—Body length from vertex to end of femur 3: 16.6 ± 0.9 (15.0-17.0). Pronotum length: 2.4 ±0.09 (2.2-2.4). Tegmen length: 8.5 ±0.6 (8.0-9.5). Fore femur length: 4.0 ± 0.4 (4.0-4.5). Mid femur length: 4.8 ± 0.25 (4.5-5.0). Hind femur length: 11.0 ± 0.7 (10.0-12.0).

Description of females.—Similar to the males (Figs 10, 16), almost completely green; occiput posteriorly dark brown-black; tegmina ventral margin white with brown spots above, a black mark on dorsal margin, approximately at mid point (Fig. 16a, b). The humeral sinus is absent. Ovipositor (Fig. 12) longer than head and pronotum together, evenly curved upward, upper margin brownish, lower margin straight on basal 3/4, distal third spinulated on upper and lower margins; basal lobe of ovipositor trapezoidal. The subgenital plate (Figs 13-14) triangular, divided by a median ridge; basal sclerites large, subtriangular with sinuous margins.

Measurements (mm) females.—Body length from vertex to end of femur 3: 17.0 ± 1.5 (15.0-19.0). Pronotum length: 3.0 ±0.2 (2.0-3.0). Tegmen length: 10.0 ±0.2 (9.5-10.0). Fore femur length: 4.0 ± 0.15 (4.0-4.2). Mid femur length: 5.0 ± 0.3 (4.0-5.0). Hind femur length: 11.0 ± 0.4 (10.0-11.0). Ovipositor length 9.0 ± 0.3 (8.0-9.0).

Distribution.—This species has been collected in several localities climbing the mountain range (Eastern Sierra Madre-ESM) surrounding Miquihuana, Tamaulipas. The elevation range is 2,650 to 3,240 m (Fig. 19).

Habitat.—Miquihuana is located in southwest Tamaulipas (Fig. 19), set at the highlands of the Eastern Sierra Madre (ESM). This municipality is endowed with the second highest peak in northeastern Mexico, "Cerro Peña Nevada" (3,650 m). Climate in the area is temperate semi-arid, BS1kx(w")(e)g, with mid-summer rainfall; in winter the rainfall rate is less than 18%. Its mean annual temperature is 17.3 °C, while its mean annual precipitation is estimated at 468 mm. Soils are a lithosol of limestone origin, with moderate to steep slopes. The area is characterized by xeric (Rzedowski 1978) or scrub rosette vegetation (González-Medrano 2003). The most abundant and common species are *Euphorbia antisyphilitica* Zucc., (Euphorbiaceae), *Chrysactinia mexicana* Gray (Asteraceae), *Dasylirion miquihuanense* Bogler (Nolinaceae), *Agave lechuguilla* Torr., *A. striata* Zucc., and *A. montana* Villarreal (Agavaceae). Montane pine-oak forest (Fig. 18), where *P. alfredoi* n. sp. has been collected, is developed on the slopes of the higher mountains between 2,600 and 3,650 m (Fig. 19). The forest is dominated by *Pinus nelsonii* Shaw, *P. cembroides* Zucc. (Pinaceae), and dwarf oaks, *Quercus miquihuanensis* Nixon & C. H. Muller (Fagaceae). This vegetation type is characterized by a dense herb layer. Among the most common herbaceous plants, we identified *Gochnatia hypoleuca* (DC.) A. Gray (Asteraceae), *Malosma laurina* (Nutt.) (Anacardiaceae), *Anisacanthus* sp. (Acanthaceae), *Asphodelus* sp. (Liliaceae), and *Aster* sp. (Asteraceae). *P. alfredoi* n. sp. lives primarily on *G. hypoleuca*, an attractive perennial shrub.

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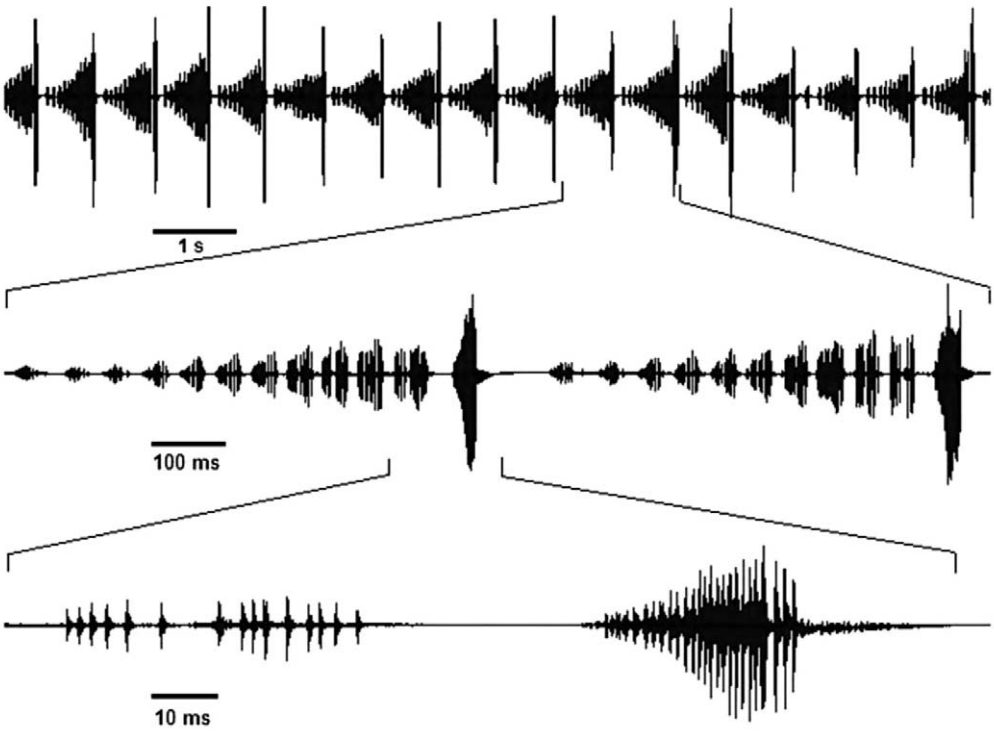


Fig. 20. *Pterodichopetala alfredoi* n. sp. male calling song.

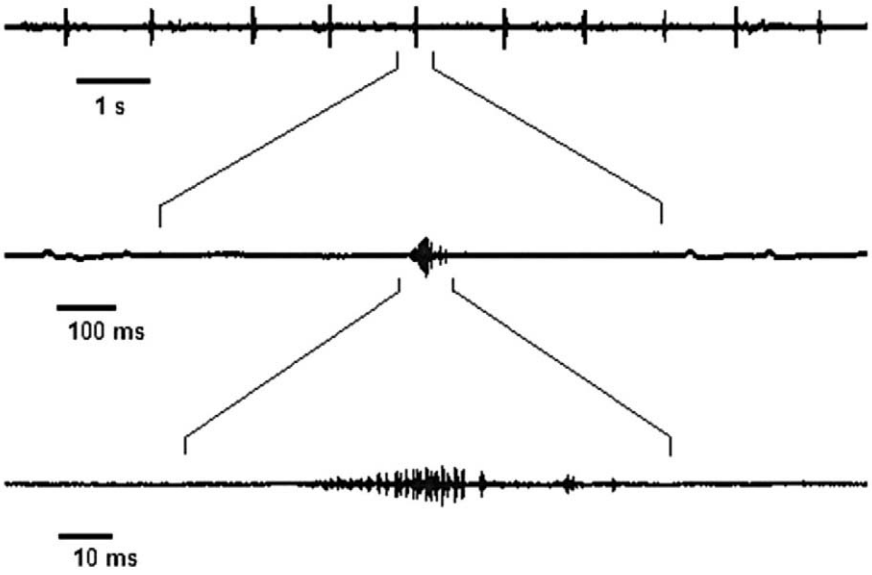


Fig. 21. *Pterodichopetala alfredoi* n. sp. male echemes sequence.

It has striking bi-colored leaves, dark green on top and white on the felty underside. It flowers from July to December; flowers are strongly fragrant and attract bees and butterflies. *P. alfredoi* n. sp. is well camouflaged with its host plants' shape and size of leaves (Figs 15-17).

Etymology.—This species is named after Alfredo Sánchez-González, who collected the first male specimen during an expedition to study the *Agave* spp., inhabiting the highlands of Miquihuana, Tamaulipas.

Acoustic behavior.—Acoustic signals were recorded as follows: male alone, male and female in the same cage, singing male plus four males in the same cage. The calling signal is a sequence of echemes produced at irregular intervals (Fig. 20), each echeme is composed of syllables, and the number of syllables per echeme increases over the entire sequence from 7-9 at the beginning (mean=8; n=15), towards the end with 11-12 (mean=11; n=15). Echeme duration also increases gradually as the male is warming up, varying from 0.45-0.57 s (mean=0.51; n=15) to 0.57-0.64 s (mean= 0.6; n= 15). The number of impulses per syllable varies from 13-30 (mean= 20; n=24) at the beginning to 11-31 (mean= 15; n= 32) at the end; as the male warms up the number of impulses per syllable decreases. At the beginning and at the end of the calling song, the last syllable of the echeme is comprised of more impulses ranging from 25-31 (mean= 28; n=20). Single males produce sometimes isolated echemes (Fig. 21) delivered at regular intervals, the approximate rate is of 1/s (n=10). They may switch from this isolated echemes into the calling song. Acoustic activity is mostly at night and singing

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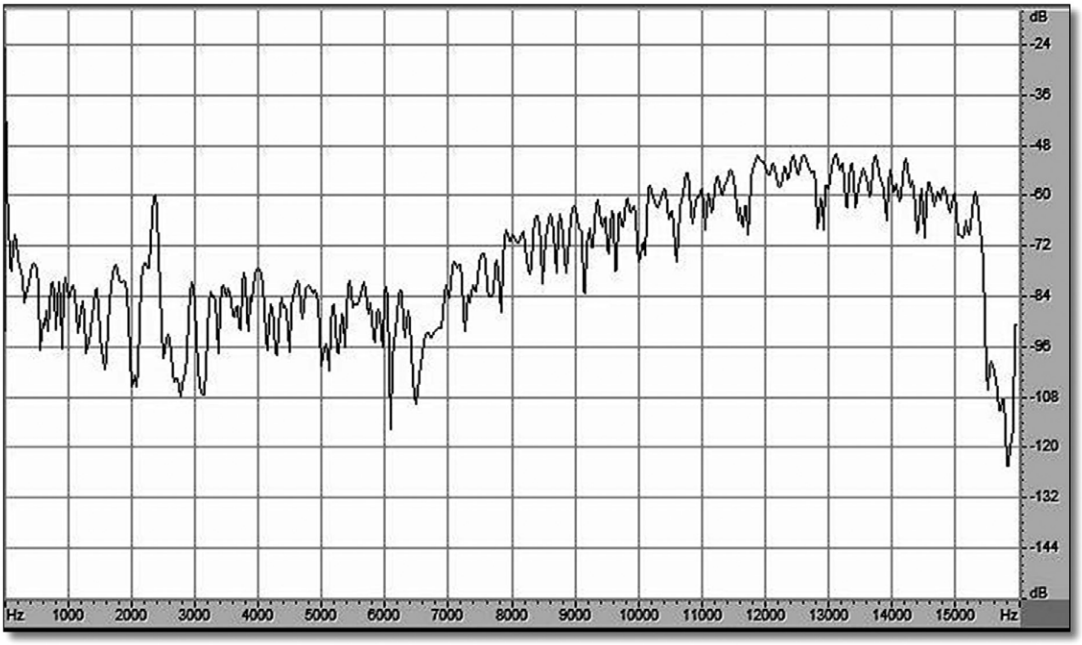


Fig. 22. Frequency spectrum of the male calling song of *Pterodichopetala alfredoi* n. sp.

males usually elicited other males to sing.

Frequency spectrum of the male calling signal (Fig. 22) was taken from a sequence of echemes (n=33; 23 s, *ca*). Most of the sound energy is spread between 7-15.5 kHz. However, the upper limit of 15.5 kHz is due to the recording and analyzing method. Frequency components of *P. alfredoi* n. sp. above 15.5 kHz are unknown.

Discussion.—A new phaneropterine katydid, *P. alfredoi* n. sp. is described. This species may be easily distinguished of its congeneric *P. cieloi* Buzzetti *et al.* 2010 because of its morphology and calling song. Both *P. alfredoi* n. sp. and *P. cieloi* are endemic to northeastern Mexico, inhabiting restricted areas at the highest mountain peaks of the Eastern Sierra Madre (ESM) and subject to unique ecological conditions (climate, soil and vegetation). *P. alfredoi* n. sp. is endemic to Miquihuana, Tamaulipas. The municipality of Miquihuana is located in the highlands of the ESM; elevation range is between 1,892 and 3,650 m. The area is characterized by a unique flora with a considerable number of endemics. *P. alfredoi* n. sp. has been collected along a transect between 2,600 and 3,240 m.a.s.l. On the other hand, *P. cieloi* was found at a single locality – in the midlands of the ESM-Gómez Farías, Tamaulipas, El Cielo Biosphere Reserve, at 1,630 m. *P. alfredoi* n. sp. inhabits the western slopes of the ESM, under temperate semiarid climate and scarce rainfall. In contrast, *P. cieloi* inhabits the east side of the ESM favoring a predominantly humid temperate climate. Endemic species in northeastern Mexico are found at the highest mountain peaks, *ca* 2,600-3,300 m; this habitat tends to have a sharply reduced number of species but those that do occur there are usually very distinctive in morphology and have very restricted geographic ranges (Hinton & Hinton 1995). Although *P. alfredoi* n. sp. and *P. cieloi* share some ecological affinities (*i.e.*, both species inhabit ESM limited geographic areas with temperate climate and their main host plants are aromatic Asteraceae), the altitudinal range they live at, as well as their ecological preferences are different (climate, composition and structure of the area occupied). How these taxa have diverged is perhaps explained as a result of the pressure that the environment exercises upon allopatric populations and the fact that isolated mountain peaks allow insular conditions that favor speciation.

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