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Taxonomic and biological notes on *Andinopanurgus* (Hymenoptera: Andrenidae)

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Abstract. Additional taxonomical and biological information on *Andinopanurgus* Gonzalez & Engel, a recently described subgenus of *Protandrena* Cockerell occurring at mid- and high elevations (1100–3400 m) in the Andes from Venezuela to Peru, is provided. The male of *Protandrena maximina* Gonzalez & Ruz is described and figured for the first time. New geographical records, an updated key to species, and observations on the foraging behavior of *P. guarnensis* Gonzalez & Ruz on flowers of cultivated potatoes (*Solanum tuberosum* L. [Solanaceae]) in central Colombia are also provided.

INTRODUCTION

Biological systematics is a dynamic discipline whose practitioners' job never ends. Several months after an account on *Andinopanurgus* Gonzalez & Engel was published (Gonzalez & Engel, 2011), we received some specimens of this group for examination that turned out to be new records, including the male of *Protandrena maximina* Gonzalez & Ruz (Fig. 1), a Venezuelan species currently known from the female. *Andinopanurgus* is a distinctive subgenus of *Protandrena* Cockerell occurring at mid- and high elevations (1100–3400 m) in the Andes from Venezuela to Peru. Although seven species are known, all are recorded from merely a few specimens. Two species groups can be recognized within *Andinopanurgus* (Table 1) by the following characters in the male: length of the first antennal flagellomere and the presence or absence of yellow maculations on the clypeus, stout spines on midapical margin of the fifth sternum, and a V-shaped median emargination on the distal margin of the seventh tergum (Gonzalez & Engel, 2011). The nesting biology and floral relationships of these bees are largely

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Table 1. Summary of currently included species in *Andinopanurgus* with information on the known sexes, distribution, and some morphological characters (updated from Gonzalez & Engel, 2011). Plus (+) and dash (–) symbols indicate presence and absence of a particular character, ? = unknown.

Taxon	**Sexes known**	**Distribution**	**Elevation (m.s.l.)**	**Male**		**Female**
				Antennal flagellum	Spines of SV	Antennal flagellum
"*bachue* species group"						
P. amyae Gonzalez & Engel	♂	Ecuador: Napo	2438	weakly crenulate	+	?
P. bachue Gonzalez & Ruz	♂♀	Colombia: Boyacá, Cundinamarca	2830–3380	strongly crenulate	+	weakly crenulate
P. maximina Gonzalez & Ruz	♂♀	Venezuela: Mérida	2360	unmodified	+	unmodified
P. rangeli Gonzalez & Ruz	♂♀	Colombia: Boyacá, Cundinamarca	2600–2830	unmodified	+	unmodified
P. wayruronga Gonzalez & Ruz	♂	Ecuador: Napo, Pichincha	3150	strongly crenulate	+	?
"*guarnensis* species group"						
P. guarnensis Gonzalez & Ruz	♂♀	Colombia: Antioquia	2000	unmodified	–	unmodified
P. femoralis Gonzalez & Engel	♂♀	Peru: Pasco, Junín	1100–1780	unmodified	–	unmodified

unknown. The only information available are the few floral records for *P. bachue* Gonzalez & Ruz, which are based on a palynological analysis of the pollen found on the scopae of a single female specimen, and the cell dimensions of *P. rangeli* Gonzalez & Ruz, which were taken from a few cells containing unemerged males and females in the ground (Gonzalez & Ruz, 2007).

Herein we provide a description of the male of *P. maximina*, new geographical records, and a revised key to species. We also present notes on the foraging behavior of *P. guarnensis* Gonzalez & Ruz on flowers of cultivated potatoes (*Solanum tuberosum* L.) in central Colombia.

MATERIAL AND METHODS

Morphological terminology follows that of Engel (2001) and Michener (2007). Measurements were taken using an ocular micrometer on an Olympus SZX-12 stereomicroscope. Photomicrographs were taken using a Nikon D1x digital camera attached to an Infinity K-2 long-distance microscopic lens. The abbreviations F, S, T, OD, and PW are used for antennal flagellomere, metasomal sternum and tergum, and ocellar diameter and puncture width, respectively. Institutional acronyms used herein are: AMNH, American Museum of Natural History, New York, USA; BBSL, USDA-ARS, Bee Biology and Systematics Laboratory, Utah State University, Logan, Utah, USA; FSCA, Florida State Collection of Arthropods, Florida State University, Gainesville, USA; MEFLG, Museo Entomológico Francisco Luis Gallego, Universidad Nacional de Colombia, Medellín, Colombia; and SEMC, Snow Entomological Collection, Division of Entomology, University of Kansas Natural History Museum, Lawrence, Kansas, USA.

The foraging behavior of *P. guarnensis* on potato crops (variety Diacol capiro) was studied by P.A.S between January 2008 and June 2010 in the following localities of the Department of Antioquia (Colombia): La Unión (2575 m), Envigado (2459 m), and Carmen de Viboral (2110 m) (see species account for geographical coordinates of these locations). Behavioral observations were done in crops that had at least 75% of their plants in bloom and consisted of video recordings of the pollen collecting behavior, time spent on each visit per flower and plant, and the number of plants visited per crop. Pollen samples from tibial scopae were treated and preserved following the acetolysis method of Erdtman (1986) and then mounted on glass slides. Pollen samples were examined at 40X and 100X magnification with a Leitz DIALUX 22 EB microscope, and are deposited in the Universidad Nacional de Colombia, Medellín. Means values are given with standard deviations.

SYSTEMATICS

Genus *Protandrena* Cockerell
Subgenus *Andinopanurgus* Gonzalez & Engel
Protandrena (*Andinopanurgus*) *maximina* Gonzalez & Ruz
(Figs. 1–7)

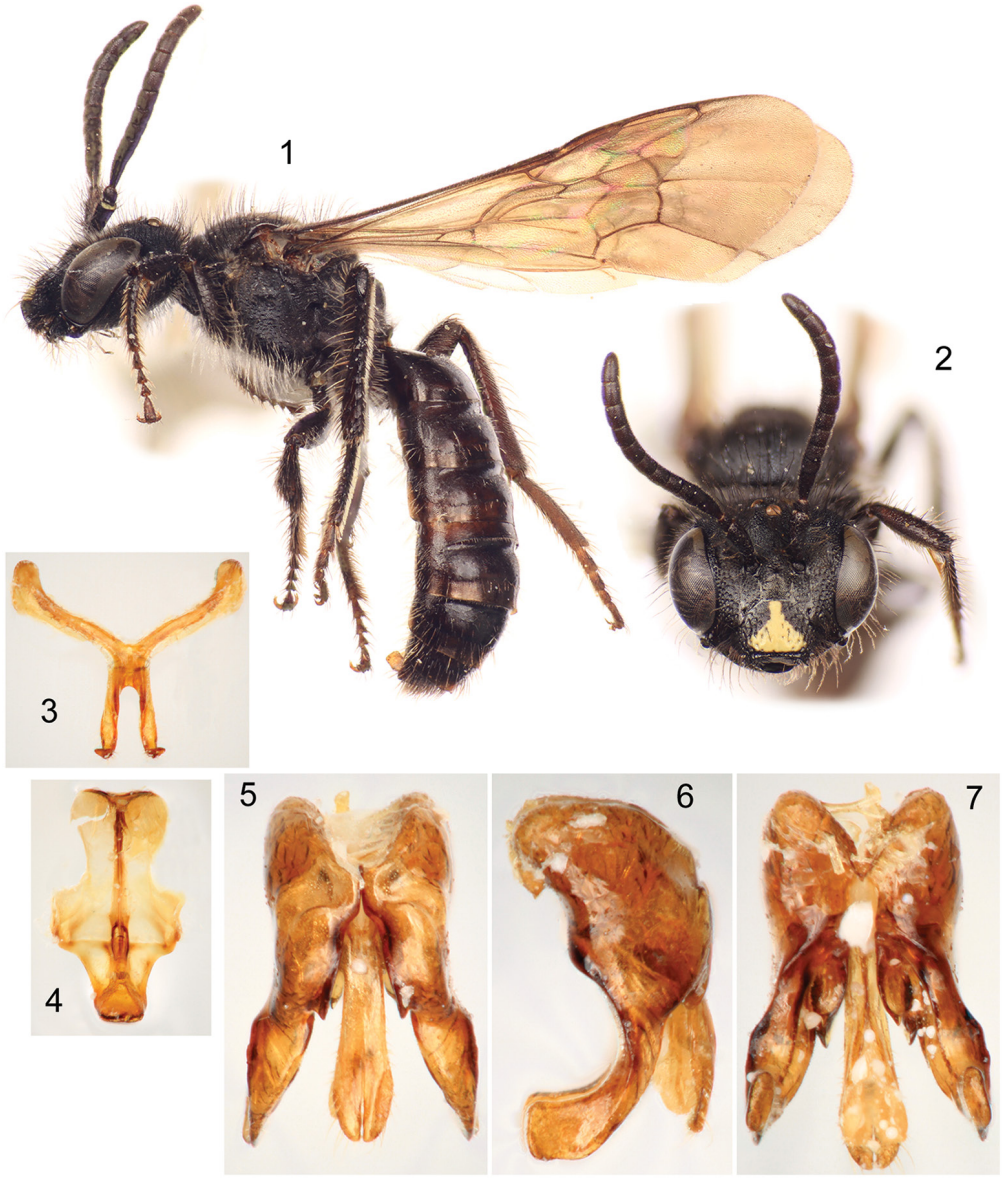
Protandrena maximina Gonzalez & Ruz, 2007: 399 [♀].
Rhophitulus maximina (Gonzalez & Ruz); Ascher & Pickering, 2012 [unjustified combination].
Andinopanurgus maximina (Gonzalez & Ruz); Moure *et al*., 2012 [unjustified combination].

DIAGNOSIS: Both sexes of this species are similar to those of *P. rangeli* in the unmodified antennal flagellum, shape of the female SVI, and male SV with a row of spines on the midapical margin. In addition to the geographical separation (*P. maximina* occurs in Venezuela whereas *P. rangeli* in Colombia), *P. maximina* can be recognized easily by its larger size (head width ~1.8 mm and body length 6.8 mm in *P. maximina* vs. head width 1.6–1.7 mm and body length 5.7–6.1 mm in *P. rangeli*) and slightly broader female facial fovea. The male of *P. maximina* also differs from that of *P. rangeli* in the digitus of the volsellae, which is more elongate, the distal portion of the gonocoxite, near the articulation with the gonostylus, which is more protuberant in lateral view, and in the medial margin of the gonocoxite dorsally, which is strong, nearly carinate, forming a distinct apical lobe (Figs. 5–7).

DESCRIPTION: ♂: Total body length 6.8 mm; forewing length 5.3 mm. Head 1.2x wider than long, width 1.8 mm; inner orbits of compound eyes converging below (Fig. 2); intertorular distance 2.1x OD, 0.9x length of torulorbital distance; torulus diameter equal to OD; ocellocular distance 3.2x OD, 2.1x greater than ocelloccipital distance; interocellar distance 1.2x OD; compound eye 1.9x longer than wide; clypeus 2.3x broader than long, projecting about 0.3x compound eye width in lateral view; gena 0.9x width of compound eye in profile; supraclypeal area, just below inferior torular tangent, distinctly protuberant; inner subantennal sulcus about 0.7x length of outer subantennal sulcus; facial fovea about 4.0x longer than broad, about half length of scape; scape 2.3x longer than broad, antennal flagellum unmodified, slightly longer than head width (Figs. 1, 2); pedicel about half length of F1, slightly longer than broad, F1 1.8x longer than broad, about 2.2x longer than F2 and F3 individually, remaining flagellomeres about as long as broad, except last flagellomere longer than broad. Forewing prestigma 2.3x longer than broad (prestigma width measured to its margin); pterostigma 3.6x longer than broad. Mesosoma narrower than head width; mesoscutum 1.3x wider than long, 2.8x longer than mesoscutellum, 5.1x longer than metanotum; propodeum with basal part about 0.6x mesoscutellum length in dorsal view; protibial spur with apical portion of rachis long, about three-fourths of malus, with distinct row of about 10 elongate branches (not including apical portion of rachis); mesotibial spur straight or nearly so, with coarse branches, slightly less than one-half mesobasitarsus length; metatibia with posterior marginal carina weakly toothed on upper half; metatibial spurs slightly curved apically, inner spur slightly longer than the outer; pretarsal claws with inner ramus slightly shorter than the outer. Lateral fovea of TII ellipsoid, about 2.4x longer than broad; TVII with V-shaped median emargination on distal margin; SV and S6 as in *P. rangeli* (*cf.* Gonzalez & Ruz, 2007: figs. 11, 15), SVII, SVIII, and genital capsule as in figures 3–7.

Color dark reddish brown to black, except clypeus with yellow maculation as in figure 2. Wing membranes brownish, veins and pterostigma dark brown.

Head with sparse, long (2.3–2.5x OD), semierect, poorly-branched, dark brown to black setae except whitish setae on gena posteriorly and hypostomal area; scape with long setae, 2x as long as maximum scape diameter, pedicel with setae as long as its maximum diameter. Pronotum with short (0.5–1.0x OD), dense, whitish setae along dorsal margin and pronotal lobe; mesoscutum, mesoscutellum, and metanotum with two types of setae: sparse, long (2.3–2.7x OD), erect, poorly-branched, black setae, and short (0.5x OD), denser (especially on metanotum), brownish setae; mesepisternum and lateral and posterior areas of propodeum with sparse, long (1.5–2.7x OD), erect, branched, whitish setae; legs with setae mostly whitish except brownish on tibiae and tarsi, longer and denser on coxae, trochanters, and profemur. Metasomal terga with



Figures 1–7. Male of *Protandrena* (*Andinopanurgus*) *maximina* Gonzalez & Ruz. **1.** Lateral habitus. **2.** Facial view. **3.** Sternum VII. **4.** Sternum VIII. **5–7.** Genital capsule in dorsal, profile, and ventral views.

minute (≤ 0.3x OD), semierect, sparse ferruginous setae on discs, laterally with denser and longer setae (1.2–1.4x OD); TVI with long (1.3–1.5x OD), semierect, dark brown setae on disc, setae denser on TVII; sterna with sparse, whitish semierect setae on discs, denser and longer laterally.

Outer surface of mandible and basal area of labrum smooth and shiny, impunctate; clypeus with sparse (1–1.5x PW), faint punctures, integument between punctures imbricate; supraclypeal area with scattered punctures laterally, weakly imbricate; subantennal area and inferior paraocular area with punctures separated by a punc-

ture width or less, integument strongly imbricate to nearly granular (as on remainder of face); remaining areas of face with coarse punctures, contiguous, smaller than on clypeus; gena strongly imbricate with faint punctures. Mesoscutum, mesoscutellum, and metanotum with small, dense punctures (≤ 1x PW), integument granular between punctures; mesepisternum strongly imbricate with large, scattered (1–2.0x PW), faint punctures, punctures coarser and denser dorsally; metepisternum transversely striate near wing base, otherwise strongly imbricate. Propodeum strongly imbricate with fine and weak striae basally, lateral and posterior surfaces with faint, scattered punctures. Metasomal terga and sterna shiny, weakly imbricate with minute, scattered punctures on discs, punctures coarser and denser on TVII; distal margins of terga shiny, weakly imbricate, impunctate except on TVII.

MATERIAL EXAMINED: Venezuela: 2♂♂, 1♀, Mérida, 15k. E. Jaji, Ruta 4, 24-July-1988, C. Porter & L. Stange, cloud forest (FSCA, SEMC).

COMMENTS: This species was previously only known from the female sex.

Protandrena (*Andinopanurgus*) *femoralis* Gonzalez & Engel

Protandrena femoralis Gonzalez & Engel, 2011: 66 [♂].
Andinopanurgus femoralis (Gonzalez & Engel); Moure *et al*., 2012 [unjustified combination].

NEW RECORD: Peru: 3♀♀, 2♂♂, Junín Dept., 21km. N. San Ramon, Pampa Hermosa Lodge, 1220m., 24–27-November-2007, J. Heppner (FSCA).

COMMENTS: This Peruvian species was previously known from Pasco, the department north of Junín.

Protandrena (*Andinopanurgus*) *guarnensis* Gonzalez & Ruz

Protandrena guarnensis Gonzalez & Ruz, 2007: 402 [♂].
Rhophitulus guarnensis (Gonzalez & Ruz); Ascher & Pickering, 2012 [unjustified combination].
Andinopanurgus guarnensis (Gonzalez & Ruz); Moure *et al*., 2012 [unjustified combination].

NEW RECORDS: Colombia: 6♀♀, Antioquia, La Unión, Corregimiento Mesopotamia, Vereda el 40.0.5°54′27.4′′N 75°18′42.3′′W, 2575m, 20°C, 63% HR, 20, 21, 24 Jul 2009, Sepúlveda-Cano, P.; Osorio, N.; 23♀♀, *idem* except: El Carmen de Viboral, Vereda la Palma, 06°06′56.3′′N, 75°20′12.8′′W, 2110 m, 24°C, 65% HR, 25 Aug, 17, 18, 20, 21 Nov 2009; 6♀♀, *idem* except: Envigado, Vereda La Loma del Escobero, 06°08′04.6′′N, 075°32′17′′W, 2459 m, 19.4°C, 65% HR, 19, 20, 21 Nov 2010 (MEFLG, SEMC, BBSL, AMNH).

COMMENTS: This Colombian species was only known from the municipality of Guarne, Antioquia; the female sex was previously known from a single paratype in poor condition.

FORAGING BEHAVIOR ON POTATO FLOWERS: *Protandrena guarnensis* was the only andrenid visiting flowers of *S*. *tuberosum* among 70 species of bees belonging to the other four families present in Colombia (Sepúlveda & Smith-Pardo, unpubl. data). Females of *P*. *guarnensis* visited a single flower per plant. About 86% of the observed visits (n = 35) of *P*. *guarnensis* on potato flowers were recorded between 11:00 and 13:00 hours, several hours after the anthesis occurred (6:00–7:00 h); remaining visits were recorded between 9:00 and 10:00 hours. To release pollen, females curled into a partial C-shape at the tip of the anthers and sonicated one to four anthers for durations of 9 to 180 sec-

onds (= 78.2, ± 1.47, n = 7); only in half of the observed visits did females contact the stigma. To groom and pack pollen in their metatibial scopae, females gripped the apex of the anthers or style with their hind legs, and either maintained their bodies somewhat perpendicular to or leaned to the anthers, facing the corolla, while removing the pollen with their remaining four legs.

A palynological analysis of the pollen taken from the metatibial scopae of 15 specimens collected at flowers of potatoes showed that on average 80.3% (± 0.36, n = 60 plates) of the pollen grains belonged to this plant; remaining grains belonged to undetermined species of the families Asteraceae, Melastomataceae, and Malvaceae (N. Osorio, pers. comm.).

Protandrena (*Andinopanurgus*) *wayruronga* Gonzalez & Ruz

Protandrena wayruronga Gonzalez & Ruz, 2007: 400 [♂].
Rhophitulus wayruronga (Gonzalez & Ruz); Ascher & Pickering, 2012 [unjustified combination].
Andinopanurgus wayruronga (Gonzalez & Ruz); Moure *et al*., 2012 [unjustified combination].

New record: Ecuador: 3♂♂, Napo Province, mtn. [mountain] side above Lake Papallacta, 8-July-1980, malaise trap, H.V. Weems (FSCA).

Key to Species of *Andinopanurgus*
Males

1. Clypeus without cream or yellow maculations; F1 short, about as long as F2; face and disc of mesoscutum weakly shiny; SV without spines on midapical margin, with fringe of normal, minutely-branched setae; TVII with distal margin straight, not medially emarginate 2
—. Clypeus with cream or yellow maculations; F1 distinctly longer than F2; face and disc of mesoscutum dull; SV with distinctly stout, short spines on midapical margin; TVII with V-shaped median emargination on distal margin 3
2(1). SVII with apical lobes narrow, parallel-sided, retrorse section of apex comma-shaped; gonostylus slender in profile, slightly tapering towards apex, basally strongly protuberant on medial margin in dorsal view (Colombia: Antioquia) ..... *P. guarnensis* Gonzalez & Ruz
—. SVII with apical lobes not parallel-sided, much broader apically (apex about twice as broad as base), retrorse section of apex not comma-shaped; gonostylus more robust in profile, about same width across its length, basally not protuberant on medial margin in dorsal view (Peru) ..... *P. femoralis* Gonzalez & Engel
3(1). Antennal flagellum weakly or strongly crenulate on posterior surface; SV with more than four spines on midapical margin; larger bees (body length 7.9–11.8 mm) 5
—. Antennal flagellum unmodified, not crenulate on posterior surface; SV with a row of four spines on midapical margin; small bees (body length 5.7–6.8 mm) 4
4(3). Small bees (head width 1.6–1.7 mm; body length 5.7–6.1 mm) (Colombia: Boyacá, Cundinamarca) ..... *P. rangeli* Gonzalez & Ruz
—. Larger bees (head width 1.8 mm; body length 6.8 mm) (Venezuela) .... *P. maximina* Gonzalez & Ruz

5(3). Antennal flagellum strongly crenulate on posterior surface, with deep concavity between flagellomeres; mandible not distinctly broad apically; posterior hypostomal carina unmodified, without a tooth; protibial spur with apex of rachis very short (less than one-third of malus length), with less than five elongate branches (not including apical portion of rachis); SIII–SV with distal margins distinctly convex; SV with midapical row of spines medially projecting 6

—. Antennal flagellum weakly crenulate on posterior surface, without deep concavity between flagellomeres; mandible distinctly broad apically; posterior hypostomal carina with strong tooth; protibial spur with apex long, about three-fourths of malus length, with a distinct row of 10 elongate branches (not including apical portion of rachis); SIII–SIV with distal margins gently convex; SV with midapical row of spines straight, not medially projecting (Ecuador: Napo) ..... *P. amyae* Gonzalez & Engel

6(5). F8 and F9 crenulate; SV midapical row of spines of unequal sizes, distal two spines distinctly longer (Ecuador: Quito, Napo) ..... *P. wayruronga* Gonzalez & Ruz

—. F8 and F9 unmodified, not crenulate; SV with midapical row of spines of about same size, without two distinctly long spines distally (Colombia: Boyacá, Cundinamarca) ..... *P. bachue* Gonzalez & Ruz

Females

Note that the females of *P. amyae* and *P. wayruronga* are unknown. However, given that the male of these species have crenulate antennal flagella they likely should run to *P. bachue* in the key.

1. Antennal flagellum unmodified, not crenulate 2

—. Antennal flagellum modified, weakly crenulate on posterior surface of F1–F5 (Colombia: Boyacá, Cundinamarca) ..... *P. bachue* Gonzalez & Ruz

2(1). F1 about as long as F2; discs of mesoscutum and mesoscutellum shiny, weakly imbricate between punctures; metatibia with brownish to whitish scopal setae 3

—. F1 distinctly longer than F2; discs of mesoscutum and mesoscutellum dull, strongly imbricate between punctures; metatibia with dark brown to black scopal setae 4

3(2). Mesofemur with posterior surface and metafemur with anterior and posterior surfaces distinctly depressed (Peru) ..... *P. femoralis* Gonzalez & Engel

—. Meso- and metafemora unmodified, not distinctly depressed (Colombia: Antioquia) ..... *P. guarnensis* Gonzalez & Ruz

4(2). Small bees (head width 1.6–1.8 mm; body length 5.6–6.3 mm) (Colombia: Boyacá, Cundinamarca) ..... *P. rangeli* Gonzalez & Ruz

—. Larger bees (head width 1.9–2.1 mm; body length 7.8 mm) (Venezuela) ..... *P. maximina* Gonzalez & Ruz

DISCUSSION

Based on the scattered floral records, *Andinopanurgus* seems to use a relatively wide range of exotic (*Veronica persica* Poiret), native (*Gaultheria* sp.) and cultivated plants (*S. tuberosum*) for pollen and nectar suggesting a polylectic diet (Table 2). However, such a statement is premature given the limited number of floral records. Our observations

Table 2. Summary of floral hosts known in *Andinopanurgus*. Records for *P. bachue* and *P. rangeli* were taken from Gonzalez & Ruz (2007). Plant species with a question mark are possibly used for nectar given the relatively low abundance of the pollen grains, although they also could be contaminants.

Bee species	Host family	Plant species	Source
P. bachue Gonzalez & Ruz	Ericaceae	*Gaultheria* sp.	pollen
	Elaeocarpaceae	*Vallea stipularis* L.f.	pollen?
	Asteraceae ('*Tubiflorae*' group)	*Loutergia-Plagiocheilus*	pollen?
	Oxalidaceae	*Oxalis* sp.	pollen?
P. guarnensis Gonzalez & Ruz	Solanaceae	*Solanum tuberosum* L.	pollen
	Asteraceae	undetermined	pollen?
	Melastomataceae	undetermined	pollen?
	Malvaceae	undetermined	pollen?
P. rangeli Gonzalez & Ruz	Scrophulariaceae	*Veronica persica* Poir.	nectar
	Oxalidaceae	*Oxalis* sp.	nectar

on the foraging behavior of *P. guarnensis* on *S. tuberosum* indicate that this species uses buzzing behavior to release pollen from flowers with poricidal anthers.

The behavioral observations and palynological analysis indicate that *P. guarnensis* females spend relatively long periods of time foraging on a small number of flowers to gather large pollen loads. Such a foraging behavior is similar to that described for *Protandrena mexicanorum* (Cockerell) on *S. elaeagnifolium* Cavanilles (Cane & Buchmann, 1989). However, unlike that species, *P. guarnensis* sonicated anthers as in most bees that exhibit buzz pollination (*i.e.*, they are positioned transversally astride the tip of the anthers) and groomed and packed pollen either maintaining their bodies somewhat perpendicular to or leaned to the anthers, facing the corolla. In *P. mexicanorum*, females began to sonicate anthers transversally positioned at the base of an anther, moving upwards to its tip, and grooming with the metasoma facing the corolla (Cane & Buchmann, 1989). Besides *Protandrena*, the only other Andean andrenid known to exhibit buzz pollination is *Alocandrena porteri* Michener on *Lycopersicon peruvianum* (L.) Mill. and *L. pennelli* (Correl) D'Arcy var. *pennelli* (Solanaceae) in western Peru (Rozen & Ugarte-Peña, 1999). However, detailed observations on how this species collects, grooms, and packs pollen are unknown.

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