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Taxonomy and Distribution of the Series *pia* of the *Lutzomyia verrucarum* Group (Diptera: Psychodidae), with a Description of *Lutzomyia emberai* n. sp.

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ABSTRACT A new species of phlebotomine sand fly, *Lutzomyia emberai* n. sp. is described and illustrated from specimens collected in a dwelling of the Emberá Indian community, situated in the foothills of the Serranía del Baudó on the Colombian Pacific coast. The morphological characteristics of *L. emberai* n. sp. suggest that it belongs to the series *pia* of the group *verrucarum*, easily differentiated from the other members of this group by diagnostic characters on the palps, labro-pharynx, thorax, and spermathecal ducts. The discovery of this new phlebotomine raises to seven the number of species in the series *pia*, including *Lutzomyia pia* (Fairchild & Hertig, 1961); *Lutzomyia reclusa* Fernandez & Rogers, 1991; *Lutzomyia suapiensis* Le Pont, Torrez-Espejo & Dujardin, 1997; *Lutzomyia tihuilensis* Le Pont, Torrez-Espejo & Dujardin, 1997; *Lutzomyia tocianensis* Le Pont, Torrez-Espejo & Dujardin, 1997; *Lutzomyia limafalcaoae* (Wolff & Galati, 2002); and *Lutzomyia emberai* Bejarano, Duque & Velez, 2004, n. sp. The taxonomy, distribution, and medical importance of this series are reviewed.

KEY WORDS Phlebotominae, taxonomy, *Lutzomyia emberai* n. sp., Colombia

THE *Lutzomyia verrucarum* group (Diptera: Psychodidae) is an informal taxonomic assemblage that includes 40 species of Neotropical phlebotomines (Bejarano et al. 2003a), several of which are involved in the transmission of *Leishmania* spp. and *Bartonella bacilliformis* (Scorza and Añez 1984, Young et al. 1987, Travi et al. 1990, Bonfante-Garrido et al. 1991, Pérez et al. 1994, Martínez et al. 1999). This group has been divided into four series of species based on the number and distribution of spines on the style of the masculine genitalia, i.e., series *verrucarum*, *serrana*, *townsendi*, and *pia* (Theodor 1965, Kreutzer et al. 1990, Galati 1995). Galati et al. (1995) consider there to be a fifth series of species (series *evansi*) based on the absence of papillae (sensilla in rosettes) on flagellomere III.

The series *verrucarum* includes the species that possess two medial and two distal spines, and incorporates *Lutzomyia verrucarum* (Townsend 1913); *Lutzomyia evansi* (Nunez-Tovar, 1924); *Lutzomyia colombiana* (Ristorcelli & Van Ty, 1941); *Lutzomyia ovallesi* (Ortiz 1952); *Lutzomyia nuneztovari* (Ortiz 1954); *Lutzomyia nevesi* (Damasceno & Arouck 1956); *Lutzomyia andina* Osorno, Osorno & Morales, 1972; *Lutzomyia disiuncta* Morales, Osorno & Osorno, 1974; *Lutzomyia moralesi* Young, 1979; *L. aulari* Feliciangeli, Ordonez & Manzanilla, 1984; *Lutzomyia deorsa* Perez, Ogusuku, Monje & Young, 1991; *Lutzomyia maranonensis* Galati, Caceres & Le Pont, 1995; *Lutzomyia cajamaricensis* Galati, Caceres & Le Pont, 1995; *Lutzomyia antio-*

quiensis (Wolff & Galati 2002); and *Lutzomyia falcaorum* (Brazil & Andrade Filho, 2002).

The series *serrana*, characterized by the presence of two distal spines and a slender medial spine, is comprised of *Lutzomyia serrana* (Damasceno & Arouck, 1949); *Lutzomyia christophei* (Fairchild & Trapido, 1950); *Lutzomyia orestes* (Fairchild & Trapido, 1950); *Lutzomyia oresbia* (Fairchild & Hertig, 1961); *Lutzomyia odax* (Fairchild & Hertig, 1961); *Lutzomyia otolinai* (Ortiz & Scorza, 1963); *Lutzomyia diazi* Gonzalez & Garcia, 1981; *Lutzomyia novae* Gonzalez & Garcia, 1981; *Lutzomyia robusta* Galati, Caceres & Le Pont, 1995; and *Lutzomyia guilvardae* Le Pont, Martinez, Torrez-Espejo & Dujardin, 1998.

The series *townsendi* consists of species that present three distal spines and an isolated basal spine and includes *Lutzomyia townsendi* (Ortiz 1959); *Lutzomyia spinicrassa* Morales, Osorno, Osorno & Munoz, 1969; *Lutzomyia longiflocosa* Osorno, Morales, Osorno & Munoz, 1970; *Lutzomyia quasitownsendi* Osorno, Osorno & Morales, 1972; *Lutzomyia sauroida* Osorno, Morales & Osorno, 1972; *Lutzomyia amilcari* Arredondo, 1984; *Lutzomyia youngi* Feliciangeli & Murillo, 1987; *Lutzomyia nadiae* Feliciangeli, Arredondo & Ward, 1992; and *Lutzomyia torvida* Young, Morales & Ferro, 1994.

In the series *pia* the males possess five spines distributed between the medial and distal regions of the style. The taxonomic determination of species in this

last series is based principally on female morphological characteristics, the males of certain species being unknown (Le Pont et al. 1997). A new Colombian species belonging to the series *pia* is described in the present article. In addition, information published since 1994 on the taxonomy, biogeography, and medical importance of the series is reviewed and a dichotomous key presented for species identification.

The type specimens were collected with a CDC-type light trap inside a dwelling of the Emberá Indian community of El Brazo, Bahía Solano (06° 13' N, 77° 24' W), Department of Chocó. This locality is situated at 100 m above sea level in the foothills of the Serranía del Baudó mountain range on the Colombian Pacific coast, a region considered to be one of the most biodiverse in the world (García-Kirkbride 1986). Ecologically, it is classified as very humid tropical forest (Holdridge 1967). The mean relative humidity, temperature and annual precipitation for the municipality of Bahía Solano are 90%, 25.6°C, and 4982 mm, respectively. Phlebotomines were collected during an eco-epidemiological study of leishmaniasis.

The description is based on morphological characters suggested by Bermudez et al. (1991), Galati (1995), and Valenta et al. (1995). The type material will be deposited in the Colección de Vectores y Hospedadores Intermediarios de Enfermedades Tropicales (VHET), Programa de Estudio y Control de Enfermedades Tropicales (PECET), at the Universidad de Antioquia in Medellín, Colombia.

Taxonomy and Distribution

Series *pia* Galati, 1995

Series *pia* Galati, 1995: 137 (as a series of the subgenus *Pifanomyia* of the genus *Pintomyia*), Wolff and Galati 2002: 322 (keys, as a series of the subgenus *Pifanomyia* of the genus *Pintomyia*), Bejarano et al. 2003a: 88 (systematics, as a series of the *verrucarum* group of the genus *Lutzomyia*), Galati 2003a: 38 (phylogenetic classification, as a series of the subgenus *Pifanomyia* of the genus *Pintomyia*), Galati 2003b: 97 (keys, as a series of the subgenus *Pifanomyia* of the genus *Pintomyia*).

Female. (Figs. 1–6). Cibarium with four to six horizontal teeth, one to two rows of vertical teeth and small lateral teeth, these which are occasionally difficult to see. Cibarial arch complete. Pharynx with striations or very rudimentary spines at its apex. Fifth palpomere relatively short, subequal to, or shorter than the sum of the lengths of the third and fourth palpomere. Newstead's spine on the third palpomere. Flagellomere II with simple ascoids and papillae. Sac-like spermatheca striated, with a prominent apical ring with almost straight sides. Spermathecal ducts thick, common duct usually striated. Common duct generally exceeding individual ducts in length.

Male. (Figs. 7–12) (including characters present in both sexes). Style with five large spines arranged between medial and distal regions, with a subapical seta. Coxite with a tuft of setae in the basal or medial region. Paramere simple with simple setae between medial and apical region.

Lutzomyia pia (Fairchild & Hertig, 1961) (Figs. 1–12)

Phlebotomus pius Fairchild & Hertig, 1961: 248 (male holotype, Santa Clara, El Volcan, Chiriqui, Panama; allotype female, Palo Santo, Chiriqui, Panama).

Lutzomyia pia (Fairchild & Hertig, 1961): Theodor 1965: 187 (listed), Young and Duncan 1994: 764 (key, figures, distribution, references), Balard et al. 1999: (distribution, habitats, methods of collection, references), Montoya-Lerma and Ferro 1999: 223 (Colombian distribution), Valenta et al. 1999: 392 (genital atrium as taxonomic character), Williams 1999: 482 (geographical distribution), Alexander et al. 2001: 368 (associated with Colombian coffee plantations), Cáceres and Villaseca 2002: 23 (listed), Rojas et al. 2002: 14 (molecular systematics), Bejarano et al. 2003a: 88 (systematics).

Pintomyia pia (Fairchild & Hertig, 1961): Galati 1995: 137 (phylogenetic systematics), Cáceres and Galati 2001: 102 (listed), Wolff and Galati 2002: 322 (key), Galati 2003a: 38 (phylogenetic classification), Galati 2003b: 97 (keys).

Distribution. BOLIVIA: La Paz (Le Pont et al. 1989); COLOMBIA: Antioquia (Agudelo et al. 2002), Boyacá (Osorno-Mesa et al. 1972), Caldas (Alexander et al. 2001), Cundinamarca (Cabrera et al. 1999), Huila (Montoya-Lerma and Ferro 1999), Meta (Molina et al. 1997), Nariño (Alexander et al. 1995), Norte de Santander (Tesh et al. 1986), Risaralda (Barreto et al. 1997), Tolima (Bejarano et al. 2003b), Valle del Cauca (Warburg et al. 1991); COSTA RICA: Alajuela (Herrero et al. 1994), Cartago (Murillo and Zeledón 1985), San José (Murillo and Zeledón 1985); PANAMA: Chiriqui (Fairchild and Hertig 1961); PERU: Pasco (Pérez et al. 1991); VENEZUELA: Aragua (Balard et al. 1999), Mérida (Valenta et al. 1999), Táchira (Ramírez-Pérez et al. 1982), Trujillo (Williams 1999).

Material Examined. COLOMBIA: Antioquia: two females, Ituango, Alto de San Agustín, 18-XI-2001, Shannon trap, D. Sierra, VHET. Caldas: 30 females, Salamina, Buenos Aires, 23-III-99, Shannon trap, B. Alexander, L. A. Agudelo, F. Ruiz, J. F. Navarro; 1 female, same data except 24-III-99; three males, 23 females, same data except 16-IX-99; one male, same data except 21-IX-99; 32 females, same data except Palo Santo, 14-IX-99; one male, same data except Palo Santo, 14-IX-99, tree; one female, same data except Los Mangos, 14-IX-99, tree; two females, same data except Cañaveral, 17-IX-99, sticky paper, VHET. Norte de Santander: two females, Villa Caro, 22-VIII-2001, Shannon trap, E. Pabón, VHET. Risaralda: four females, Marsella, 25-II-2004, human bait, E. Bejarano, D. Sierra, VHET.

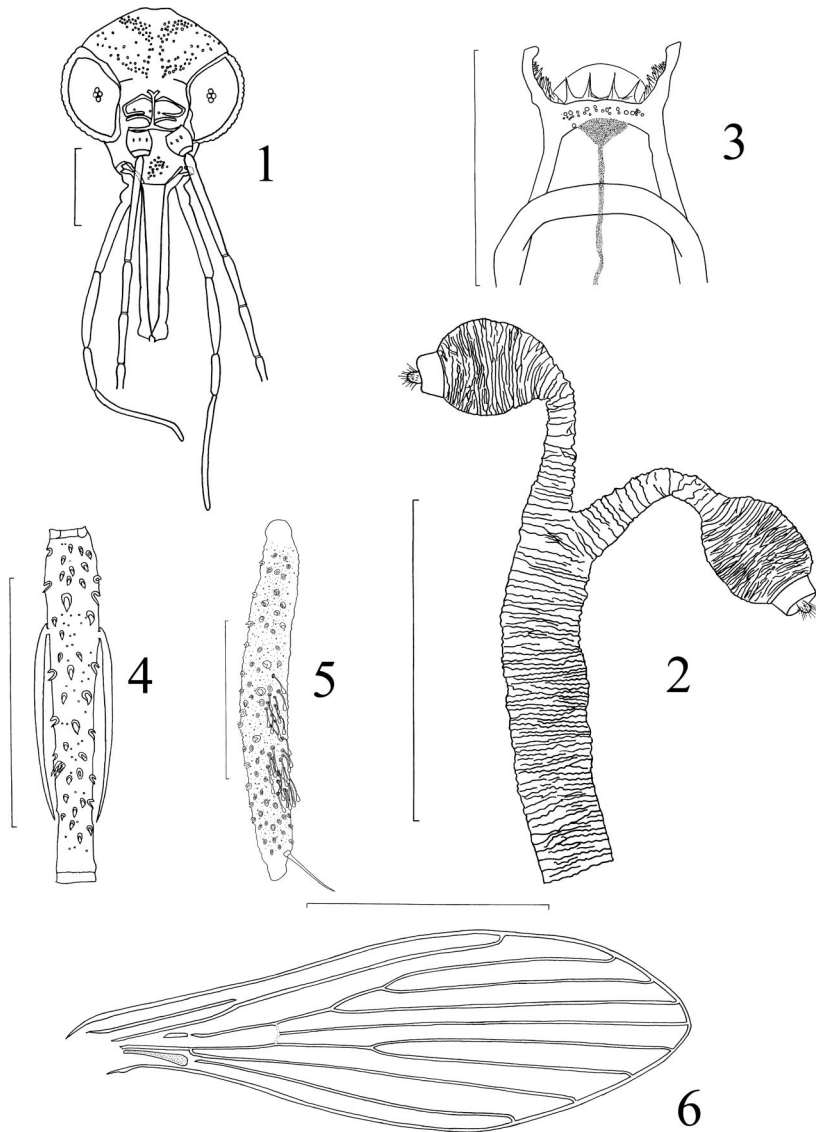


Fig. 1-6. Female of *L. pia* Fairchild & Hertig, 1961. (1) Head. (2) Spermathecae and ducts. Scale lines, 200 μ m. (3) Cibarium. (4) Flagellomere II. (5) Palpomere 3. Scale lines, 100 μ m. (6) Wing. Scale line, 1000 μ m.

Morphological Remarks. The females of the Colombian populations of *L. pia* examined all had numerous sharp pointed lateral teeth on either side of the horizontal teeth (Fig. 2). These structures are difficult to observe with the 40 \times objective but are easily identifiable at 100 \times . The lateral teeth are not mentioned in any of the descriptions of this species available to date (Fairchild and Hertig 1961, Forattini 1973, Young 1979, Murillo and Zeledón 1985, Young and Duncan 1994), so specimens from populations in other countries should be examined. Furthermore, in the Colombian specimens examined here the number of horizontal teeth varied between four and six. This was also noted by Young (1979) in studying specimens from Panama and Costa Rica.

***Lutzomyia reclusa* Fernandez & Rogers, 1991**

Lutzomyia reclusa Fernandez & Rogers, 1991: 129 (male holotype, El Monte, Catache, Santa Cruz, Cajamarca, Peru), Young and Duncan 1994: 715 (key, figures, distribution, references), Balard et al. 1999: (distribution, habitats, references), Williams 1999: 482 (geographical distribution), Cáceres and Villaseca 2002: 23 (listed), Bejarano et al. 2003a: 90 (systematics).

Pintomyia reclusa (Fernandez & Rogers, 1991): Galati 1995: 137 (phylogenetic systematics), Cáceres and Galati 2001: 102 (listed), Wolff and Galati 2002: 322 (key), Galati 2003a: 38 (phylogenetic classification), Galati 2003b: 97 (key).

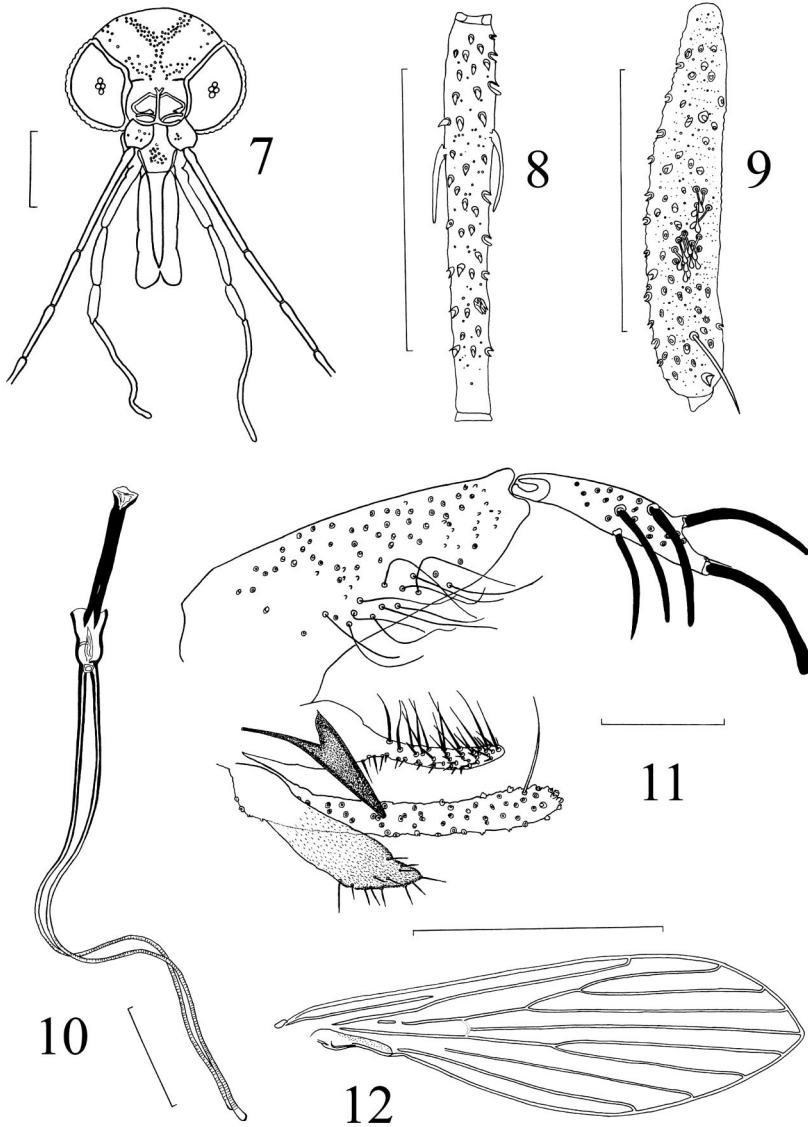


Fig. 7-12. Male of *L. pia* Fairchild & Hertig, 1961. (7) Head. Scale line, 200 μm . (8) Flagellomere II. (9) Palpomere 3. (10) Genital pump and filaments. (11) Terminalia. Scale lines, 100 μm . (12) Wing. Scale line, 1000 μm .

Distribution. PERU: Cajamarca (Fernandez and Rogers 1991).

Distribution. BOLIVIA: La Paz (Le Pont et al. 1997); PERU: Cusco (Cáceres et al. 2001).

Lutzomyia suapiensis Le Pont, Torrez-Espejo & Dujardin, 1997

Lutzomyia suapiensis Le Pont, Torrez-Espejo & Dujardin, 1997: 56 (female holotype, Suapi, Nor Yungas, La Paz, Bolivia), Cáceres and Villaseca 2002: 23 (listed), Bejarano et al. 2003a: 90 (systematics).

Pintomyia suapiensis (Le Pont, Torrez-Espejo & Dujardin, 1997): Cáceres and Galati 2001: 102 (listed), Cáceres et al. 2001: 25 (Peru), Wolff and Galati 2002: 322 (key), Galati 2003a: 38 (phylogenetic classification), Galati 2003b: 97 (key).

Lutzomyia tihuilienis Le Pont, Torrez-Espejo & Dujardin, 1997

Lutzomyia tihuilienis Le Pont, Torrez-Espejo & Dujardin, 1997: 56 (female holotype, Suapi, Nor Yungas, La Paz, Bolivia), Cáceres and Villaseca 2002: 23 (listed), Bejarano et al. 2003a: 90 (systematics).

Pintomyia tihuilienis (Le Pont, Torrez-Espejo & Dujardin, 1997): Cáceres and Galati 2001: 102 (listed), Wolff and Galati 2002: 322 (key), Galati 2003a: 38 (phylogenetic classification), Galati 2003b: 97 (key).

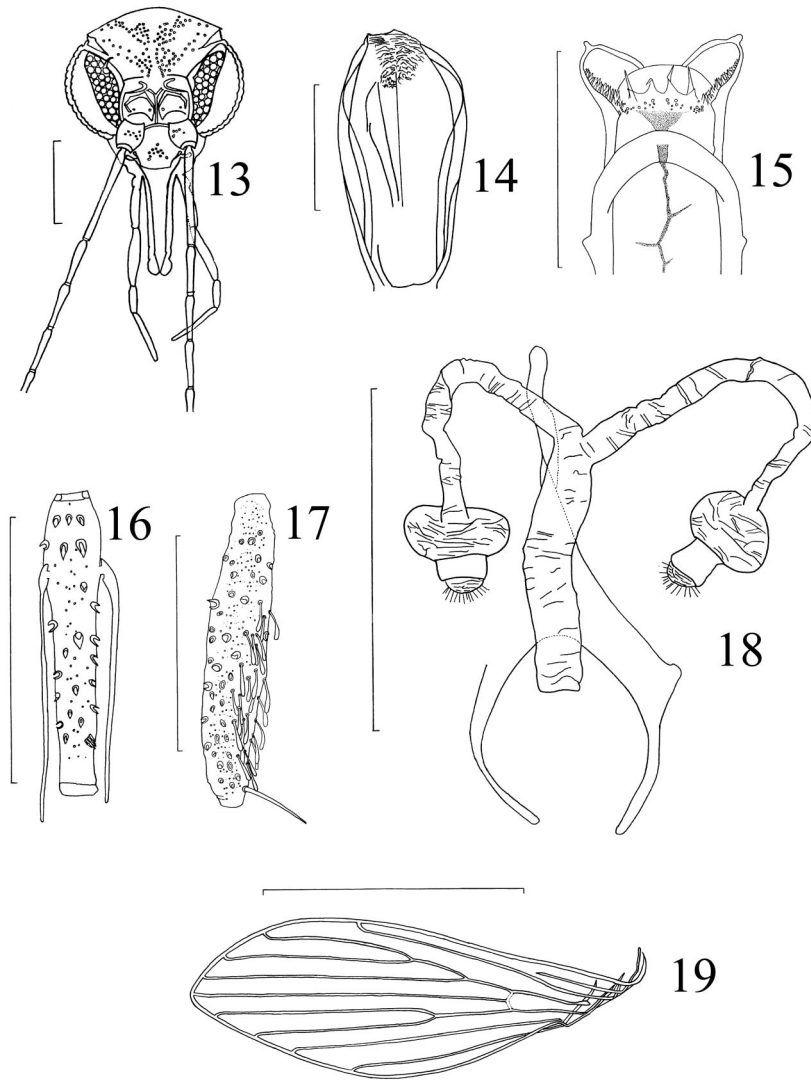


Fig. 13–19. Female of *L. emberai* Bejarano, Duque & Velez, 2004, n. sp. (13) Head. Scale line, 200 μm (14) Pharynx. (15) Cibarium. (16) Flagellomere II. (17) Palpomere 3. (18) Spermathecae, ducts and genital atrium. Scale lines, 100 μm . (19) Wing. Scale line, 1000 μm .

Distribution. BOLIVIA: La Paz (Le Pont et al. 1997); PERU: (Cáceres and Galati 2001).

***Lutzomyia tocaniensis* Le Pont, Torrez-Espejo & Dujardin, 1997**

Lutzomyia tocaniensis Le Pont, Torrez-Espejo & Dujardin, 1997: 58 (female holotype, Suapi, Nor Yungas, La Paz, Bolivia), Cáceres and Villaseca 2002: 23 (listed), Bejarano et al. 2003a: 90 (systematics).

Pintomyia tocaniensis (Le Pont, Torrez-Espejo & Dujardin, 1997): Cáceres and Galati 2001: 102 (listed), Cáceres et al. 2001: 25 (Peru), Wolff and Galati 2002: 322 (key), Galati 2003a: 38 (phylogenetic classification), Galati 2003b: 97 (key).

Distribution. BOLIVIA: La Paz (Le Pont et al. 1997); PERU: Cusco (Cáceres et al. 2001).

***Lutzomyia limafalcaoae* (Wolff & Galati, 2002)**

Pintomyia limafalcaoae Wolff & Galati, 2002: 317 (male holotype and female allotype, Savanitas, Montebello, Antioquia, Colombia).

Lutzomyia limafalcaoae (Wolff & Galati, 2002): Bejarano et al. 2003a: 90 (systematics).

Distribution. COLOMBIA: Antioquia (Wolff and Galati 2002).

***Lutzomyia emberai* Bejarano, Duque & Velez, 2004, new species (Figs. 13–19)**

Type Locality. El Brazo, Bahía Solano, Chocó, Colombia.

Holotype Female (measurements in micrometers). Medium-sized phlebotomine, length 2,378.3.

Head. Pale brown. Height of head from vertex to the tip of the clypeus 408, width 436.8. Length of clypeus 109.2, bearing 12 setae. Length of labro-epipharynx 268.8. Hypopharynx with 16–17 lateral apical teeth. Lacinia of maxilla with six longitudinal external and 22 internal teeth. Length of the eyes 237.6, width 144. Interocular distance 139.2, equivalent to 8.42 facet diameters. Interocular suture incomplete. Ratio of length of labro-epipharynx/height of head 0.66. Labrum longer than flagellomere I, reaching the medial part of flagellomere II and third palpomere. Length of the flagellomeres: I 255.6, II 114.7, III 113.7, IV 113.7, V 112.3, VI 108.9, VII 107.4, VIII 106.9, IX 107.4, X 107.4, XI 101.1, XII 88.9, XIII 68, XIV 63.2. Ratio of the length of flagellomeres I/II+III 1.11. Paired ascoids present on flagellomeres I to XIII, those of flagellomere II inserted at almost the same level and exceeding the apex of the segment. Papilla on the distal fifth of the internal border of flagellomere II. Length of the palpomeres: first 54.9, second 89.1, third 146.4, fourth 66.6, fifth 132. Fifth palpomere shorter than sum of lengths of third and fourth palpomeres. Palpal formula 1.4.2.5.3. Approximately 26 Newstead's spines, distributed between the proximal 0.34 and 0.84 of the internal border of the third palpomere. Pharynx unarmed, flared and with fine striations in its apical portion. Length of pharynx 206.4, maximum width 84. Cibarial armature formed by four long horizontal teeth distributed equidistantly and ≈ 40 vertical teeth arranged in two very irregular transverse rows. Numerous small lateral teeth also present at each side of the horizontal teeth. Pigmented area very faint and subtriangular. Cibarial arch complete.

Thorax. Proscutum, scutum, and lower part of the pleura dark brown. Pronotum, proepisternum, anepisternum, scutellum, postscutellum, halteres, coxae, legs, and upper part of the pleura pale brown. Length of thorax from anterior of proscutum to posterior of scutellum 648. Pleura with 21 upper and six lower anepisternal setae. Length of wing from start of the costal vein 1787.8, maximum width 600. Length of the principal wing veins: R_2 (α) 595.2, R_3 (ϵ) 720, R_4 (θ) 1004.5, R_5 1214.4, R_2+R_3 (β) 201.6, $R_2+R_3+R_4$ (γ) 184.8. Distance from bifurcation R_2+R_3 to termination of R_1 (δ) 237.6, distance from bifurcation $R_2+R_3+R_4$ to bifurcation M_1+M_2 (π) 96. δ and π positive. Wing index α/β 2.95. Length of the femur, tibia and basitarsus: anterior leg 710.4, 823.2, 518.4; median leg 667.2, 1065.6, 652.8; and posterior leg 806.4, 1310.4, 729.6, respectively. Length of tarsomeres II, III, IV and V: anterior leg 266.4, 192, 163.2, 115.2; median leg 292.8, 208.8, 177.6, 112.8; and posterior leg 314.4, 224.4, 187.2, 115, respectively. Femur unarmed.

Abdomen. Color pale brown. Length of abdomen 1432.7. Cercus simple, length 105.6. Spermatheca sac-like, with little incomplete transverse striations and a prominent, smooth apical ring with straight sides. Terminal button short and wide with short filaments. Length of apical ring, including the terminal button, 15.5, width 12. Individual and common ducts with little transverse striations. Length of common duct 78.7, width 14.6. Length of individual ducts 108.4, width 7.8.

Ratio of lengths common duct/individual duct 0.73. Total length of genital atrium 149.7. Internal width of genital atrium 50.5. Genital furca strongly sclerotized. Length of furca 87.5. Ratio between the length of the furca and internal width 1.73. Ratio between total atrium length and length of the furca 1.71.

Material Examined. HOLOTYPE: one female, El Brazo, Bahía Solano, Chocó, COLOMBIA, 13-X-93, CDC light trap, P. Duque, VHET. PARATYPE: one female, same data.

Etymology. The name of the new species refers to the Emberá Indian Community that inhabits the area where the type specimens were collected. The Emberá occur in groups from Panama to Ecuador, along the Pacific Coast and western cordillera of the Colombian Andes.

Distribution. COLOMBIA: Chocó.

Taxonomic observations. The presence of striated, sac-like spermathecae, long, thick and striated spermathecal ducts, complete cibarial arch, cibarium with four horizontal teeth, two rows of vertical teeth and small lateral teeth, simple ascoids, femur and pharynx without spines, suggest that *L. emberai* n. sp. belongs to the *verrucarum* group. The new species exhibits the typical spermatheca of females of the series *pia*, which are characterized by the presence of a smooth, differentiated apical ring with almost straight sides. *L. emberai* n. sp. can be distinguished easily from other species of this series by the length of the individual ducts, which exceeds that of the common duct. In *L. emberai* n. sp. the ratio of the lengths of the common/individual ducts is ≈ 0.73 , whereas in the other species the ratio is ≥ 2 .

The characteristic of a fifth palpomere shorter than the third also permits *L. emberai* n. sp. to be separated from the other members of the series *pia*. The palpal formula of *L. emberai* n. sp. is 1.4.2.5.3., whereas that of other species is 1.4.(2.3).5, the fifth palpomere being subequal to the sum of the lengths of the third and fourth palpomeres. In addition to the previous characters, *L. emberai* n. sp. can be differentiated from *L. tocaniensis*, *L. suapiensis* and *L. tihuilienensis* by the color of pleura. These are totally pigmented in the new species, unpigmented in *L. tocaniensis* and partially pigmented in *L. suapiensis* and *L. tihuilienensis*. *L. emberai* n. sp. also differs from *L. pia* in the length of the labro-epipharynx <300 versus >350 in the latter species.

It has recently been postulated that the series *pia* could represent an ancestral lineage within the *verrucarum* group (Bejarano et al. 2003a). The hypothesis of the ancestral condition is based on analyses of morphological (Galati 1995) and molecular systematics (Rojas et al. 2002). If correct this hypothesis would also validate the suggestion of Theodor (1965) that reduction of the number of spines of the style is an evolutionary tendency. Theodor (1965) considered the presence of five spines on the style to be a primitive condition, suggesting that the reduction in their number occurred independently in several species groups of the subfamily Phlebotominae. Under this scheme, the series *serrana* whose members possess

three spines would correspond to the most advanced lineage within the group *verrucarum*, the series *verrucarum* and *townsendi* with four spines would be intermediate and the series *pia* with five spines would represent the most primitive lineage. Nevertheless, further molecular studies that include other five-spined *Lutzomyia* species are needed to permit evaluation of the monophyly and robustness of the evolutionary relationship between the series *pia* and the *verrucarum* group.

Key for the Species of the Series *pia*

[Adapted from Le Pont et al. (1997) and Wolff and Galati (2002)].

- 1. Female 2
- 1' Male 7
- 2. Common sperm duct clearly longer than individual ducts, ratio of the lengths of the common/individual ducts ≥ 2 . Fifth palpomere longer than third palpomere 3
- 2'. Common sperm duct shorter than individual ducts, ratio of the lengths of the common/individual ducts ≈ 0.73 . Fifth palpomere shorter than third palpomere.
 *L. emberai* Bejarano, Duque & Velez, 2004, n. sp.
- 3. Pleura completely pigmented 4
- 3'. Pleura pale or partially pigmented 5
- 4. Common and individual sperm duct striated. Labro-epipharynx longer than 350 μm
 *L. pia* (Fairchild & Hertig, 1961)
- 4'. Common and individual sperm duct smooth. Labro-epipharynx shorter than 310 μm
 *Lutzomyia limafalcaoae* (Wolff & Galati, 2002)
- 5. Pleura all pale *Lutzomyia tocaniensis* Le Pont, Torrez-Espejo & Dujardin, 1997
- 5'. Pleura partially pigmented 6
- 6. Labro-epipharynx equal to, or shorter than, 310 μm . Second palpomere shorter than or equal to 150 μm *Lutzomyia suapiensis* Le Pont, Torrez-Espejo & Dujardin, 1997
- 6'. Labro-epipharynx equal to, or longer than, 350 μm . Second palpomere longer than or equal to 170 μm *L. tihuilienis* Le Pont, Torrez-Espejo & Dujardin, 1997
- 7. Coxite with compact tuft of setae inserted at basal half of structure *L. reclusa* Fernandez & Rogers, 1991
- 7'. Coxite with diffuse tuft of setae inserted at middle third of structure 8
- 8. Dorsal margin of the paramere almost straight, with setae covering the apical half of structure *L. pia* (Fairchild & Hertig, 1961)
- 8'. Dorsal margin of the paramere curve, with setae restricted to apical fifth of structure.
 *L. limafalcaoae* (Wolff & Galati, 2002)

Biogeography

The species of the series *pia* are restricted to north-western South America, with the exception of *L. pia*, which occurs from Costa Rica to Bolivia. *L. pia* presents the widest altitudinal range within the series, occurring from 100 to 1900 m a.s.l. (Pérez et al. 1991, Alexander et al. 1995), whereas *L. suapiensis*, *L. tihuilienis*, and *L. tocaniensis* are found from 1000 to 1,500 m a.s.l. in Bolivia and Peru (Le Pont et al. 1997, Cáceres et al. 2001). The known distributions of the other species are based on single records. *L. reclusa* has been recorded at 1360 m a.s.l. in Peru (Fernandez and Rogers 1991). *L. limafalcaoae* is endemic to the Central Cordillera of the Andes in Colombia, where it lives in small caves at 2,060 m a.s.l. (Wolff and Galati 2002). *L. emberai* n. sp. is present in the foothills of the Serranía del Baudó on the Colombian Pacific coast at 100 m a.s.l.

Little is known about the ecological preferences of these species. Nevertheless, almost all the members of the series coexist sympatrically, with up to five species of the *verrucarum* group (Alexander et al. 1992) present in the Andes. *L. suapiensis*, *L. tihuilienis* and *L. tocaniensis* are the only members of the series that have been found in sympatry in Bolivia and Peru (Le Pont et al. 1997, Cáceres et al. 2001).

The latitudinal and altitudinal distribution of the series *pia* suggests that it is of Andean origin. The speciation and distribution of the series could be the result of geological and climatic events that affected the flora and fauna of the region (Bejarano et al. 2003a). One of the most plausible explanations is the isolation of ancestral populations in humid forest refugia during the Quaternary period (Young 1979, Haffer 1982). This process was driven by climatic changes characterized by cyclical periods of glaciation and thawing (Peltier 1994) that caused several species to become extinct, whereas others survived unchanged and some populations diverged at the subspecies and species level. Young (1979) suggested that the majority of Colombian phlebotomine species originated in the cis-Andean region (east of the Andes), where *L. pia* has been recorded. This author also suggested that some *Lutzomyia* species could have crossed the Andes via the River Marañón Valley in southern Ecuador and northern Peru during interglacial periods, when primary forests occupied the now dry valleys (Young 1979). Some evidence for this last route comes from the finding of *pia* series females in the Marañón region of Peru (Cáceres et al. 1995).

Although less probable, a *trans-Andean* origin (i.e., one west of the Andes) should also be considered for some species of the series such as *L. emberai* n. sp. given its presence on the Pacific Coast of Colombia. However, it is also possible that *L. emberai* n. sp. and *L. pia* reached the Pacific Coast region by means of inter-Andean valleys during humid periods when the forested zones coalesced. Additionally, the occurrence of *L. pia* in Panama and Costa Rica could have been facilitated by the appearance of the Isthmus of

Panama that permitted dispersion of species between South and Central America. The exploration of little-studied areas within the Andes could provide new records that contribute to the knowledge of the genesis of the series *pia*.

Medical Importance

To date, none of the taxa that comprise the series *pia* have been directly incriminated in the transmission of pathogenic agents to man. Nevertheless, several species exhibit anthropophilic tendencies throughout their distribution (Zeledón et al. 1985, Le Pont et al. 1989, Alexander et al. 1992, Barreto et al. 1997, Cáceres et al. 2001, Agudelo et al. 2002). *L. suapiensis*, *L. tihuilensis*, and *L. tocaniensis* are recognized by their anthropophilic behavior in *Leishmania*-endemic areas of Bolivia and Peru (Le Pont et al. 1997, Cáceres et al. 2001). The strongest evidence for a possible vectorial role for *L. pia* is from Colombia, where in addition to biting man it has been shown to be susceptible to infection with *Leishmania braziliensis* (Warburg et al. 1991). Experimentally infected females presented a high percentage of parasites in the stomodeal valve and the anterior midgut, suggesting that they are potentially capable of transmitting the parasite by bite (Killick-Kendrick 1990). Despite the anthropophily of *L. pia*, slight behavioral differences have been observed among Colombian populations. Warburg et al. (1991) found that *L. pia* in Valle del Cauca in the Western Cordillera did not attempt to bite immediately after settling, whereas Zuleta (2002) observed that in Valle de Aburrá (central Cordillera) it began to bite as soon as it landed on human skin. These subtle bionomic differences merit more detailed investigation, given that they could reflect evolutionary divergences within the species.

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