*Journal of Medical Entomology*, 2016, 1–8
doi: 10.1093/jme/tjw094
Research article

Morphology, Systematics, Evolution

# On the Synonyms of *Psathyromyia* (*Psathyromyia*) *shannoni* (Dyar, 1929) and *Pa. bigeniculata* (Floch & Abonnenc, 1941) and the Resuscitation of *Pa. pifanoi* (Ortiz, 1972) With the Description of Its Female (Diptera: Psychodidae: Phlebotominae)

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Received 11 March 2016; Accepted 15 May 2016

## Abstract

*Psathyromyia shannoni* until recently presented several taxa: *Phlebotomus limai*, *Ph. bigeniculatus*, *Ph. pifanoi*, and *Ph. microcephalus* as its junior synonyms. In a previous study, the two former synonyms were resurrected and here a revision based on morphological characters of the taxonomic status of *Ph. microcephalus* and *Ph. pifanoi* is presented. *Psathyromyia pifanoi* **stat. rev.; comb. n.** is resurrected from the synonymy of *Pa. shannoni* and its female is described. *Phlebotomus microcephalus* is removed from the synonymy of *Pa. shannoni* and proposed as a new synonym of *Pa. bigeniculata*. *Lutzomyia cuzquena* **syn. n.**, occurring in the Amazon region, is designated as a junior synonym of *Pa. pifanoi*. The geographical distributions of *Pa. shannoni*, *Pa. bigeniculata*, and *Pa. pifanoi* in the Americas are presented.

**Key words**: American sand fly, *Psathyromyia*, Shannoni series, synonym, taxonomy

The Shannoni series consists of 20 species classified in the genus and subgenus *Psathyromyia* Barretto, 1962 (Psychodidae, Phlebotominae, Phlebotomini, Psychodopygina) (Galati 2015, Sábio et al. 2016). According to Sábio et al. (2016), seven species of this series: *Psathyromyia abonnenci* (Floch & Chassignet, 1947), *Psathyromyia barata*i Sábio, Andrade & Galati, 2016, *Psathyromyia bigeniculata* (Floch &Abonnenc, 1941), *Psathyromyia cuzquena* (Martins, Llanos & Silva, 1975), *Psathyromyia limai* (Fonseca, 1935) (syn. of *Phlebotomus pestanai* Barretto & Coutinho, 1941), *Psathyromyia ribeirensis* Sábio, Andrade & Galati, 2014, and *Psathyromyia shannoni* (Dyar, 1929) together with the latter's junior synonyms *Phlebotomus microcephalus* Barretto & Duret, 1953 and *Phlebotomus pifanoi* Ortiz, 1972 are included in the Shannoni complex.

*Psathyromyia shannoni* was considered the taxon with the widest geographical distribution, from the United States to Argentina, as from the 40 s. However, with the resurrection of its junior synonym *Pa. bigeniculata* (Sábio et al. 2014), which in fact occupies several Brazilian biomes, and the description of *Pa. barata*i (Sábio et al., 2016), which had been misidentified as *Pa. shannoni*, the distribution of this latter species seems to be much more restricted within South America.

In Argentina, *Pa. shannoni* has been recorded in five Provinces, Chaco, Jujuy, Misiones, Salta, and Tucuman (Fernández et al. 2012, Quintana et al. 2012), but these records are questionable seeing that in Brazil this species has been misidentified (Sábio et al. 2014, 2016). Furthermore, *Ph. microcephalus* has been described from one male collected in Chaco (Barretto and Duret 1953), this being the only specimen known of this species, which was proposed by Forattini (1973) as a junior synonym of *Pa. shannoni*—although without offering any justification. However, *Ph. microcephalus* is morphologically different from *Pa. shannoni* and very close to *Pa. bigeniculata*.

*Phlebotomus pifanoi* described from one male collected in the Amazonian region of Venezuela (Sierra Parima) by Ortiz (1972) was proposed as another junior synonym of *Pa. shannoni* by Martins et al. (1975) as well as *Ph. microcephalus* though without any justification. However, *Ph. pifanoi* is morphologically distinct from *Pa. shannoni* and similar to *Pa. cuzquena*, which has been described on the basis of two males from the Amazonian region of Peru

(Cuzco; Paucartambo province). Additionally, it has also been registered in Brazilian, Colombian, and Venezuelan Amazonia (Young and Morales 1987, Piñero 1988, Llanos et al. 1975, Silva et al. 2007, Bermúdez 2009).

Thus, the present authors suspect that *Ph. microcephalus* and *Ph. pifanoi* should not be considered junior synonyms of *Pa. shannoni*, which further restricts the distribution of this latter species in South America, possibly only to Andean and trans–Andean areas (Sábio et al. 2016).

Some recent studies of the sand fly fauna have recorded the collection of females of *Pa. cuzquena* (Alves et al. 2012, Gama–Neto et al. 2012, Gomes et al. 2013) despite no description of this sex having been formally presented. Males of *Pa. cuzquena* have been collected in the Xapuri municipality (Acre, Brazil) together with a single female yet undescribed (whose external characters permit its association with the males of that species) by one of the authors of the present study (A F. Brilhante).

Thus, in view of: 1) the uncertain distribution of *Pa. shannoni* in Argentina; 2) the doubt as to whether *Ph. microcephalus* is a junior synonym of *Pa. shannoni* or of *Pa. bigeniculata*, widespread in Brazil; 3) the morphological difference between *Pa shannoni* and *Ph. pifanoi* and the latter's morphological similarity to *Pa. cuzquena*; and 4) the finding of *Pa. cuzquena* females in the Amazon region of Brazil, we decided to investigate the taxonomic status of *Ph. microcephalus*, *Ph. pifanoi*, and *Pa. cuzquena*, and discuss the geographical distribution of all the taxa mentioned above.

## Materials and Methods

The holotype *Ph. microcephalus* and specimens of the type-series of *Pa. cuzquena* and *Pa. shannoni* were examined, as well as two other non-type specimens of *Pa. bigeniculata* (though from the type locality). Additionally, 90 males and 87 females mounted on slides and identified as *Pa. shannoni*, *Pa. bigeniculata*, and *Pa. cuzquena* deposited in the following collections were examined. In Brazil: Coleção de Referência da Faculdade de Saúde Pública (FSP–USP), Coleção Entomológica do Laboratório de Entomologia em Saúde Pública (FSP/LESP–Phlebotominae), the Museu de Zoologia da Universidade de São Paulo (MZUSP), the Coleção de Referência Nacional e Internacional do Centro de Pesquisas René Rachou (COLFLEB–FIOCRUZ), and the Coleção Entomológica do Instituto Oswaldo Cruz (CEIOC–FIOCRUZ). In Argentina: Instituto Superior de Entomologia da Facultad de Ciencias Naturales and Instituto Miguel Lillo, Universidad Nacional de Tucumán (FCN and IML, UNT). In the United States: Collection of the Smithsonian Institution's National Museum of Natural History (NMNH). In the United Kingdom: Museum of Natural History, London (MNH). The diagnosis of the species *Pa. shannoni* and *Pa. bigeniculata* is given by Sábio et al. (2014).

The geographical distribution was defined based on the original descriptions of the males of *Ph. pifanoi* (Ortiz 1972) and *Pa. cuzquena* (Martins et al. 1975) and other information found in the literature, as well as the observation of *Pa cuzquena* specimens collected in various localities and deposited in entomological collections.

The description of the female of *Ph. pifanoi* (= *Pa. cuzquena*) has been based on the morphological analysis of one female specimen collected in the Xapuri municipality (Acre State, Brazil), and the redescription of the male has been based on the morphological analysis of three males collected together with the female and on the type-series of *Pa. cuzquena*.

For the majority of the morphological characters, the terminology adopted follows Galati (2003). However, for some characters of the male terminalia and palpi, Ilango's (2004) and Cumming and Wood's (2009) terminologies have been adopted though, in these cases, that of Galati (2003) is given between parentheses. The morphological analysis was based on the characters described by Sábio et al. (2016), as well as on the comparison and classification of the thoracic pigmentation of the taxa. Abbreviations of generic names follow Marcondes (2007).

The drawings were made with the aid of an Olympus camera lucida. Measurements (μm) of all specimens, including types of *Pa. cuzquena*, were taken with a Zeiss ocular micrometer calibrated using a standard Zeiss scale. Conversion of the micrometer readings was made using an objective lens (5×) = 196 μm, (10×) = 100 μm, and (40×) = 26 μm. In the redescription of the male of *Pa. pifanoi*, the measurements given out of the parentheses correspond to those of the holotype and paratype of *Pa. cuzquena*, while those within the parentheses are for the three additional males collected in Xapuri (Acre, Brazil).

## Results

### *Psathyromyia (Psathyromyia) shannoni* (Figs. 1A, B)

*Phlebotomus shannoni* Dyar, 1929: 121. Type-series: Three cotype males, Canal Zone, Panama, May 1923, R. C. Shannon coll. (NMNH); Rozeboon, 1944: 274 (registered in the USA as *Ph. limai*); Barretto, 1946: 11 (proposal of synonyms); Fairchild and Hertig, 1950: 524 (description of female); Johnson and Hertig, 1961: 765 (biological cycle).

*Lutzomyia shannoni* Barretto, 1962: 99 (comb., cat., tax.); Theodor, 1965: 189 (comb., cat., tax., fig.); Lewis et al., 1977: 325 (cat.); Martins et al., 1978: 109 (cat., in part); Morales et al., 1982: 19 (key, fig.); Young and Perkins, 1984: 268 (cat., key, fig.); Killick–Kendrick, 1986: 135 (exp. inf. *Leishmania mexicana*); Endris et al., 1987: 412 (biology); Lawyer et al., 1987: 347 (exp. inf. *Leishmania mexicana*); Lawyer and Young, 1987: 458 (experimental transmission *Leishmania mexicana*); Comer et al., 1990: 483 (infection *Vesiculovirus*, Rhabdoviridae); Brinson et al., 1992: 178 (seasonality); Memmott, 1992: 188 (biology); Comer et al., 1993: 555 (epidemiology *Vesiculovirus*); Comer and Brown, 1993: 613 (biology); Young and Duncan, 1994: 349 (cat., tax., key, fig., in part); Comer et al., 1994: 850 (epidemiology *Vesiculovirus*); Ferro et al., 1998: 195 (biological cycle); Cárdenas et al., 1999: 158 (biology); Cárdenas et al., 2001: 189 (population genetics); Ibánez–Bernal, 2001: 372 (listed, key, fig.); Travi et al., 2002: 83 (exp. inf. *Leishmania chagasi*); Ibanez–Bernal, 2005: 202 (key, fig.); Petersen and Barr, 2009: 2 (potential vector of *Leishmania infantum*); Florin et al., 2010: 952 (anomaly).

*Psathyromyia shannoni* Artemiev, 1991: 73 (comb., cat.); Galati, 2003: 43 (cat., tax, key); Sábio et al., 2014: 332 (tax., key, fig); Sábio et al., 2016: 83 (key, fig.).

#### Diagnosis

(see Sábio et al. 2014).

#### Material Examined

BELIZE: 2 males (MNH and NMNH). COLOMBIA: North Santander, 1 female (FSP/LESP/Phlebotominae). COSTA RICA: Puntarenas, 1 female (NMNH); San José, 3 males and 2 females (FSP/LESP/Phlebotominae). MEXICO: Oaxaca, 1 male (NMNH). PANAMÁ: Canal Zone, 5 males and 3 females (COLFLEB–

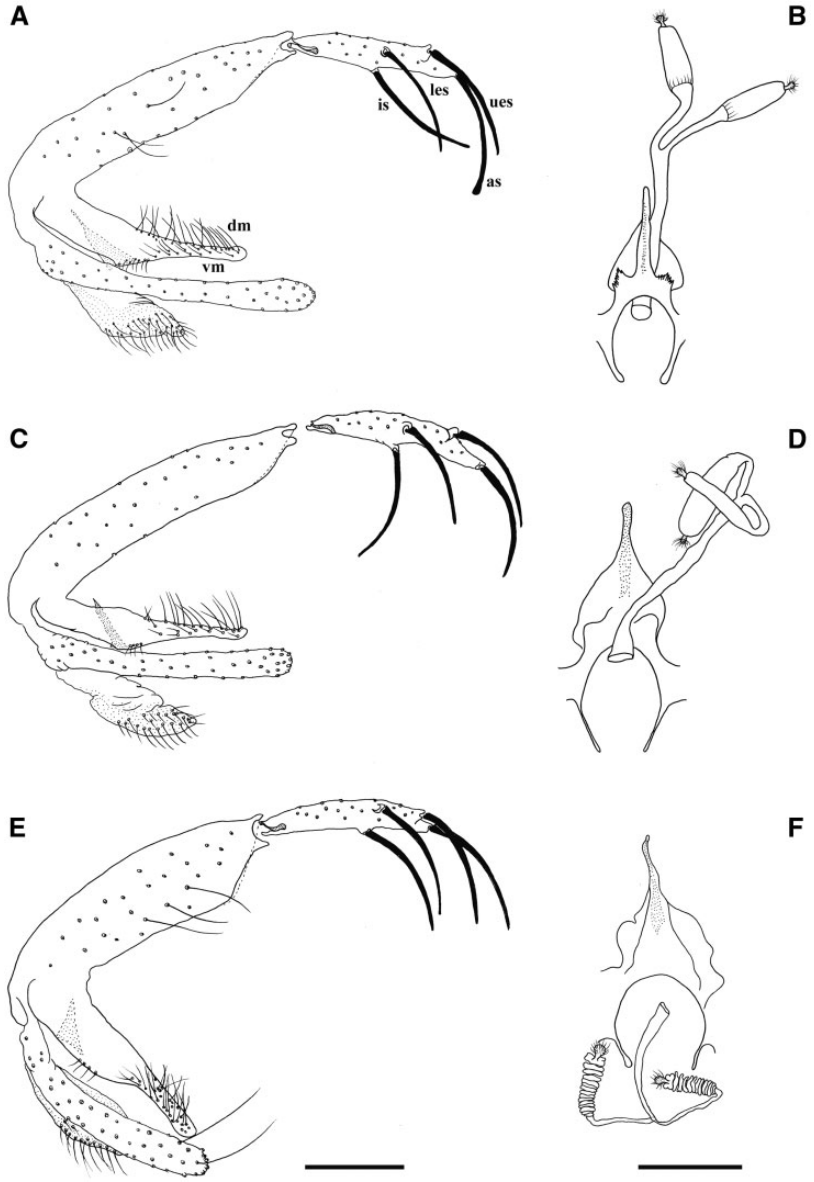


**Fig. 1.** Terminalia of—(**A**) Male cotype of *Pa. shannoni*. (**B**) Female topo-type of *Pa. shannoni*. (**C**) Male of *Pa. bigeniculata*: (Salta, Argentina). (**D**) Female of *Pa. bigeniculata*: (Mato Grosso do Sul, Brazil). (**E**) Male of *Pa. pifanoi* (holotype of *Lu. cuzquena* **syn. n.**). (**F**) Female of the *Pa. pifanoi* (Bar: 100 μm). Gonostylus: as: apical spine; is: internal spine; ues: upper external spine; les: lower external spine; Paramere: dm: dorsal margin; vm: ventral margin.

FIOCRUZ, FSP–USP, FSP/LESP/Phlebotominae and NMNH: type-series). VENEZUELA: E. Táchira, 1 male (CEIOC).

### *Psathyromyia (Psathyromyia) bigeniculata* (Figs. 1C, D)

*Phlebotomus bigeniculatus* Floch & Abonnenc, 1941: 3. Type-series: 4 males and 3 females (holotype male n.209, paratype female n.143 and 5 paratypes), Cayenne, FRENCH GUYANA, Jun. 1941, H. Floch and E. Abonnenc colls. (L'Institut Pasteur de la Guyane et ou Territoire de L'Inini); Barretto, 1946: 11 (proposal of synonym of *Pa. shannoni*); Floch and Abonnenc, 1946: 1 (listed); Barretto, 1950: 110 (key); Barretto, 1962: 99 (cat., tax.); Theodor, 1965: 189 (cat., tax.); Forattini, 1971: 102; 1973: 294 (cat., tax.); Leger et al., 1977: 225 (listed); Martins et al., 1978: 109 (cat., in part); Young and Duncan, 1994: 349 (cat., tax. in part); Forattini, 1971: 102 (cat., tax.); 1973: 294 (cat., tax., fig.); Artemiev, 1991: 73 (comb., cat.); Galati, 2003: 43 (cat., tax., key): as synonym of *Pa. shannoni*.

*Phlebotomus limai* Barretto and Coutinho, 1940: 127 (female described as *Pa. limai*).

*Phlebotomus microcephalus* Barretto & Duret, 1953: 341. Type-series: Holotype male, Presidencia Roca, Presidente Peron (Chaco), ARGENTINA, December 1949, J. F. Bejarano and J. P. Duret colls. (Centro de Medicina Preventiva e Higiene Militar de la Direcion general de Sanidad del Ministerio del Ejercito, Buenos Aires, Argentina) **syn. n.**; Forattini, 1973: 294 (cat., tax., fig., proposal of synonym of *Pa. shannoni*); Leger et al., 1977: 225 (listed); Young and Duncan, 1994: 349 (cat., tax.); Galati, 2003: 43 (cat., tax.): as synonym of *Pa. shannoni*.

*Lutzomyia microcephala* Barretto, 1962: 99 (comb., cat., tax.); Theodor, 1965: 189 (comb., cat., tax.); Forattini, 1971: 102 (cat., tax.); Lewis, 1977: 325 (cat.); Martins et al., 1978: 107 (cat.); Artemiev, 1991: 73 (comb., cat.).

*Psathyromyia bigeniculata* Sábio et al., 2014: 334 (stat. rev., comb., tax., key, fig.); Sábio et al., 2016: 83 (key, fig.).

### Diagnosis

(see Sábio et al. 2014).

### Material Examined

ARGENTINA: Chaco, 1 male (NMNH: holotype of *Ph. microcephalus*); Jujuy, 1 female; Salta, 11 males and 50 females (FCN and IML, UNT); Misiones, 3 males and 1 female (COLFLEB–FIOCRUZ). BRAZIL: Acre, 2 males and 1 female (FSP/LESP/Phlebotominae); Amapá, 1 female (FSP–USP); Bahia, 1 male (FSP–USP); Amazonas, 6 males and 2 females (FSP–USP and FSP/LESP/Phlebotominae); Ceará, 1 male (MZUSP); Mato Grosso, 1 female (FSP/LESP/Phlebotominae); Mato Grosso do Sul, 29 males and 10 females (FSP/LESP/Phlebotominae); Pará, 19 males and 8 females (COLFLEB–FIOCRUZ; FSP–USP; FSP/LESP/Phlebotominae and MNH); São Paulo, 7 males and 5 females (FSP–USP; FSP/LESP/Phlebotominae and MZUSP). FRENCH GUYANA: Cayenne, 2 males and 2 females (FSP/LESP/Phlebotominae).

## *Psathyromyia* (*Psathyromyia*) *pifanoi* stat. rev.; comb. n.

(Figs. 1E, F)

*Phlebotomus pifanoi* Ortiz, 1972: 21. Type-series: Holotype male, Sierra Parima (Niyayobateri region), Amazonas, VENEZUELA, December 1971, F. Pifano C., J. Romero, A. Alavarez and R. Vargas colls. (National Institute of Hygiene, Caracas, Venezuela); Martins et al., 1978: 109 (proposal of synonym of *Pa. shannoni*); Artemiev, 1991: 73 (cat., tax.); Young and Duncan, 1994: 349 (cat., tax., key); Galati, 2003: 43, 67 (cat., tax., key): as synonym of *Pa. shannoni*.

*Lutzomyia cuzquena* Martins, Llanos and Silva, 1975: 650. Type-series: 2 males (holotype n.46.212 and paratype n.46.213), Pilcopata, Vale de Kosñipata, Província de Paucartambo, Cuzco, PERU, Jun. 1973, A. V. Martins coll. (COLFLEB–FIOCRUZ) **syn. n.**; Martins et al., 1978: 107 (cat.); Llanos, 1981: 183 (cat.); Young and Duncan, 1994: 341 (cat., tax., key, fig.).

*Psathyromyia cuzquena* Artemiev, 1991: 73 (comb., cat.); Galati, 2003: 43, 67 (cat., tax., key); Sábio et al., 2014: 340 (key); Sábio et al., 2016: 83 (key).

### Diagnosis

Both sexes: thoracic coloration: mesonotum, pronotum, metanotum and postnotum brown; pleura off-white. Male: terminalia: gonostyle with four spines, the upper external implanted subapically from the apical spine and the lower external spine implanted more apically than the internal one; paramere digitiform with dorsal margin covered with bristles in an area extending from its apex to the level of those of the ventral angle; aedeagus (ejaculatory ducts) with rounded apex. Female: cibarium with two pairs of posterior teeth; spermathecae ringed with long common duct *ca*. 1.6 times longer than the individual duct; the ducts are smooth-walled.

### Description of the Female

Head (**Fig. 2A**) 410 long, 350 wide; clypeus 151 long; eyes 237 long, 159 wide; interocular distance 104. Apical region of hypopharynx with developed teeth (**Fig. 2B**). Labrum–epipharynx (**Fig. 2C**) (LE): 305 and with 32 teeth in the apical region. Lacinia of the maxillae have three external teeth and 21 internal teeth (**Fig. 2D**). Cibarium with four well-developed posterior teeth distributed in two transversal rows; sclerotized area short and triangular; sclerotized arch complete (**Fig. 2E**). Antenna (**Figs. 2F–H**): flagellomere length: FI 330, FII 150, FIII 150, and FXIII 70. Ascoids with pedunculated implantation and long posterior spur, which almost reaches the basis of their article (excepting in FI), the anterior spur is long and reaches the apex of their article; in FI the ascoids are implanted at different levels, the external more basal than the internal (**Fig. 2F**); antennal formula FI–FXII 2, FXIII–FXIV 0; FI–III with apical papilla; FIV–FXI without papilla; FXII–FXIV with papillae; absence of simple setae on FI–FXII. Palpi (**Figs. 2I–K**): palpal segment length: PI 60, PII 130, PIII 153, PIV 60, PV lost; palpal formula: 1–4–2–3–5 lost; palp II (**Fig. 2I**) with Newstead's sensilla; palp III with Newstead's sensilla distributed in the middle segment (**Fig. 2J**). Labial suture forming a fork (**Fig. 2A**).

Cervix. Ventro-cervical sensilla absent. Cervical sclerites with two spiniform sensilla.

Thorax: 595 long, mesonotum 570 long. Thoracic coloration: mesonotum, pronotum, metanotum and postnotum brown; pleura off-white. Two proepimeral setae; 7–8 upper anepisternal setae. Setae absent on the anterior region of the katepisternum. Wing (**Fig. 2L**): 2,356 long, 653 wide; veins: $R_5$ 1,228; *alfa* 475; *beta* 337; *gamma* 198; *delta* 119; *pi* 119. Legs: anterior; median; posterior: coxa: 337; 356; 337; femur: anterior, median and posterior missing; tibia: anterior, median and posterior missing; tarsomeres I–V anterior, median and posterior missing.

Abdomen: 1,426 long. Spermathecae ringed (**Fig. 1F**): 41 long and 15 wide; common spermathecal duct 74 long and 6.9 wide; individual spermathecal duct 45 long and 4.0 wide; the spermathecae and the spermathecal ducts are smooth-walled and membranous.

### Redescription of the Male

Head (**Fig. 3A**) 362 and 366 (320; 340 and 350) long, 363 and 346 (320; 340 and 350) wide; clypeus 75 and 78 (83; 88 and 99) long; eyes 228 and 197 (213; 216 and 226) long, 146 and 116 (112; 135 and 146) wide; interocular distance 56 (78; 86 and 86). Cibarium without teeth. Labrum–epipharynx (LE) 223 and 230 (200; 210 and lost). Antennae (**Figs. 3B–D**): flagellomeres (F) length: FI 350 and 320 (lost), FII 166 and 152 (lost), FIII 156 and 151 (lost), FXIII 71 and 75 (lost), FXIV 51 and 68 (lost). Holotype with two antennae FI–FXIV; paratype with one antenna with FI–FVII and the other with FI–FXIV; ascoids with pedunculated implantation and long posterior spur which almost reaches the basis of their article (excepting in FI), and the apex of the anterior spur is close to the level of the papilla; antennal formula FI–FXII 2, FXIII– FXIV 0; in FI the ascoids are implanted at different levels, the external more basal than the internal (**Fig. 3B**); FI–FIII with apical papilla; FIV–FXI without papillae; FXII–FXIV with papillae; absence of simple setae on FI–FXII. Palpi (**Figs. 3E–H**): palpal segment (P) length: PI 37 and 37(44; 44 and 48), PII 105 and 92 (81; 88 and 88), PIII 119 and 122 (lost; lost and 120), PIV 51 and 54 (lost; lost and 62), PV 170 and 163 (lost; lost and 161). Palpal formula: 1–4–2–3–5; palp II with Newstead's sensilla (spines); palp III with several Newstead's sensilla dispersed in the middle region (**Fig. 3F**). Labial suture forming a fork (**Fig. 3A**).

Cervix. Ventro-cervical sensilla absent. Cervical sclerites with two spiniform sensilla.

Thorax: 608 and 598 (480; 540 and 560) long, mesonotum 524 and 511 (440; 475 and 500) long. Thoracic coloration: mesonotum, pronotum, metanotum and postnotum brown; pleura off-white. Two proepimeral setae; 5–7 upper anepisternal setae. Setae on the anterior margin of the katepisternum absent. Wing (**Fig. 3J**): 2,070 and 2,001 (1,802) long, 621 and 593 (594) wide; veins $R_5$ 1,173

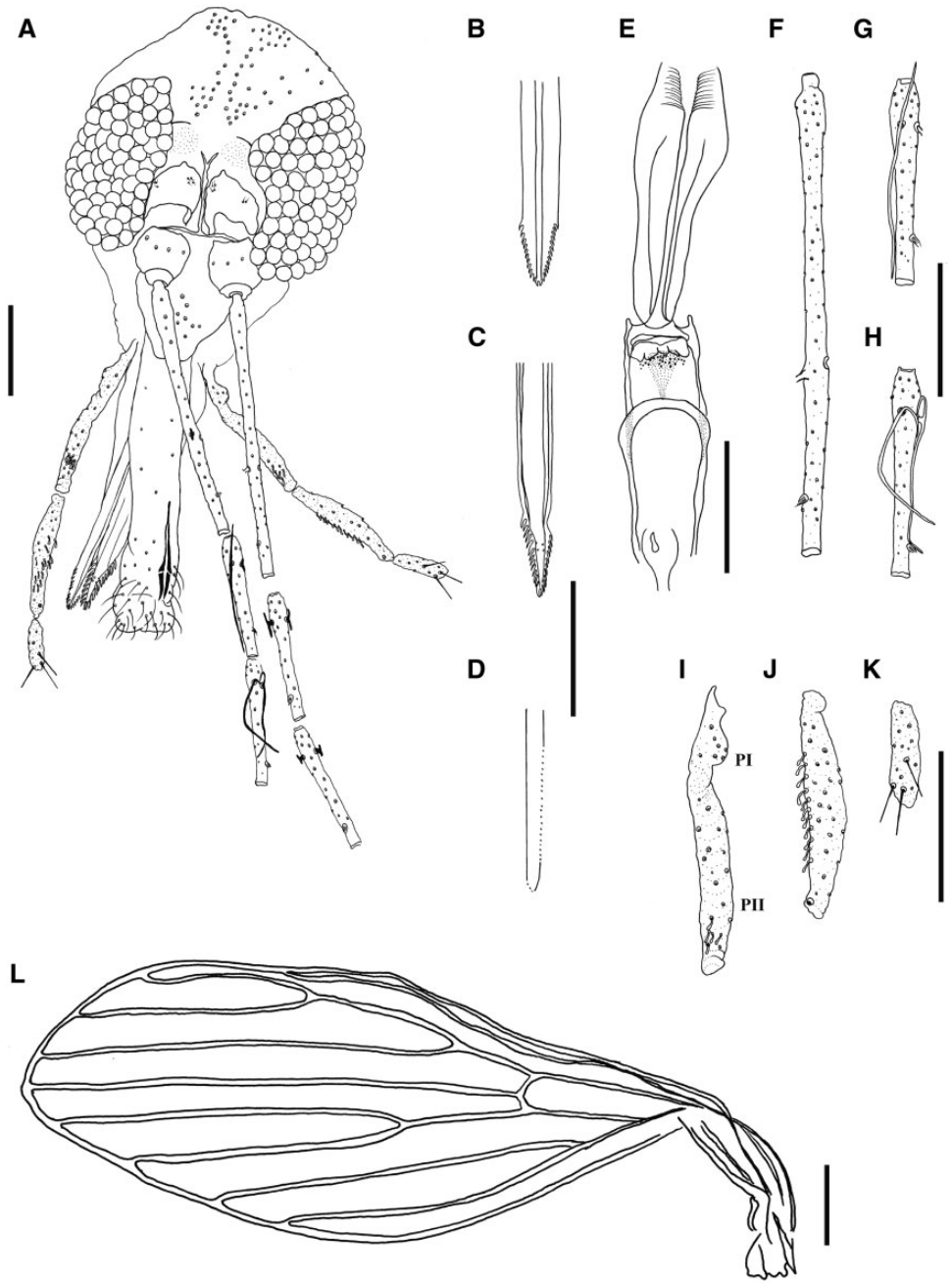


**Fig. 2.** Female of *Psathyromyia pifanoi*. (**A**) Head. (**B**) Hypopharynx. (**C**) Labrum–epipharynx. (**D**) Apical region of lacinia of the maxilla. (**E**) Cibarium. (**F**) Flagellomere I. (**G**) Flagellomere II. (**H**) Flagellomere III. (**I**) Palp I and II. (**J**) Palp III. (**K**) Palp IV. (Bar: 100 μm). (**L**) Wing (Bar: 200 μm).

and 1,132 (970); *alfa* 497 and 400 (436); *beta* 276 and 331 (277); *gamma* 173 and 197 (139); *delta* 142 and 100 (158); *pi* 77 and 126 (139). Legs: anterior; median; posterior: coxa: 304 and 345 (297; 317 and 337); 345 and 331 (297; 317 and 337); 345 and 331 (297; 337 and 337); femur: 745 (lost); 745 (lost); 869 and 828 (lost); tibia: 1,725 (lost); median missing; 1,945 and 1,947 (lost); tarsomere I: 1,104 (lost); 1,201 (lost); 1,201 and 1,132 (lost). Sum of tarsomeres II + III + IV + V 800 (lost); 814 (lost); 856 and 787 (lost).

Abdomen: 1,386 and 1,421 (1,089; 1,148 and 1,327) long; absence of the tergal papillae on all tergites. Terminalia (Fig. 1E): gonocoxite 276 and 262 (250; 270 and 280) long, 83 and 55 (60; 60 and 70) wide, without persistent setae; gonostyle 168 and 175 (lost; 160 and 175) long, without preapical setae and with four well-developed spines: one apical, two external (upper external spine and lower external spine) and one internal one; the upper external implanted subapically of the apical spine and the lower external spine implanted more apically than the internal one; paramere simple with rectangular base and the apical half digitiform; its dorsal margin with apical half covered with spiniform setae pointing towards the base of the terminalia; dorsal margin 180 and 167 (156; 172 and 177) and ventral 225 and 201 (203, 213 and 226) long; parameral sheath (aedeagus) conical; epandrial lobes (lateral lobes) 221 and 221 (200; 200 and 210) long, 34 and 31 (26; 26 and 29) wide and with rounded apex; sperm pump (ejaculatory pump) 158 and 160 (159; 169 and 169) long; ejaculatory apodeme (piston) 119 and 119 (117; 133 and 143) long; aedeagus (ejaculatory ducts) with rounded apex, 356 and 332 (300; 330 and 340) long, 2.0 times longer than the sperm pump (ejaculatory apodeme + sperm sac) (Fig. 3I).

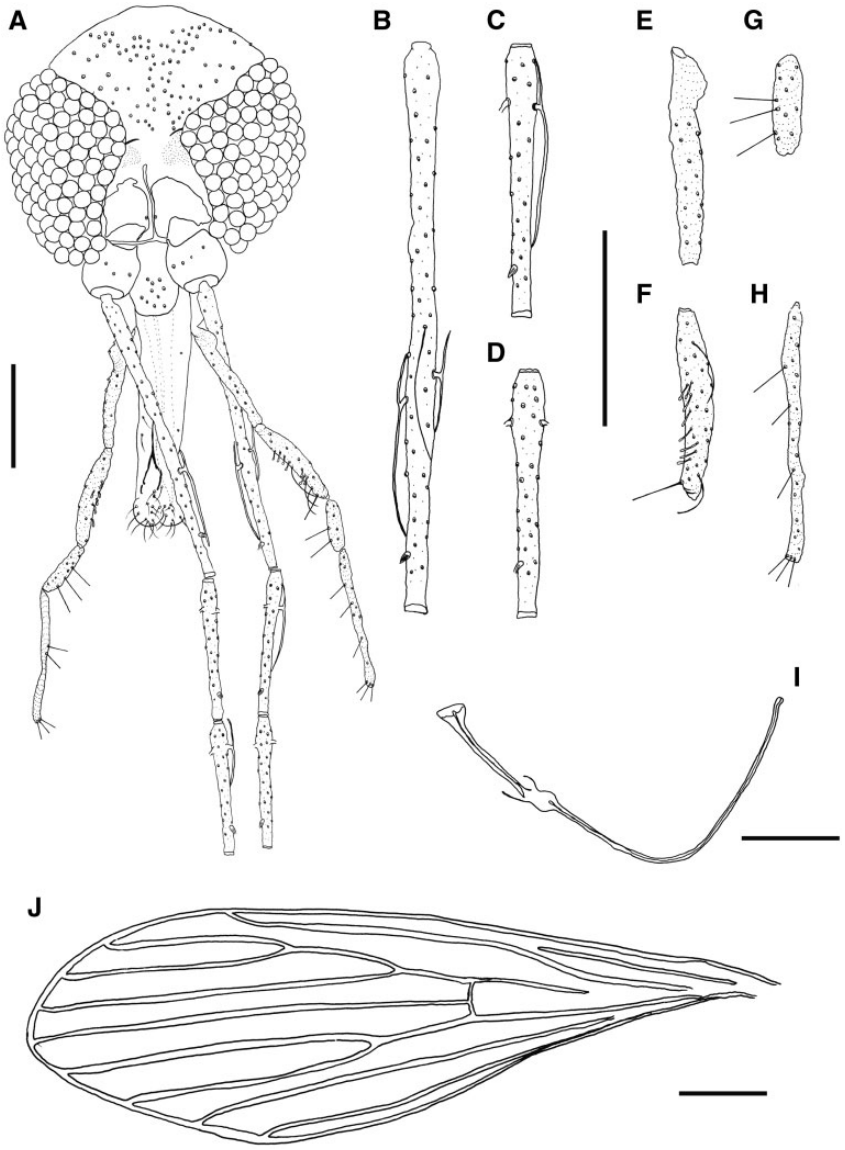


**Fig. 3.** Male of the *Psathyromyia pifanoi* (holotype of *Lu. cuzquena* **syn. n.**). (**A**) Head. (**B**) Flagellomere I. (**C**) Flagellomere II. (**D**) Flagellomere III. (**E**) Palp I and II. (**F**) Palp III. (**G**) Palp IV. (**H**) Palp V. (**I**) Aedeagus (ejaculatory ducts) (Bar: 100 μm). (**J**) Wing (Bar: 200 μm).

### Material Examined

Type-series of *Lu. cuzquena* (FIOCRUZ–COLFLEB) with the slides numbered as follows: holotype male n°41212 and paratype male n°41213; collected on 18–VI–1973; Pilcopata, Vale de Kosñipata, Província de Paucartambo, Cuzco, PERU; coll: A.V. Martins. Female deposited in (COLFLEB–FIOCRUZ); collected on 20–II–2014; Xapuri, Acre, Brazil; coll: A.F. Brilhante. The association between male and female was proposed based on the genital and extra-genital characteristics and coloration pattern. **Other specimens examined** BRAZIL: Acre—Xapuri, 3 males; Manaus, 1 male (FSP/LESP/Phlebotominae). COLOMBIA: Amazonas—Leticia, 2 males (NMNH).

## Taxonomic Discussion

*Psathyromyia shannoni* was described from males collected in Panama (Dyar 1929) and according to Sábio et al. (2014) has only Trans-Andean and Andean geographical distribution. This distribution was corroborated in accordance with the origin of other specimens examined, deposited in entomological collections (CEIOC, FSP–USP, FSP/LESP/Phlebotominae, COLFLEB–FIOCRUZ, MNH, and NMNH), and analyzed in the present study. The majority of the specimens responsible for the wide distribution attributed for many years to *Pa. shannoni* in Brazil do in fact belong to *Pa. bigeniculata*, as well as some others identified as *Pa. limai* and *Pa. baratai* (Sábio et al. 2016). However, there was still the question as to what had been identified as *Pa. shannoni* in Argentina, whether it was in fact *Pa. shannoni*, *Pa. bigeniculata* or *Ph. microcephalus* (considering the last to be a valid species).

Thus, after analyzing the holotype of *Ph. microcephalus* deposited at the NMNH and additional specimens identified as *Pa. shannoni* from Argentina, deposited at FCN and IML, UNT, and COLFLEB–FIOCRUZ, it was possible to elucidate this doubt. The species described as *Ph. microcephalus* by Barretto and Duret (1953) as well as all the specimens from Argentina that were examined, correspond to *Pa. bigeniculata*. Thus, *Ph. microcephalus* ceases to be a junior synonym of *Pa. shannoni* and becomes a junior synonym of *Pa. bigeniculata*.

*Phlebotomus pifanoi*, another junior synonym of *Pa. shannoni*, was described from a single male by Ortiz (1972). In his description, used as the basis for the taxonomic study of this species—since there is no present information as to where the holotype is deposited—morphological differences between the two species can be clearly seen, leaving no doubt that *Ph. pifanoi* and *Pa. shannoni* are distinct species and not synonyms. The male terminalia of *Ph. pifanoi* presents the upper external spine on the gonostyle implanted very close to the apical spine, whereas in *Pa shannoni*, it is implanted equidistant between the apical and lower external spines. Another difference is in the morphology of the paramere, whose basal half in *Ph. pifanoi* tends to be rectangular while in *Pa. shannoni* it tends to be triangular. Thus, the proposal of Martins et al. (1978) that *Ph. pifanoi* should be considered a junior synonym of *Pa. shannoni* has no support. *Psathyromyia pifanoi* **stat. rev.**; **comb. n.** differs from *Pa. shannoni*, being a valid species.

It was not possible to distinguish *Lu. cuzquena* from *Pa. pifanoi* after examining the type-series and additional specimens, the two species being morphologically identical, both as regards the male terminalia and the thoracic coloration. In his description of *Pa. pifanoi*, Ortiz (1972) describes the off-white pleura as contrasting with the brown mesonotum, scutellum, metanotum, and postnotum. This pattern of thoracic coloration is identical to that observed in the type-series and additional specimens identified as *Lu. cuzquena*.

According to the literature, the geographical distribution of *Pa. pifanoi* and *Lu. cuzquena* is restricted to the Amazon region (Llanos 1981, Feliciangeli 2006, Bejarano et al. 2007, Bermúdez 2009), corroborating the findings of the morphological studies that conclude that they are one and the same species. Thus, *Pa. pifanoi* becomes a senior synonym of *Lu. cuzquena* **syn. n.** and the female of *Pa. pifanoi* is described for the first time, on the basis of one specimen collected in Xapuri municipality (Acre, Brazil).

Based on Galati's classification (2003, 2015), both sexes of *Pa. pifanoi* present characters consistent with the genus and subgenus *Psathyromyia* and the Shannoni series, but not with the Shannoni complex (Sábio et al. 2016). *Psathyromyia pifanoi* presents two cervical sensilla, ascoids with pedunculated implantation, the female having ringed spermathecae and the male the gonostyle with the upper external spine implanted subapically. Whereas the species of the Shannoni complex present three sensilla, ascoids without pedunculated implantation, the females have banana-shaped spermathecae and the males the gonostyle with the upper external spine between the lower external and apical spine. Thus, some morphological characters of both sexes distinguish *Pa. pifanoi* from all the other species of the Shannoni complex, as discussed below and presented in the identification key.

Further, their thoracic coloration distinguishes both sexes of the *Pa. pifanoi* from those of all the other species of the Shannoni complex, except *Pa. shannoni*. *Psathyromyia pifanoi* presents the pronotum and paratergite straw, the mesonotum, scutellum, metanotum and postnotum brown and the pleura off-white, while in *Pa. limai* and *Pa. ribeirensis* the pronotum and paratergite are brown; in *Pa. baratai* the paratergite is off-white; and in *Pa. bigeniculata* and *Pa. abonnenci* the pronotum, paratergite, and anepisternum are all brown.

*Psathyromyia shannoni* for >40 years presented four junior synonyms, *Pa. limai*, *Pa. bigeniculata*, *Pa. pifanoi* and *Ph. microcephalus*, which thus included morphologically distinct species of *Pa. shannoni*, the first three being valid species and responsible for various taxa that were identified as *Pa. shannoni* in the cis-Andean area. *Phlebotomus microcephalus*, described on the basis of a male in Argentina, belongs in fact to *Pa. bigeniculata*, which was identified as having a wide geographical distribution, from French Guyana (type locality) to Argentina. Further, Sábio et al (2016) when described *Pa. baratai* reported that this taxon had been erroneously identified as *Pa. shannoni*. Excepting *Pa. pifanoi*, with its ringed spermathecae, the other species of the Shannoni complex all present closely similar banana-shaped spermathecae. This similarity of the spermathecae has contributed to the misidentification. Furthermore, as the wild males of some species such as *Pa. limai* are rarely collected, the certain identification of species can be difficult, as the males present the characters, which most clearly differentiate the species (Sábio et al. 2014).

## Identification Key

**Males**

1. Gonostyle with the upper external spine implanted closer to the apical spine than to the external lower spine ..... *Pa. pifanoi*

z Gonostyle with upper external spine implanted equidistant between the apical spine and the lower external spine ..... 2

2 (1). Thorax: anepisternum brown ..... 3
Thorax: anepisternum off-white ..... 4

3(2). Paramere with the bristles on the dorsal margin distributed only in the apical third ..... *Pa. abonnenci*
Paramere with the bristles on the dorsal margin distributed as far as the apical half ..... *Pa. bigeniculata*

4(2). Thorax: pronotum and paratergite brown ..... 5
Thorax: pronotum and paratergite straw or off-white ..... 6

5(4). Paramere with curvature between the apical and median region of the dorsal margin ..... *Pa. limai*
Paramere straight along the dorsal margin with the bristles on the dorsal margin being distributed as far as the apical half ..... *Pa. ribeirensis*

6(4). Paramere with the bristles on the dorsal margin distributed from the apex to the basal level of the implantation of the bristles of the ventral angle ..... *Pa. shannoni*
Paramere with the bristles of the dorsal margin distributed from its apex to a little before the implantation level of those of the ventral angle ..... *Pa. baratai*

**Females**

1. Cervical sclerites: present two spiniform sensilla. Spermathecae ringed ..... *Pa. pifanoi*
Cervical sclerites: present three spiniform sensilla. Spermathecae banana-shaped ..... 2

2(1). Thorax: anepisternum brown ..... 3
Thorax: anepisternum off-white ..... 4

3(2). Thorax: pronotum, paratergite, anepisternum and postnotum brown ..... *Pa. abonnenci*
Thorax: pronotum, paratergite, and anepisternum brown; postnotum straw ..... *Pa. bigeniculata*

4(2). Thorax: pronotum and paratergite brown ..... *Pa. limai*
*Pa. ribeirensis*
Thorax: pronotum and paratergite straw or off-white ..... 5

5(4). Thorax: pronotum and paratergite straw ..... *Pa. shannoni*
Thorax: pronotum straw and paratergite off-white ..... *Pa. baratai*

## Acknowledgments

We wish to thank the curators of FSP–USP, FSP/LESP–Phlebotominae; MZUSP; COLFLEB–FIOCRUZ; CEIOC–FIOCRUZ; FCN and IML, UNT

and NMNH for permitting that the researchers examine their specimens of the Shannoni complex. We appreciate the help of Paloma F. Shimabukuro, PhD, who sent us information on the specimens of the Shannoni complex deposited in MNH. P.B. Sábio has a PhD scholarship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

## References

**Alves, V. R., R. A. Freitas, F. L. Santos, A.F.J. Oliveira, T. V. Barrett, and P. H. F. Shimabukuro. 2012.** Sand flies (Diptera, Psychodidae, Phlebotominae) from Central Amazonia and four new records for the Amazonas state, Brazil. Rev. Bras. Entomol. 56: 220–227.

**Bermúdez, E.G.C. 2009.** *Lutzomyia* sand flies in the Brazilian Amazon basin (Diptera: Psychodidae). Ed. INPA, Manaus, Amazonas, Brazil.

**Barretto, M. P., and J. P. Duret. 1953.** Uma nova espécie de flebótomo da República Argentina: *Phlebotomus microcephalus*, n. sp. (Diptera, Psychodidae). Papéis Avulsos. 11: 341–344.

**Bejarano, E. E., P. Duque, and I. D. Vélez. 2007.** Confirmación de la presencia de *Lutzomyia lutziana* (Diptera: Psychodidae) en Colombia. Caldasia 29: 153–157.

**Cumming, J. M., and D. M. Wood. 2009.** Adult morphology and terminology, pp. 9–502. *In*: B. V. Brown, A. Borkent, J. M. Cumming, D. M. Wood, N. E. Woodley, and M. A. Zumbado (eds.), Manual of Central American Diptera, Volume 1. National Research Council of Ottawa, Canada.

**Dyar, H. D. 1929.** The present knowledge of the American species of *Phlebotomus* Rondani (Diptera: Psychodidae). Am. J. Trop. Med. Hyg.10: 112–124.

**Feliciangeli, M. D. 2006.** Sobre los flebótomos (Diptera: Psychodidae: Phlebotominae), com especial referencia a las espécies conocidas em Venezuela. Acta Biol. Venez. 26: 61–80.

**Fernández, M. S., E. A. Lestani, R. Cavia, and O. D. Salomón. 2012.** Phlebotominae fauna in a recent deforested area with American Tegumentary Leishmaniasis transmission (Puerto Iguazú, Misiones, Argentina): seasonal distribution in domestic and peridomestic environments. Acta Tropica. 122: 16–23.

**Forattini, O. P. 1973.** Entomologia Médica. Psychodidae. Phlebotominae. Leishmanioses. Bartonelose. Ed. Blücher/Edusp, São Paulo, Brasil.

**Galati, E.A.B. 2003.** Morfologia, terminologia de adultos e identificação dos táxons da América, pp. 53–175. *In*: E. F. Rangel, R. Lainson (eds.), Organizadores. Flebotomíneos do Brasil. Ed. Fiocruz, Rio de Janeiro, Brasil.

**Galati, E.A.B. 2015.** Apostila de Bioecologia e Identificação de Phlebotominae (Diptera, Psychodidae) – Departamento de Epidemiologia, Faculdade de Saúde Pública da USP, São Paulo, Brasil, p. 127. (http://www.fsp.usp.br/~egalati) (accessed 30 November 2015).

**Gama–Neto, J. L., J. M. Baima, R. A. Freitas, and M.A.B. Passos. 2012.** Fauna flebotomínica (Diptera: Psychodidae) em floresta preservada e alterada do Município de Caroebe, Estado de Roraima, Brasil. Rev. Pan–Amaz. Saúde. 3: 41–46.

**Gomes, L.H.M., M.I.C. Albuquerque, L.C.R. Rocha, F. G. Pinheiro, and A.M.R. Franco. 2013.** Diversity and distribution of sandflies (Diptera: Psychodidae: Phlebotominae) in a military area in the state of Amazonas, Brazil. Mem. Inst. Oswaldo Cruz. 108: 651–656.

**Ilango, K. 2004.** Phylogeny of the Old World Phlebotomine sandflies (Diptera, Psychodidae) with special reference to structural diversity of female spermathecae. Oriental Insects 38:419–462.

**Llanos, Z. B. 1981.** Los flebotomos del Peru y su distribución geográfica (Diptera: Psychodidae, Phlebotominae). Rev. Peru. Entomol. 24: 183–184.

**Llanos, Z. B., A. V. Martins, and J. E. Silva. 1975.** Estudos sobre os Flebotomíneos do Perú (Diptera, Psychodidae, Phlebotominae) I – departamento de Cuzco: 3 – Descrição do macho e redescrição da fêmea de *Lutzomyia* (*Psychodopygus*) *amazonensis* (Root, 1934) e lista das espécies coletadas. Rev. Brasil. Biol. 35: 665–672.

**Marcondes, C. B. 2007.** A proposal of generic and subgeneric abbreviations for phlebotomine sandflies (Diptera: Psychodidae: Phlebotominae) of the world. Entomol. News 118: 351–356.

**Martins, A. V., B. Llanos, and J. E. Silva. 1975.** Estudos sobre os flebotomíneos do Peru (Diptera, Psychodidae, Phlebotominae) Departamento de Cuzco: Descrição de três espécies novas. Rev. Bras. Biol. 35: 645–654.

**Martins, A. V., P. Williams, and A. L. Falcão. 1978.** American Sand Flies (Diptera, Psychodidae, Phlebotominae). Academia Brasileira de Ciências, Rio de Janeiro, Brasil.

**Ortiz, I. 1972.** *Phlebotomus pifanoi* nov. sp. nueva espécie de *Phlebotomus* (Diptera: Psychodidae) de la region sur–este amazonica venezolana. Rev. Inst. Nac. Hig. 5:21–28.

**Piñero, M.D.F. 1988.** La fauna flebotômica (Diptera, Psychodidae) Venezuela: Taxonomía y distribución geográfica. Bol. Dirección Malariol. Saneam. Ambient. 28: 3–4.

**Quintana, M. G., M. S. Fernández, and O. D. Salomón. 2012.** Distribution and Abundance of Phlebotominae, vectors of Leishmaniasis, in Argentina: Spatial and temporal analysis at different scales. J. Trop. Med. 652803: 1–16.

**Sábio, P.B., A. J. Andrade, and E.A.B. Galati. 2014.** Assessment of the taxonomic status of some species included in the Shannoni Complex, with the description of a new species of *Psathyromyia* (Diptera: Psychodidae: Phlebotominae). J. Med. Entomol. 51: 331–341.

**Sábio, P.B., A. J. Andrade, and E.A.B. Galati. 2016.** Description of *Psathyromyia* (*Psathyromyia*) *baratai* sp. n. (Diptera: Psychodidae: Phlebotominae) from Cantareira State Park, São Paulo, Brazil. J. Med. Entomol. 53: 83–90.

**Silva, D. F., R. A. Freitas, and A.M.R. Franco. 2007.** Diversidade e abundância de flebotomíneos do gênero *Lutzomyia* (Diptera: Psychodidae) em áreas de matas do nordeste de Manacapuru, AM. Neotrop. Entomol. 36: 138–144.

**Young, D. G., and A. Morales. 1987.** New species and records of Phlebotominae sand flies from Colombia (Diptera: Psychodidae). J. Med. Entomol. 24: 651–665.