

## Review Article

# The Phlebotomine sandfly fauna (Diptera: Psychodidae) of Kenya

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### ABSTRACT

Visceral and cutaneous leishmaniases are endemic in some parts of Kenya, where they are transmitted by phlebotomine sandflies of genus *Phlebotomus*. This review is a compilation of the currently known distribution of phlebotomine sandflies in the parts of Kenya that have been studied, from the time sandflies were first reported in the country. So far 48 species of sandflies have been identified falling in the genera *Phlebotomus* Rondani & Berte and *Sergentomyia* Franca & Parrot. Genus *Phlebotomus* in Kenya is represented in five subgenera, namely *Phlebotomus*, *Larroussius*, *Synphlebotomus*, *Paraphlebotomus* and *Anaphlebotomus*. Genus *Sergentomyia* has the largest number of sandflies, and is represented in four subgenera, namely *Sergentomyia*, *Sintonius*, *Grassomyia* and *Parvidens*.

**Key words** Distribution; Kenya; *Leishmania*; *Phlebotomus*; *Sergentomyia*

Phlebotomine sandflies were first reported in Mombasa on the Kenya Coast in 1912<sup>1</sup>. Later in 1930 and 1932, Sinton<sup>2</sup> identified and reported the presence of *Sergentomyia schwetzi* Adler, Theodor & Parrot, *S. africana* Newstead, *S. yusafi* Sinton and *S. bedfordi congolensis* Bequaert & Walravens<sup>2,3</sup>. During the succeeding years, knowledge of the sandfly fauna of Kenya has widened as a result of sporadic collections of sandflies through attempts to find vectors of both cutaneous and visceral leishmaniases<sup>4–19</sup>.

Until 1982, 40 species of sandflies and subspecies had been reported to occur in Kenya<sup>20</sup>. Following continuous collections in different parts of the country, so far 48 species of sandflies have been identified, belonging to the genera *Phlebotomus* Rondani & Berte and *Sergentomyia* Franca & Parrot. Sandflies of the genus *Phlebotomus* are important vectors of the leishmaniases whereas those in *Sergentomyia* are not known to transmit any disease but can be a biting nuisance<sup>21</sup>. Genus *Phlebotomus* in Kenya is represented in five subgenera, namely *Phlebotomus*, *Larroussius*, *Synphlebotomus*, *Paraphlebotomus* and *Anaphlebotomus*. Genus *Sergentomyia* has the largest number of sandflies, and is represented in four subgenera, namely *Sergentomyia*, *Sintonius*, *Grassomyia* and *Parvidens*. The sandfly species presented here are not exhaustive and it is possible to have more species reported from Kenya.

### The genus *Phlebotomus* Rondani & Berte

The genus *Phlebotomus* can be easily identified when sandflies are mounted using Chloral hydrate gum on a slide. The ciborium usually has no teeth (also known as armatures) and can have only tiny spicules. The pigment patch is always absent. Hind ends of abdominal tergites 2–6 always have erect hair. Pleural setae are absent.

### Subgenus *Phlebotomus* Rondani

In Kenya, this genus is represented by only one species, *Phlebotomus (Phlebotomus) duboscqi* Neveu-Lemaire. The male of this sandfly usually has 2 terminal and 3 subterminal spines, and 3 of which are arranged in a row. The paramere is trilobed. Females have spermathecae with 8 segments and a pharynx with a network of scales. It is the only known vector for human cutaneous leishmaniasis caused by *Leishmania (Leishmania) major* Yarkimoff & Schokhor<sup>22</sup>.

*Phlebotomus duboscqi* has a limited distribution and it is found in a small focus in Baringo district, Rift Valley province. It is closely related to *P. (Phlebotomus) papatasi* Scopoli which is found in the neighbouring Republic of Sudan. *Phlebotomus duboscqi* is known to rest, breed and feed in rodent burrows<sup>23</sup>. Rodents such as *Arvicanthis niloticus* Geoffrey, *Aethomys kaiseri* Noak, *Taterillus*

*emini* Thomas, *Tatera robusta* Cretzschmar and *Mastomys natalensis* Smith are the major blood meal sources for this sandfly. It is also the known reservoir host for *L. major* in Baringo County<sup>24,25</sup>. *Phlebotomus duboscqi* is an exophagic and a perennial breeding species. It only bites human hosts whose frequent areas with plenty of animal burrows and some vegetation. *Phlebotomus papatasi* has been shown to be a more efficient vector than the latter since it displays gonotrophic discordance<sup>26</sup>.

### Subgenus *Synphlebotomus* Theodor

This subgenus is composed of sandflies that are associated with transmission of visceral leishmaniasis caused by *L. donovani* Laveran & Mesnil. Species in this group that have been collected are *P. martini* Parrot, *P. celiae* Minter and *P. vansomerena* Heisch, Guggisberg & Teesdale<sup>10</sup>. *Phlebotomus martini* has wide distribution in semi-arid parts of the Rift Valley and Eastern Provinces, and has been caught in Baringo, West Pokot and Turkana districts<sup>16,18</sup> in Rift Valley, Machakos, Kajiado, Kitui and Meru counties<sup>9,10,13</sup>. It is the confirmed vector for *L. donovani* in Baringo county<sup>9,16</sup>. In the field, it has been shown through blood meal analysis to feed on man, cattle, the dog (*Canis familiaris* L.), the wild rabbit (*Oryctolagus cuniculus* L.), more commonly on the goat (*Capra hircus* L.)<sup>27</sup>.

*Phlebotomus celiae* and *P. vansomerena* are thought to play a role in the transmission of *L. donovani* but no parasite had been isolated from these two subspecies<sup>28</sup>. Separation of these three species (*P. martini*, *P. celiae* and *P. vansomerena*) can only be based on the differences in male genitalia appendages. Females are inseparable. Males of the *Synphlebotomus* species group usually have genital filaments that are shorter than 3× the length of the genital pump. The coxite always has persistent hair inserted on the long arm. The coxite tuft of *P. martini* male usually has 6 flat hair and about 12 thin ones. That of *P. celiae* usually has 7 setae, a few thin hair, and the paramere is sickle shaped dorsally. Males of *P. vansomerena* usually have 10 flat hairs on the coxite and fewer than 12 thin hair. All the 3 have five terminal spines on the style. Spermathecae of female sandflies are either segmented, smooth-walled or filamentous depending on the sandfly species. The females of *Synphlebotomus* group all have spermathecae with 9–10 segments. The pharynx has ridges with small teeth. These sandflies are closely associated with termite mounds constructed by the termite, *Macrotermes subhyalinus* Rambur<sup>29</sup>, where they are thought to breed and rest. *Phlebotomus martini* is highly anthropophilic and to some extent endophilic<sup>5,6</sup>. It mainly bites at night. Within this species group, it is the only one

from which *L. donovani* has been isolated<sup>16</sup>. The feeding preferences and behaviours of *P. celiae* and *P. vansomerena* have not been established. As compared to *P. martini*, the two sandflies have been caught in very few numbers. Their distribution and bionomics are poorly known.

### Subgenus *Larroussius* Nitzulescu

Females of the subgenus *Larroussius* are usually identified easily because they have spermathecae that always have long terminal knobs. The wing length will vary from 1.9–3.7 mm. The antennal segment 3 length varies from 0.25–0.5 mm. Five sandfly species belonging to this subgenus that are known to occur in Kenya are : *P. pedifer* Lewis, Mutinga & Ashford<sup>30–32</sup>, *P. longipes* Parrot & Martin<sup>32</sup> and *P. elgonensis* Ngoka, Madel & Mutinga are found in Mt Elgon caves in Bugoma county, western Kenya<sup>33</sup>. *Phlebotomus orientalis* Parrot<sup>6</sup>, *P. guggisbergi* Kirk & Lewis<sup>34</sup> and *P. aculeatus* Lewis, Minter & Ashford are found in the caves in Utut, Gilgil area in Rift Valley province<sup>35</sup>. Apart from *P. orientalis* which is associated with woodlands that are characterized by vegetation composed of *Acacia seyal* Delile, *Prosopis juliflora* (Swartz) DC and *Balanites egyptica* (L.) Delile in north-eastern Kenya, where it is thought to transmit visceral leishmaniasis also known as kala-azar<sup>35</sup>. All the other sandfly species are often found in caves<sup>18,33,36,37</sup>. Females of *Larroussius* are not easy to distinguish but males can be easily separated using morphology of the style, coxite, genital pump and aedagus<sup>18,37</sup>.

The *Larroussius* subgenus is of particular importance in Kenya in the sense that it comprises of sandflies that have been incriminated as vectors for cutaneous leishmaniasis caused by *L. aethiopica* Bray, Ashford & Bray<sup>38</sup>, and *L. tropica* Wright. *Phlebotomus pedifer* and *P. longipes* are confined around Mt Elgon where these are known to feed on the rock hyrax, *Procavia johnstoni* Thomas, the tree hyrax, *Dendrohyrax arboreus* Smith, and the giant rat *Cricetomys gambianus* Waterhouse, which are the known reservoirs for *L. aethiopica*<sup>36,39,40</sup>. *Phlebotomus aculeatus* was recently more incriminated as the vector of *L. tropica* in the sparsely inhabited volcanic Utut Reserve that lies approximately 5 km south of Lake Elementaita (36° 15' E, 0° 30' S; 2000 m above the sea level). This area is extremely rocky with numerous cracks and crevices. It also supports an abundant population of *P. johnstoni*<sup>18</sup>. It was previously thought to be confined only in the caves on the western slopes of Mt Elgon (2100 to 2500 m asl).

Among the members of this subgenus, *P. longipes* and *P. pedifer* are closely related<sup>41</sup> with the former having been

incriminated as the vector of *L. aethiopica* in Ethiopia<sup>41</sup>. The distribution of *P. pedifer* fits well with the distribution of *L. aethiopica* in Kenya. Apart from *P. aculeatus* from which *L. tropica* has been isolated in only a few female sandflies<sup>18</sup>, the other confirmed vector for this parasite is *P. guggisbergi*<sup>17</sup> in Muruku sub-location in Laikipia district, Rift Valley province, 225 km NW of Nairobi, at approximately 2000 m asl. It is mainly found in the caves. This area supports an abundant population of the hyrax, *Pr. capensis* Pallas<sup>18</sup>. *Phlebotomus guggisbergi* is also found in Karura forest caves in Nairobi.

### Subgenus *Paraphlebotomus* Theodor

In other parts of the world, this subgenus is known to have sandflies that are able to transmit *L. tropica* and *L. major*. In Kenya, this subgenus is represented by *P. saevus* Parrot & Martin and a recently identified sandfly, *P. mireillae* Killick-Kendrick, Tang, Johnson, Ngumbi & Robert<sup>42</sup>. The location of *P. mireillae* is Utut Reserve, near Gilgil, Nakuru county. These two species have similar characteristics and can easily be confused with one another. *Leishmania* parasites have not been isolated from these two species in Kenya. Their role in the epidemiology of leishmaniasis in Kenya is still unclear. These two species are mainly found in the Rift Valley province.

### Subgenus *Anaphlebotomus* Theodor

The only species in this subgenus that has been identified in Kenya is *P. rodhaini* Parrot, in Machakos county, Eastern Province<sup>43</sup>. It is a rainy season species. The role played by this species in the epidemiology of the leishmaniasis is as yet unclear. No parasite had been isolated from a number of these sandflies that were trapped in Masinga county (Anjili, unpublished data). It rests and probably breeds in the Bissel type termite mounds. Females can be easily identified because they have smooth-walled non-segmented spermathecae with long highly convoluted ducts. The paramere of the male is forked and resembles with *P. longiductus* found in the Kazakh area of the former Soviet Union where it transmits *L. infantum*<sup>44</sup>. The bionomics of this sandfly is poorly known. Continuous trapping and dissections and blood meal analysis studies could shed light on its feeding preferences and the type of parasite can support. The distribution of sandflies of the genus *Phlebotomus* is shown in Table 1.

### The genus *Sergentomyia* Franca & Parrot

Females of the genus *Sergentomyia* usually have

armatures and a pigment patch in the ciborium. The abdominal tergites always have recumbent hair. Pleural setae may or may not be present.

### Subgenus *Sergentomyia* Franca & Parrot

Sandflies in this subgenus have erect setae at the caudal part of the first dorsal tergite that are uniformly recumbent. Exceptions are females of *Sergentomyia ingrami* Newstead, *S. edwini* Minter and *S. harveyi* Heisch, Guggisberg & Teesdale<sup>6</sup>. All the females have tubular spermathecae with walls of uniform width. Antennal segment 3 is shorter than segments 4 and 5. Male styles have four spines, 2 terminal and 2 subterminal and with a short stout aedagus<sup>45</sup>.

Despite the fact that *Sergentomyia* species are not known to transmit mammalian *Leishmania*, *S. kitonyii* Minter that was trapped in Masinga location, Machakos district<sup>46</sup>, and *S. schwetzi* Adler, Theodor & Parrot<sup>2,3</sup> that were trapped in Marigat location, Baringo district were found to harbour parasites that were typed as *L. donovani*. In both foci, *Sergentomyia* species that are infected with both mammalian flagellates and reptilian *Sauroleishmania* Ranque are very common, suggesting that these sandflies feed on both mammals and reptiles<sup>47</sup>. Blood meal analysis studies using sandflies trapped in Marigat, Baringo district showed that *S. schwetzi* also bites man, cow, goat and rabbit; *S. antennata* Newstead was shown to bite man and lizards<sup>6,27</sup>. It has been reported that mixed feeding on different hosts is likely to result when a sandfly is interrupted before it fully engorges, or when it discovers that the animal it had bitten is not its favoured host<sup>48</sup>. This could be the case with *Sergentomyia* species. It could also be that some of them are catholic feeders, since *S. antennata* has always been regarded as primarily a reptile feeding species<sup>49,50</sup>. Other sandflies that belong to this subgenus are listed in Table 1.

### Subgenus *Parvidens* Theodor & Mesghali

In this subgenus, the 2 species that have been recorded in Kenya are *S. heischii* Kirk & Lewis in Wajir county<sup>51</sup>, and *S. leslayae* Lewis & Kirk near Sericho, in Isiolo county<sup>5</sup> both in north-eastern Kenya. This is a rare sandfly whose bionomics is poorly known. It is only found in the semi-arid northern area. The main distinctive feature of females of this sandfly is that these have spermathecae in the form of a thin-walled tube. Other features are the presence of 2 ascoids on the third antennal segment. The female ciborium has lateral longitudinal and irregular rows of teeth. Males in this species unlike

other *Sergentomyia* have a style with five spines<sup>52</sup>. The other sandfly species that has been recorded in this subgenus in Kenya is *S. thomsoni* Theodor. This sandfly

was trapped in the Utut reserve<sup>18</sup>. Since only a few sandflies were caught and only at one site in Kenya, it appears like it has a limited distribution. The main dis-

Table 1. The distribution of phlebotomine sandflies in Kenya by provinces

Genus	Subgenus	Species or subspecies	Distribution (Province)
<i>Phlebotomus</i>	<i>Phlebotomus</i>	<i>P. dubosqi</i> Neveu-Lemaire 1906	Rift Valley
		<i>Paraphlebotomus</i>	<i>P. saevus</i> Parrot & Martin 1939
	<i>P. mireillae</i> Killick-Kendrick, Tang, Johnson, Ngumbi Robert 1997		R. Valley, Eastern
	<i>Synphlebotomus</i>	<i>P. martini</i> Parrot 1936	Eastern
		<i>P. celiae</i> Minter 1962	Eastern
	<i>Larroussius</i>	<i>P. vansomerena</i> Heisch, Guggisberg & Teesdale 1956	Eastern, R. Valley
		<i>P. aculeatus</i> Lewis, Minter & Ashford	R. Valley, Nairobi
		<i>P. guggisbergi</i> Kirk & Lewis 1952	R. Valley, N. Eastern
		<i>P. pedifer</i> Lewis, Mutinga & Ashford Lewis 1972	Western, Eastern
		<i>P. orientalis</i> Parrot 1936	Ubiquitous
	<i>Anaphlebotomus</i>	<i>P. longipes</i> Parrot & Martin 1939	Ubiquitous
		<i>P. elgonensis</i> Ngoka, Madel & Mutinga 1975	Ubiquitous, Coast
	<i>Sergentomyia</i>	<i>Sergentomyia</i>	<i>P. rodhaini</i> Parrot 1930
<i>S. schwetzi</i> Adler, Theodor & Parrot 1929			Eastern
<i>S. antennata</i> Newstead 1912			Coast
<i>S. bedfordi</i> Newstead 1914			Coast
<i>S. yusafi</i> Sinton 1930			Eastern
<i>S. teesdalei</i> Minter 1963			Eastern
<i>S. multidentis</i> Heisch, Guggisberg & Teesdale 1956			Eastern
<i>S. blossi</i> Kirk & Lewis 1952			Eastern
<i>S. rosannae</i> Heisch, Guggisberg & Teesdale 1956			Eastern
<i>S. durenii</i> Parrot 1934			Eastern
<i>S. decipiens</i> Theodor 1931			Eastern
<i>S. ingrami</i> Newstead 1912			Eastern
<i>S. serrata</i> Parrot & Malbrant 1945			N. Eastern, Coast
<i>S. kirki</i> Parrot 1948			Eastern
<i>S. kitonyii</i> Minter 1963			Eastern
<i>S. gracilis</i> Kirk & Lewis 1952		Eastern	
<i>S. christophersi</i> Sinton 1927		Coast	
<i>S. clastrieri</i> Abonnenc 1964		Eastern	
<i>Sintonius</i>		<i>S. harveyi</i> Heisch, Guggisberg & Teesdale 1956	R. Valley, Eastern
		<i>S. garnharmi</i> Heisch, Guggisberg & Teesdale 1956	Coast, R. Valley, Eastern
		<i>S. freetownensis</i> Meillon & Lavoipierre 1932	R. Valley, Eastern
<i>Grassomyia</i>		<i>S. edwini</i> Minter 1963	Ubiquitous
		<i>S. affinis</i> Theodor 1933	Eastern, Coast
		<i>S. caffrarius</i> Meillon & Lavoipierre 1944	R. Valley, Eastern
		<i>S. meilloni</i> Sinton 1932	Eastern, R. Valley
		<i>S. adami</i> Abonnenc 1960	R. Valley, Eastern
<i>Parvidens</i>		<i>S. adleri</i> Theodor 1933	R. Valley, Eastern
		<i>S. graingeri</i> Heisch, Guggisberg & Teesdale 1956	Eastern, R. Valley
		<i>S. suberecta</i> Sinton 1932	Coast
		<i>S. clydei</i> Sinton 1928	Ubiquitous
		<i>S. squamipleuris</i> Newstead 1912	Ubiquitous
		<i>S. inermis</i> Theodor 1938	Ubiquitous
		<i>S. africana</i> Newstead 1912	Ubiquitous
	<i>S. heischi</i> Kirk & Lewis 1950	Eastern	
<i>S. leslayae</i> Kirk & Lewis 1950	North-eastern		
<i>S. thomsoni</i> Theodor 1938	R. Valley		

Keys for the identification of all the listed sandflies apart from *P. mireillae* can be found in an identification manual by Abonnenc & Minter<sup>45</sup>.



tinguishing feature is that the ciborium in the female usually has 55–70 narrow parallel teeth in a palisade<sup>45</sup>. Its biology is poorly known.

### Subgenus *Sintonius* Nitzulescu

Females of sandflies in this subgenus have segmented spermathecae with the segments being symmetrical and almost equal in size. Males have a short sharp aedagus as can be seen in species such as *S. adleri* Theodor and *S. adami* Abonnenc<sup>45</sup>. Most of the sandflies in this subgenus are closely associated with termite mounds in semi-arid areas of eastern, north-eastern and Rift Valley provinces<sup>6,10,11,50,53</sup>. A summary of the species found in Kenya and their distribution is shown in Table 1. Like other *Sergentomyia*, they have been shown to feed mainly on reptiles, but *S. adleri* has also been shown to bite man and the porcupine, *Hystrix cristata* L<sup>27</sup>.

### Subgenus *Grassomyia* Theodor

In this subgenus, female spermathecae are round or globular sclerotized capsules with annular rings with small pleural setae as in *S. squamipleuris* Newstead. Ciboria have armatures in a distinct convex row of teeth. The third antennal segment lacks ascoids. Males have styles with 4 spines. Other species are listed in Table 1. A total of 8 species, particularly *S. squamipleuris*, *S. clydei* Sinton, *S. inermis* Theodor, *S. suberecta* Sinton, *S. affinis* Theodor, *S. adleri* Theodor, *S. graingeri* Heish, Guggisberg & Teesdale and *S. meilloni* Sinton have been reported in Kenya<sup>52</sup>.

### General observations on the biology of Kenyan sandflies in the field and in captivity

Most Kenyan phlebotomine sandflies are crepuscular and nocturnal in their activities. However, some species may bite during the day<sup>54</sup>. Activities of the sandflies are controlled by climatic conditions such as rainfall, humidity, speed of wind in addition to their physiological state. Rainfall appears to have important effects on the breeding, conducive larva survival, availability of larval food due to high humidity, distribution and local abundance of sandflies, with some species having a wide distribution and being found throughout the year (perennial species). The commonest perennial species in Kenya are *Sergentomyia* species<sup>6,8,43</sup>. These species are able to tolerate a wide range of conditions compared to the rainy season species which can only be caught following the onset of rains. The presence of perennial and rainy season

species is thought to reflect a fundamental difference in sandfly physiology and ecology. Perennial species are usually small in size (with an exception of *P. duboscqi*) as adults and tolerate dry conditions relatively well which enables them to have an extensive geographical distribution. They therefore have an apparently rather low reproductive rate since large populations are seldom found<sup>44</sup>. Some of the sandflies that have been identified as perennial species are : *P. martini*, *P. celiae*, *P. vansomerena*, *P. duboscqi*, *S. affinis*, *S. graingeri*, *S. schwetzi*, *S. antennata* and *S. squamipleuris*<sup>6,43</sup>. Some of the rainy season species that have been identified are *S. kirki*, *S. harveyi*, *S. multidens*, *S. rosannae*, *S. garnharmi* and *S. adami*<sup>6,8,13</sup>. These sandflies are usually robust with a high reproductive capacity following the onset of rain and disappear rapidly when dry conditions appear<sup>43</sup>. Some sandfly species, e.g. *S. clydei* collected from the arid and semi-arid regions of northern Kenya were found to diapause in the laboratory (Personal observation). This is an adaptation to the harsh climatic conditions experienced in the northern arid regions of Kenya during the dry months in the year.

Some of the *Phlebotomus* species which have been incriminated as vectors of either visceral or cutaneous leishmaniasis are: *P. martini* (visceral leishmaniasis), which lives predominantly in termite mounds<sup>16,23</sup>; *P. duboscqi* (cutaneous leishmaniasis), which lives in the animal burrows<sup>22</sup>; *P. guggisbergi* (cutaneous leishmaniasis) which lives in the caves<sup>17</sup>; *P. aculeatus* (cutaneous leishmaniasis) and lives in the caves and rock crevices<sup>18</sup> and *P. pedifer* which lives in the caves, transmits cutaneous leishmaniasis<sup>55</sup>. Laboratory experiments on transmission of *Leishmania* parasites by sandfly vectors have been carried out and showed that they can infect clean animals with their infective bites<sup>56</sup>.

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