The sandflies of Egypt (Diptera: Phlebotominae)

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Synopsis

The medical importance of, and previous studies on, the sandflies of Egypt are reviewed. Phlebotomine sandflies transmit phlebotomus fever (= sandfly fever) and two forms of leishmaniasis to man in Egypt. The number of species known from Egypt is increased from seven to 21 (8 *Phlebotomus*, 13 *Sergentomyia*). Following an identification key, a diagnosis is given for each species together with a discussion of taxonomic and biological data, including vector status. The Egyptian sandfly fauna is composed of three faunal elements, one clearly Palaearctic, the others Afrotropical but having particular affinity to the sandflies of the Arabian peninsula.

Introduction

The study of the phlebotomine sandflies of Egypt, including the Sinai peninsula, is important for two reasons: these flies act as vectors of pathogenic organisms there (phlebotomus fever virus and two species of *Leishmania*) and secondly, the area in which they occur is an important interface between the Palaearctic and Afrotropical zoogeographic regions. In a review of leishmaniasis in the eastern Mediterranean, Zahar (1980: 11) commented on the dearth of knowledge of Egyptian sandflies and recommended that a 'thorough revision of the sandfly fauna' should be made.

The principal objective of this paper is to provide descriptions and keys to the sandflies of Egypt and indicate established or potential vectors of disease, thus facilitating future studies on their biology and assessment of their medical importance in the area. The biogeographical relationships of the fauna are discussed in relation to other parts of the Middle East and Africa. Before dealing with the taxonomy of the phlebotomines, a review of the pertinent literature is made. This is divided into the medical importance of phlebotomines and previous taxonomic studies.

Medical importance of sandflies in Egypt

In Egypt phlebotomine sandflies are important as vectors of phlebotomus fever virus and two species of *Leishmania*: *Le. major* and *Le. donovani*, the causative agents of cutaneous and visceral leishmaniasis respectively.

Phlebotomus fever (sandfly fever) is a systemic and well-studied febrile disease of man and is

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endemic in many parts of Egypt (Schmidt *et al.*, 1971; Darwish & Hoogstraal, 1981; Taylor, 1958). *Phlebotomus papatasi* was incriminated as the vector in Egypt by Schmidt *et al.* (1960) who isolated the virus from flies collected in human dwellings in suburban Cairo. Phlebotomines may also be vectors of another viral fever, Rift Valley Fever. RVF is an arthropod-borne disease which usually attacks domestic ungulates but, more importantly, has caused considerable human disease and mortality in two recent outbreaks in Egypt (Meegan, 1979; Hoogstraal *et al.*, 1979). The vector of RVF virus has not been discovered yet, although mosquitoes are thought to be the most likely, particularly *Culex pipiens* (Meegan *et al.*, 1980). However, authors regularly state that *Phlebotomus* species should still be examined as potential vectors in view of their abundance and distribution throughout the affected areas. This cautious view is supported by Hoch & Bailey's (1983) findings that five out of 34 attempts to transmit mechanically RVF virus to hampsters by using sandflies (*Lutzomyia longipalpis*) were successful.

Until recently, neither cutaneous nor visceral leishmaniasis was considered common in Egypt as they were only known from occasional cases diagnosed clinically. Cutaneous leishmaniasis had been recorded by Khalil (1934), Halawani (1940) and Cahill *et al.* (1966) who found an area where *Le. tropica* is endemic in the Hihya district of Sharqiya Governate. Cahill (1965) also made a leishmanin skin test survey in various villages of the Nile Delta and found that most positive cases were either in Sharqiya Governate or originated there. In a sample of 612 patients in the Faquus area of the governate, 17% of those tested were positive (i.e. had been challenged by *Leishmania*) with an equal sex distribution. However, recent studies by Soliman & Abo-Shady (1981), Morsy *et al.* (1982) and Rifaat *et al.* (1983*a*, 1983*b*) have shown cutaneous leishmaniasis to be more widespread and common than previously thought. The sandfly *P. papatasi* is a common peridomestic species throughout Lower Egypt and is probably the vector of *Le. major* there as it is in neighbouring Israel (Schlein *et al.*, 1982, 1984; Adler & Theodor, 1925). Furthermore, *P. papatasi* was the only *Phlebotomus* species caught in a survey in Sinai (30° 50′N, 34° 20′E) where cutaneous leishmaniasis is common amongst members of the Multinational Peacekeeping Forces. *P. papatasi* is probably the vector there also as this area of Sinai is a very similar habitat to that described by Schlein *et al.* (1984) who are working in the Negev and central Arava regions of Israel, which are contiguous with northern Sinai. Some cases of cutaneous leishmaniasis have recently been recorded formally from southern Sinai (Bassili *et al.*, 1983), but it is undoubtedly more prevalent there as numerous cases are known from central Sinai (J. Zimmerman, pers. comm.) and along the coast of the Red Sea and Gulf of Aqaba of Saudi Arabia (R. Cross, pers. comm.). In southern Sinai several vector species other than *P. papatasi* have been found (see below). To date, there have not been any isolations of *Leishmania* from wild-caught sandflies in Egypt and therefore any suggestion that a species is a vector must be speculative, although the circumstantial evidence for *P. papatasi* is considerable.

Until recently, the only autochthonous cases of visceral leishmaniasis recorded from Egypt were those of Phillips (1904), who found that 32% of patients with splenomegaly in a Cairo hospital had *Leishmania* bodies detected in smears following spleenic puncture. The case described by Hassan (1968*b*) was thought to be imported from Saudi Arabia. Cahill (1968) reports that no visceral infections were found in an extension of his earlier leishmanin survey (Cahill, 1965) to different ecological zones of Egypt. Rifaat *et al.* (1968) examined potential reservoirs (443 dogs and 324 rodents) and 'vectors' (*P. papatasi* and *P. sergenti*) of visceral leishmaniasis in 13 'indicator areas' of Egypt but did not find any infected with *Leishmania*. However, Morsy *et al.* (1982) found that 21·3% of *Rattus norvegicus* and 12% of *R. rattus* reacted positively in serological tests for *Leishmania* in Ismailiya Governate. Subsequently, smears from only one *R. norvegicus* and four *R. rattus* were found to have *Leishmania* bodies, but this was sufficient evidence to consider the rats to be reservoirs of the disease. Recently, Tewfik *et al.* (1983) detected a case of infantile visceral leishmaniasis from Al Agamy, near Alexandria. Subsequently, 20 patients have been detected (to June 1984) and the parasite identified as *Le. donovani donovani* (Mansour *et al.*, 1984). Al Agamy is an area of new housing development on a narrow limestone strip between the Mediterranean and a large brackish lake. There is very little vegetation around the patients' houses other than small fig orchards. Intensive sandfly collecting in and around houses produced only two species of *Phlebotomus*:

P. papatasi and *P. langeroni* (J. Beier, H. Kassem and B. Sawaf, pers. comm.). Sawaf *et al.* (1984) have suggested that *P. langeroni* is the most likely vector species, for two reasons: it is a close relative of *P. orientalis* Parrot, a well-established vector of visceral leishmaniasis in Sudan, and *P. papatasi* is the only other *Phlebotomus* species present and is known to be a poor vector of *Le. donovani* (Lewis & Ward, in press). The unlikely possibility remains that the vector is neither of these species but another, such as *P. tobbi* Adler & Theodor, living well away from human dwellings.

Previous studies of Egyptian sandflies

Previous studies of the sandfly fauna of Egypt have been fragmentary, and the Sinai and upper Egypt have not been studied at all. Willcocks (1917) recorded the ubiquitous vector species *P. papatasi* from lower Egypt and in 1948 Theodor recorded another anthropophilic species, *P. sergenti*, from metropolitan Cairo. Khalil (1934) reported *Sergentomyia squamipleuris* from Sharkiya Governate during a leishmaniasis study. Zein el Dine (1972) made the first attempt at a phlebotomine survey in Egypt, concentrating on the Bahariya, Kharga and Dakhla oases, but only found *P. papatasi* and *S. palestinensis*. She also reports the collection of *S. minuta*, a common Mediterranean species, by Eflatoon in 1922. During a survey to find visceral leishmaniasis vectors, Rifaat *et al.* (1968) added *S. tiberiadis* to the faunal list. Recently, *P. langeroni* has been discovered at Al Agamy, a focus of visceral leishmaniasis near Alexandria (Sawaf *et al.*, 1984), bringing the known sandfly fauna to seven species: three *Phlebotomus* and four *Sergentomyia*. Based on recent collecting and material in the British Museum (Natural History), the present study increases this to 21 species: eight *Phlebotomus* and 13 *Sergentomyia*. No comprehensive taxonomic work exists facilitating the identification of these species.

Materials and methods

Specimens for this study of Egyptian sandflies came from several sources and were collected by a variety of methods. Details of the methods used by early collectors such as Omer-Cooper, who collected in Siwa Oasis in 1909, are not available. However, the methods of recent collectors who submitted material for identification are available. Rifaat (Cairo) and Braverman (Israel) both used CDC light-traps (with incandescent, not fluorescent, bulbs) in epidemiological surveys, the first in a visceral leishmaniasis survey, the second during a search for Rift Valley Fever vectors. The author's collections were made with sticky traps, with a small lightweight chemical light-trap, and by aspirating from walls and inside animal houses.

With the exception of the *P. sergenti* material collected by Theodor and mounted in Balsam, all specimens were mounted in Berlese medium. The head was removed from the body and mounted ventral side uppermost in a thin film of medium, thus allowing examination at high magnification. The body was mounted laterally under a separate coverglass. It was necessary to remount many female specimens to show the spermathecae which were usually obscured by developing ova or fat-body. The specimens were immersed in a 1% detergent solution for up to 24hrs to remove fat; ova, if present, were dissected out.

Abbreviations

DEPOSITORIES

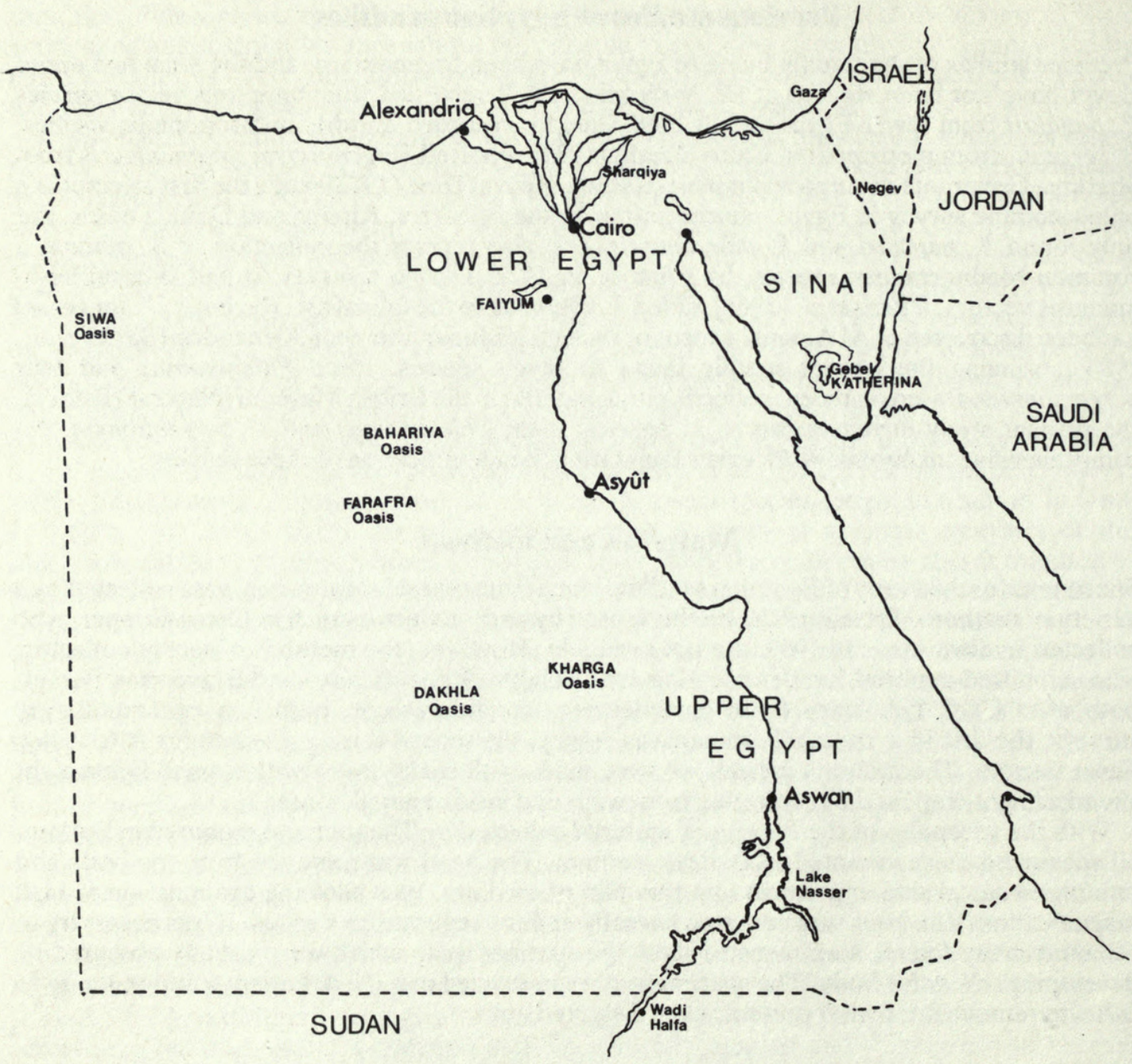
BMNH	British Museum (Natural History), London, U.K.
FM	Laboratoire de Parasitologie, Faculté de Médicine, Paris, France.
IPA	Institut Pasteur, Algiers, Algeria.
IPH	Institute of Public Health, Teheran, Iran.
MI	Institute of Tropical Medicine and Parasitology, Moscow, U.S.S.R.
U,Pavia	University of Pavia, Italy.

NAMES OF COLLECTORS MENTIONED

K.Z.D.	K. Zein el Dine
M.A.R.	M. A. Rifaat
R.P.L.	R. P. Lane
Z.A.H.	Z. A. Hassan
Y.B.	Y. Braverman

VARIOUS

A3, A4 etc.	Antennal segment 3, 4, etc.
Le.	*Leishmania*



Map 1 The principal towns, oases and areas mentioned in the text.

Composition and distribution of the sandfly fauna in Egypt

	LOWER EGYPT	UPPER EGYPT	SOUTHERN SINAI
Phlebotomus alexandri Sinton	–	–	*
P. arabicus Theodor	–	–	*
P. kazeruni Theodor & Mesghali	–	–	*
P. langeroni Nitzulescu	*	–	–

	Lower Egypt	Upper Egypt	Southern Sinai
P. major Annandale 'Sinai form'	–	–	*
P. orientalis Parrot	–	–	*
P. papatasi (Scopoli)	*	*	–
P. sergenti Parrot	*	–	*
Sergentomyia adleri (Theodor)	–	–	*
S. antennata (Newstead)	*	–	–
S. christophersi (Sinton)	–	*	–
S. cincta (Parrot & Martin)	*	–	–
S. clydei (Sinton)	–	–	*
S. fallax (Parrot)	–	–	*
S. minuta (Rondani)	?	–	–
S. palestinensis (Adler & Theodor)	–	*	*
S. schwetzi (Adler, Theodor & Parrot)	–	*	*
S. squamipleuris (Newstead)	*	*	–
S. taizi Lewis	–	–	*
S. theodori (Parrot)	*	–	–
S. tiberiadis (Adler, Theodor & Lourie)	–	*	–

* denotes presence of a species.

Key to the species of Phlebotominae in Egypt

1 Female without cibarial armature or pigment patch; male with four or five spines on style; all abdominal sclerites with erect hairs (***PHLEBOTOMUS***) 2

– Female with cibarial armature and pigment patch present; male with four spines on style; abdominal sclerites with recumbent hairs only, except in subgenus *Sintonius* (***SERGENTOMYIA***) 16

2 Males 3

– Females 9

3 Style with five short tooth-like spines (Fig. 39), surstyle with spines apically, paramere with three lobes.
Small basal tubercle on coxite with non-deciduous hairs ..... ***papatasi*** (p. 15)

– Style with five long spines, surstyle without spines apically, paramere simple 4

4 Coxite with basal lobe bearing long hairs 5

– Coxite without basal lobe 7

5 A3 short and thick (Fig. 8). Plunger of sperm pump not much wider than barrel (Fig. 11), barrel not much longer than wide. Basal coxite tuft short and broad (Fig. 10) ..... ***alexandri*** (p. 9)

– A3 long (Fig. 41). Plunger of sperm pump wider than barrel, barrel longer than wide (Fig. 43). Basal coxite tuft long and slender (Fig. 17) 6

6 Style less than half length of coxite, mesonotum pale ..... ***sergenti*** (p. 17)

– Style about half length of coxite, mesonotum dark ..... ***kazeruni*** (p. 9)

7 Aedeagus with keel just before tip (Fig. 6); coxite with hair group of more than 30 hairs; sperm ducts with transverse ridges, more than eight times pump length ..... ***arabicus*** (p. 7)

– Aedeagus smooth to tip; hair group less than 20 hairs; sperm ducts smooth, less than 5 times pump length 8

8 Two ascoids on antennal segments 8–12 ..... ***langeroni*** (p. 11)

– One ascoid on antennal segments 8–12 ..... ***orientalis*** (p. 13)

9 Spermathecae with single segmented capsule.
Pharynx narrow, with scale-like armature, posterior margins of hind scales minutely serrated (Fig. 15) ..... ***kazeruni*** (p. 9)

– Spermathecae either indistinctly (Fig. 5) or distinctly segmented (Fig. 34) 10

10 Spermathecae indistinctly segmented (Fig. 5) ..... ***arabicus*** (p. 7)

– Spermathecae distinctly segmented 11

11 Pharyngeal armature composed of broad scale-like teeth (Fig. 7) 12

– Pharyngeal armature composed of rows of minute teeth or ridges (Fig. 38) 13

12 Pharynx triangular, lateral and posterior margins straight (Fig. 7); ascoids on A3 and A4 short and stout (Fig. 8); combined length of A3+A4 shorter than labrum ..... ***alexandri*** (p. 9)

– Pharynx indented posteriorly (Fig. 40); ascoids on A3 and A4 long and slender, almost reaching end of segment (Figs 41, 42); combined length of A3+A4 longer than labrum ***sergenti*** (p. 17)

13 Pharyngeal armature extending to half length of pharynx (Fig. 32) ..... ***major*** 'Sinai form' (p. 12)

– Pharyngeal armature not extending beyond posterior third of pharynx 14

14 Spermathecae with segments subequal, apical segment short (Fig. 37) ..... ***papatasi*** (p. 15)

– Spermathecae with segments unequal in size, middle segments larger than others, apical segment long (Fig. 26) 15

15 Ascoids on A4 more than 0·5 length of segment (Fig. 20)..... ***langeroni*** (p. 11)

– Ascoids on A4 less than 0·4 length of segment (Figs 21, 22) ..... ***orientalis*** (p. 13)

16 Males 17

– Females 28

17 Aedeagus finger-shaped, with blunt rounded tip (Fig. 67)..... 18

– Aedeagus with straight tapering sides, pointed (Figs 53, 64)..... 23

18 Aedeagus curved downwards towards surstyle (Fig. 67)..... 19

– Aedeagus straight or curved upwards 21

19 Style with two apical and two subapical spines (Fig. 64).
Cibarial teeth irregular, outer teeth only slightly larger than central teeth, pharyngeal armature a series of fine transverse ridges ..... ***schwetzi*** (p. 23)

– Style with all spines apical..... 20

20 Outer cibarial teeth scale-like, very much larger than central teeth ..... ***taizi*** (p. 25)

– All cibarial teeth small, outer teeth same size as central teeth.
Aedeagus tapering ..... ***minuta*** (p. 21)

21 Cibarium with 18–22 teeth, the central teeth distinctly smaller than lateral teeth .... ***theodori*** (p. 25)

– Cibarium with 16–18 subequal teeth..... 22

22 Style slender, five to seven times as long as wide (Fig. 58), accessory seta on style close to apical spines ..... ***fallax*** (p. 21)

– Style stout, four times as long as wide (Fig. 57), accessory seta at about 0·75 style length ***antennata*** (p. 19) and ***cincta*** (p. 20)

23 Aedeagus truncated (Fig. 64), style with two subterminal and two terminal spines.
Cibarium with straight row of 12 teeth ..... ***palestinensis*** (p. 23)

– Aedeagus tapering to pointed tip, all spines on style terminal 24

24 Cibarium with small process in front of teeth, mesanepimeron with setal sockets; aedeagus short and gently tapering..... ***squamipleuris*** (p. 25)

– Cibarium without any processes, mesanepimeron without setal sockets, aedeagus otherwise.... 25

25 Cibarium with convex row of uneven-sized, curved horizontal teeth (Fig. 75)..... ***tiberiadis*** (p. 26)

– Cibarium with straight horizontal teeth..... 26

26 Cibarium with 3–4 horizontal teeth (Fig. 51), large cornua..... ***christophersi*** (p. 19)

– Cibarium with 16–26 fine horizontal teeth, cornua small (not wider than long)..... 27

27 Cibarium with a single row of vertical teeth, horizontal teeth usually small and in groups ***clydei*** (p. 20)

– Cibarium with two or three rows of vertical teeth, horizontal teeth usually well developed ***adleri*** (p. 17)

28 Spermatheca clearly segmented (Fig. 52), ducts long and narrow. Abdominal tergites 2–6 with large setal sockets (erect hair sockets) 29

– Spermathecae not segmented but sometimes indistinctly striated, ducts not long and narrow. Abdominal tergites 2–6 without large setal sockets (recumbent hair sockets) 32

29 Cibarium with 4–5 long slender widely spaced horizontal teeth (Fig. 49) (numerous spicules may also be present)..... ***christophersi*** (p. 19)

– Cibarium with 12–14 closely packed horizontal teeth..... 30

30 Cibarium with strong, curved horizontal teeth, those at sides longer than central teeth (Fig. 78) ***tiberiadis*** (p. 26)

– Cibarium with straight, closely packed horizontal teeth 31

31 Cibarium with 40–80 vertical teeth in 3–5 rows, more than 20 horizontal teeth (Fig. 48) ***adleri*** (p. 17)

– Cibarium with 12–30 vertical teeth in one or two rows, 12–13 horizontal teeth ..... ***clydei*** (p. 20)

32 Spermatheca with capsule covered in numerous small spicules, cibarial teeth in convex row (Fig. 69)..... ***squamipleuris*** (p. 25)

– Spermatheca smooth, without spicules, cibarial teeth in straight or concave row 33

33 Spermatheca with capsule (Fig. 62). Well-developed cibarial teeth in straight row (Fig. 61) ***palestinensis*** (p. 23)
– Spermatheca simple, tubular. Cibarial teeth not straight and palisade-like 34
34 Cibarium with 50–60 equal-sized, horizontal teeth in a comb-like row ..... ***minuta*** (p. 21)
– Horizontal cibarial teeth either unequal or row concave 35
35 Cibarium with central horizontal teeth at least half size of lateral horizontal teeth 36
– Cibarium with all horizontal teeth subequal, or lateral teeth only slightly larger than medial teeth 37
36 Cibarium with lateral horizontal teeth scale-like, very much larger than medial horizontal teeth ***taizi*** (p. 25)
– Cibarium with lateral horizontal teeth same shape as medial horizontal teeth ..... ***theodori*** (p. 25)
37 Pharynx narrowing posteriorly with transverse striations or vague scale-like patterns ***schwetzi*** (p. 23)
– Pharynx widening posteriorly with distinct teeth 38
38 Pharynx without distinct shoulder (Fig. 54), sides almost straight, hind margin straight without notch. Cibarium with 16–18 horizontal teeth (Fig. 55) ..... ***cincta*** (p. 20)
– Pharynx with distinct shoulder to give cordiform or funnel shape, hind margin with medial notch or depression. Cibarium with 16–26 horizontal teeth 39
39 Pharynx cordiform, hind pharyngeal teeth punctate, much smaller than anterior teeth (Fig. 59). Cibarium with 16–22 horizontal teeth, pigment patch usually rounded anteriorly (Fig. 60) ..... ***fallax*** (p. 21)
– Pharynx not cordiform, without notch in anterior margin. Pharyngeal teeth large, little difference in size between posterior and anterior teeth (Fig. 56). Cibarium with more than 22 horizontal teeth, pigment patch usually angular anteriorly ..... ***antennata*** (p. 19)

Review of species

Specimens were examined from many countries but, for brevity, only those from Egypt are listed. All type-specimens in the BMNH were examined.

Phlebotomus arabicus Theodor

(Figs 1–6)

Phlebotomus (Adlerius) chinensis arabicus Theodor, 1953: 120 [♂♀]. Lectotype ♂, YEMEN (BMNH), designated by Lewis & Buttiker (1982: 362).
Phlebotomus (Adlerius) arabicus Theodor; Artemiev, 1980: 1190. [Raised to species.]
Phlebotomus (Adlerius) davidi Artemiev, 1980: 1191 [♂♀]. Holotype ♂, YEMEN (MI). [Synonymised by Lewis & Büttiker, 1982: 362.]

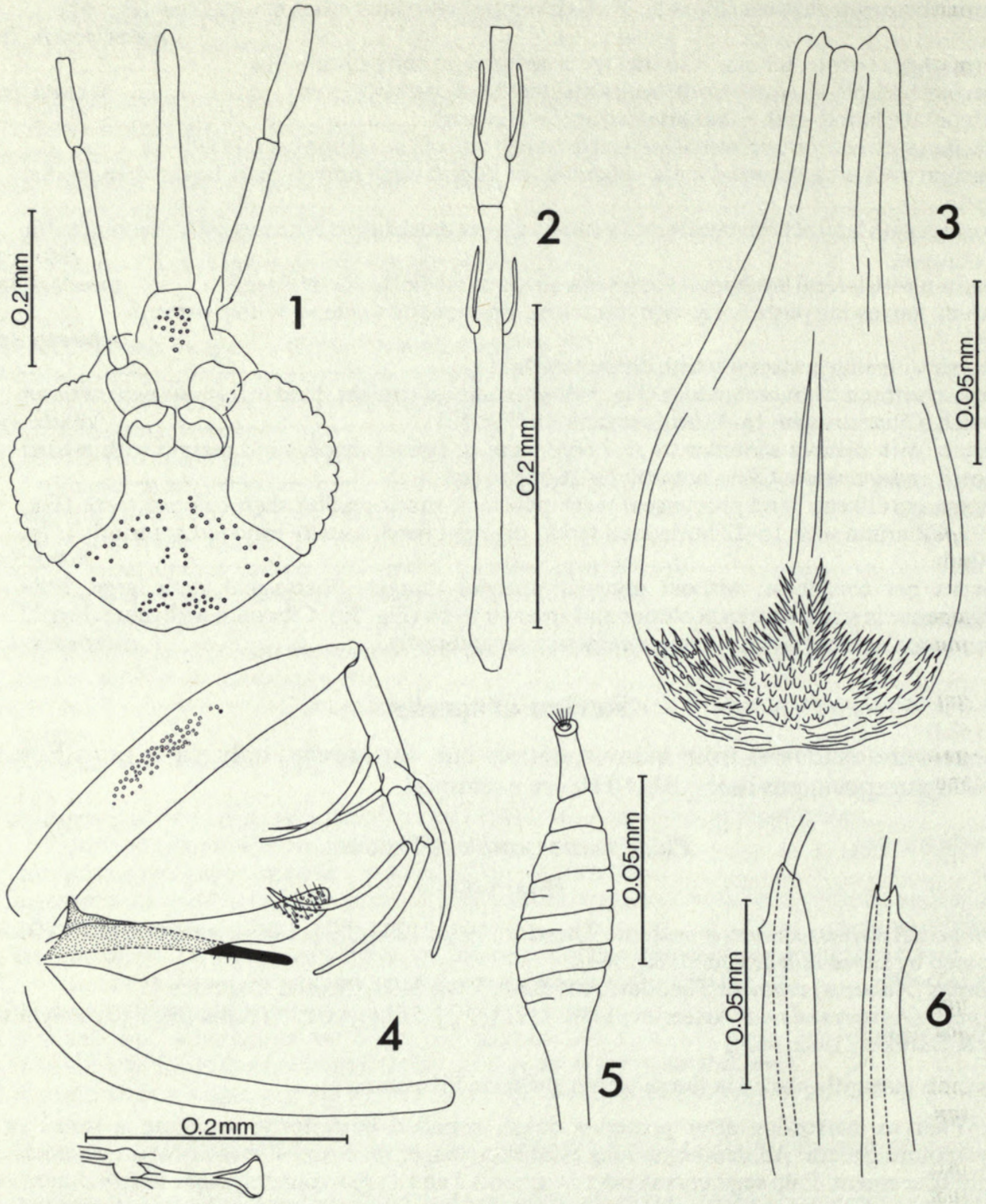
This species is currently placed in the subgenus *Adlerius* Nitzulescu.

FEMALE. Pharynx narrowing after posterior bulge, rounded posteriorly; armature a series of long backward-pointing teeth. A3 slender, as long as labrum, longer than A3+4. Ascoids short, slender, on A4 half length of segment. Palp segments slender, segments 2 and 3 approximately same length. Spermatheca delicate, elongated, ovoid and incompletely striated (Fig. 5) with small terminal knob and thick individual duct.
MALE. Wing length 2·29 mm (2·18–2·49 mm; n = 5). Pharynx slender; armature numerous small backward-pointing triangular teeth. Genitalia slender (Fig. 4). Aedeagus with pointed keel (Fig. 6). Style with two terminal spines, two on protuberance at 0·55 length style and one at 0·45 length style. Coxites with 58·4 (54–63, n = 4) hairs. Surstyles longer than coxites. Sperm ducts nines times length of pump.

MATERIAL EXAMINED
Egypt. Sinai: 3 ♂, 3 ♀, Mt Katherina, 15–16.vi.1979 (*Y.B.*); 3 ♂, 2 ♀, Tharfet el Qidren, 13–14.vi.1979 (*Y.B.*); 1 ♀, Upper Wadi Nasb, 14–15.vi.1979 (*Y.B.*); 1 ♀, Feiran, 12–13.vi.1979 (*Y.B.*).

DISTRIBUTION. Egypt, Ethiopia, Yemen, Saudi Arabia. This species has not previously been recorded from Egypt.

Lewis & Büttiker (1982) discussed the variation in this species and distinguished another taxon, *P.* 'Naqben sp.', from Naqben in northern Saudi Arabia, on four main features: darker thorax, larger size, higher number of coxite hairs (significantly different at $P<0{\cdot}001$) and relatively longer sperm ducts. They did not



Figs 1–6 *Phlebotomus arabicus*. 1, ♀, head; 2, ♀, antennal segments 3 and 4; 3, ♀, pharynx; 4, ♂, genitalia; 5, ♀, spermatheca; 6, ♂, tip of aedeagus. (Figs 1–3 and 5, 6 from southern Sinai; Fig. 4 Ethiopia, Langano.)

formally name this species because of the variation in this group and the lack of female specimens from Naqben. Naqben is in the Jebel Aja mountain system well to the north of the Asir mountains and Yemen, where most *P. arabicus* in the Arabian peninsula have been found, therefore the specimens of *P. arabicus* from Sinai might reasonably be expected to show closer affinity to 'Naqben sp.' than to Asir *P. arabicus*. Table 1 compares three of the four features which distinguish 'Naqben sp.' and *P. arabicus*. Pigmentation was not included because the Sinai specimens were collected into, and stored in, alcohol which tends to make them darker. In the features measured, the Sinai *arabicus* clearly show a greater similarity to typical *P. arabicus* (as well as the lectotype) than to 'Naqben sp.', suggesting that the latter is a distinct taxon and not simply a geographic variant of *P. arabicus*. Table 1 also demonstrates that 'Naqben sq.' is distinct from *P. arabicus* only in the number of coxite hairs and not in overall size and relative length of the sperm ducts.

Table 1 Comparison of *P. arabicus* and *P.* 'Naqben sp.'

	arabicus lectotype	*arabicus* S. Arabia Lewis & Büttiker (1982)	Sinai	'Naqben sp.'
wing length	2.43 mm	2.34 mm (2·21–2·47)	2.29 mm (2·18–2·49)	2.47 mm (2·31–2·67)
sperm ducts: pump	9·75	7·6	9	9·9
number of coxite hairs	57	51·5 (41–59)	58·4 54–63)	76·2 (54–98)

P. arabicus is a high-altitude species which Buttiker & Lewis (1984) found in association with *P. orientalis* and *S. taizi* in areas with cool or even cold winters.

The vectorial status of *P. arabicus* is unknown but, as several species of the subgenus *Adlerius* are vectors of visceral leishmaniasis in Asia, including the southern U.S.S.R. (*P. halepensis*; Sergiev, 1979: 208), Afghanistan (*P. longiductus*; Artemiev, 1978: 20) and the eastern Mediterranean (*P. simici*; Theodor, 1964: 480), *P. arabicus* should be investigated in any visceral leishmaniasis studies.

Phlebotomus alexandri Sinton

(Figs 7–14)

Phlebotomus sergenti var.; Newstead, 1920: 309 [♂].
Phlebotomus sergenti var. *alexandri* Sinton 1928*a*: 308 [♂]; Adler, Theodor & Lourie, 1930: 533 [♀].
Lectotype ♂, IRAQ (BMNH), designated by Lewis (1982: 143).
Phlebotomus alexandri Sinton; Perfil'ev, 1966: 72–74. [Raised to species.]

This species is currently placed in the subgenus *Paraphlebotomus* Theodor.

FEMALE. Head round (Fig. 9). Pharynx triangular with sides and posterior margin almost straight (Fig. 7); armature with large scale-like plates, each fringed anteriorly with long fine teeth. A3 much shorter than labrum (Fig. 9). Ascoids on A3 short and stout (Fig. 8). Spermatheca with 6–7 segments.
MALE. Pharynx narrow, not tapering after posterior bulge, posterior margin straight; armature a series of irregular transverse striations. A3 stout, very much shorter than labrum, A3+4 only slightly longer than labrum. Genitalia overall very short and thick; coxite lobe short and broad (Figs 11, 12). Sperm pump with barrel as long as or only slightly longer than wide; plunger narrower than barrel (Figs 13, 14). Surstyles as long as coxite.

MATERIAL EXAMINED
Egypt. Sinai: Wadi Sa'al, 4 ♂, 2 ♀, 15–16.x.1979; 1 ♂, 9–10.vi.1979; 1 ♀, 14–15.vi.1979 (*Y.B.*); 1 ♀, Feiran, 12–13.vi.1979 (*Y.B.*).

DISTRIBUTION. North Africa (including Egypt), Turkey, southern U.S.S.R., Israel, Ethiopia, Yemen, Saudi Arabia, Iraq, Iran, Kuwait, United Arab Emirates, Afghanistan, Pakistan. This species has not previously been recorded from Egypt.

P. alexandri is usually considered a highland species but it also occurs in suitable lowland areas (e.g. Kuwait: Lane & Al Taqi, 1983). It has been found naturally-infected with unidentified promastigotes in Turkmenia, where it is thought to be an important vector of cutaneous leishmaniasis (Dedet, 1979: 72; Petrishcheva, 1971: 573), and in Iran (Javadian *et al.*, 1977). It is a suspected vector of cutaneous leishmaniasis in several countries and Xiong *et al.* (1963) suggested that it may be involved in the transmission of visceral leishmaniasis in China.

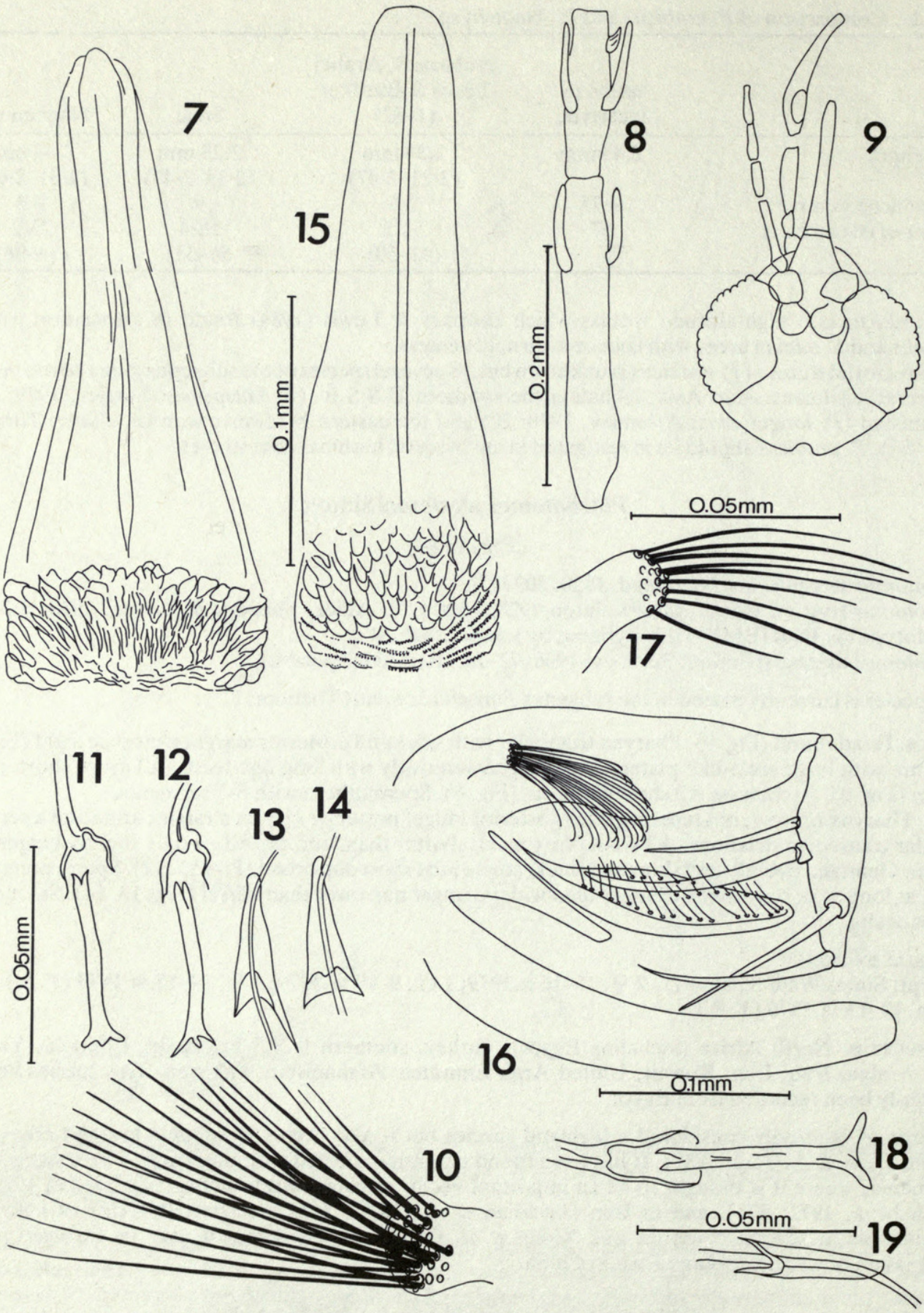
Phlebotomus kazeruni Theodor & Mesghali

(Figs 15–19)

Phlebotomus (Paraphlebotomus) kazeruni Theodor & Mesghali, 1964: 289, partim [♂ (♀ = *sergenti*)].
Holotype ♂, IRAN (IPH).

This species is currently placed in the subgenus *Paraphlebotomus*.

FEMALE. Pharynx slender with sides straight or slightly concave after posterior bulge (Fig. 15); hind margin



Figs 7–19 7–14, *Phlebotomus alexandri*. (7) ♀, pharynx; (8) ♀, antennal segments 3 and 4; (9) ♀, head; (10) ♂, basal process of coxite; (11, 12) ♂, sperm pump; (13, 14) ♂, aedeagus. (Figs 7–14 from Sinai, Wadi Sa'al.) 15–19, *P. kazeruni*. (15) ♀, pharynx; (16) ♂, genitalia; (17) ♂, basal process of coxite; (18) ♂, sperm pump; (19) ♂, aedeagus. (Fig. 15 from Saudi Arabia, Wadi Khumbra; Figs 16–19 Sinai, Mt Katherine.)

convex; armature extending to 0·25 pharynx length; a series of scales with those at anterior diagonal, becoming progressively transverse posteriorly; rows of minute teeth present on posterior scales; anterior margin of armature straight or slightly convex. A3 only slightly shorter than labrum, ascoid slender. Spermatheca a single capsule.

MALE. Pharynx narrowing after posterior bulge, convex posteriorly; armature a series of fringed scales. A3 longer than labrum. Parameres long and slender in lateral view, broad dorsally. Coxite lobe long and broad (Fig. 17). Style three and half times as long as wide. Barrel of sperm pump longer than wide, plunger at least as wide as barrel (Fig. 18). Surstyles longer than coxites.

MATERIAL EXAMINED

Egypt. Sinai: 2 ♂, St Katherina, 15–16.vi.1979 (*Y.B.*); 7 ♂, Tharfet el Qidren, 13–14.vi.1979 (*Y.B.*). Several females from various parts of southern Sinai may be this species or *P. sergenti*, but their spermathecae, the diagnostic character, are not visible.

DISTRIBUTION. Egypt, central Saudi Arabia, southern Iran, Afghanistan. This species has not previously been recorded from Egypt.

In Afghanistan, *kazeruni* occurs in low rocky deserts (Artemiev, 1978). In Saudi Arabia it is not peridomestic but is only found in remote wadis and hills, some very dry with sparse vegetation (Buttiker & Lewis, 1984). Lewis (1982) suggests that this species is sufficiently common in Saudi Arabia to transmit *Leishmania* among rodents.

Phlebotomus langeroni Nitzulescu

(Figs 20, 23–28)

Phlebotomus perniciosus var.; Nitzulescu, 1930*a*: 382 [♂].
Phlebotomus langeroni Nitzulescu, 1930*b*: 548 [♂]. Holotype ♂, TUNISIA (?FM).

This species is currently placed in the subgenus *Larroussius* Nitzulescu.

FEMALE. Pharynx not tapering after posterior bulge, posterior margin straight or slightly convex, armature extending 0·27 (0·24–0·29) length of pharynx and consisting of series of tightly packed irregular rows of minute denticles and lateral scales without teeth. A3 slightly shorter than labrum (0·90). Ascoids on A4 more than 0·50 length of segment (Fig. 20). Spermatheca with 10–11 segments, neck long, over half length of spermathecal body, individual ducts with transverse striations (Fig. 26).

MALE. Pharynx slender, parallel-sided after posterior bulge, armature a series of transverse ridges of minute teeth. Antennal segments 3–12 with two ascoids. Aedeagus slender with ventral subapical opening (Fig. 25). Parameres finger-like. Surstyles longer than coxites. Coxites slender, 5·42 (5·25–5·58) times longer than wide (Fig. 24).

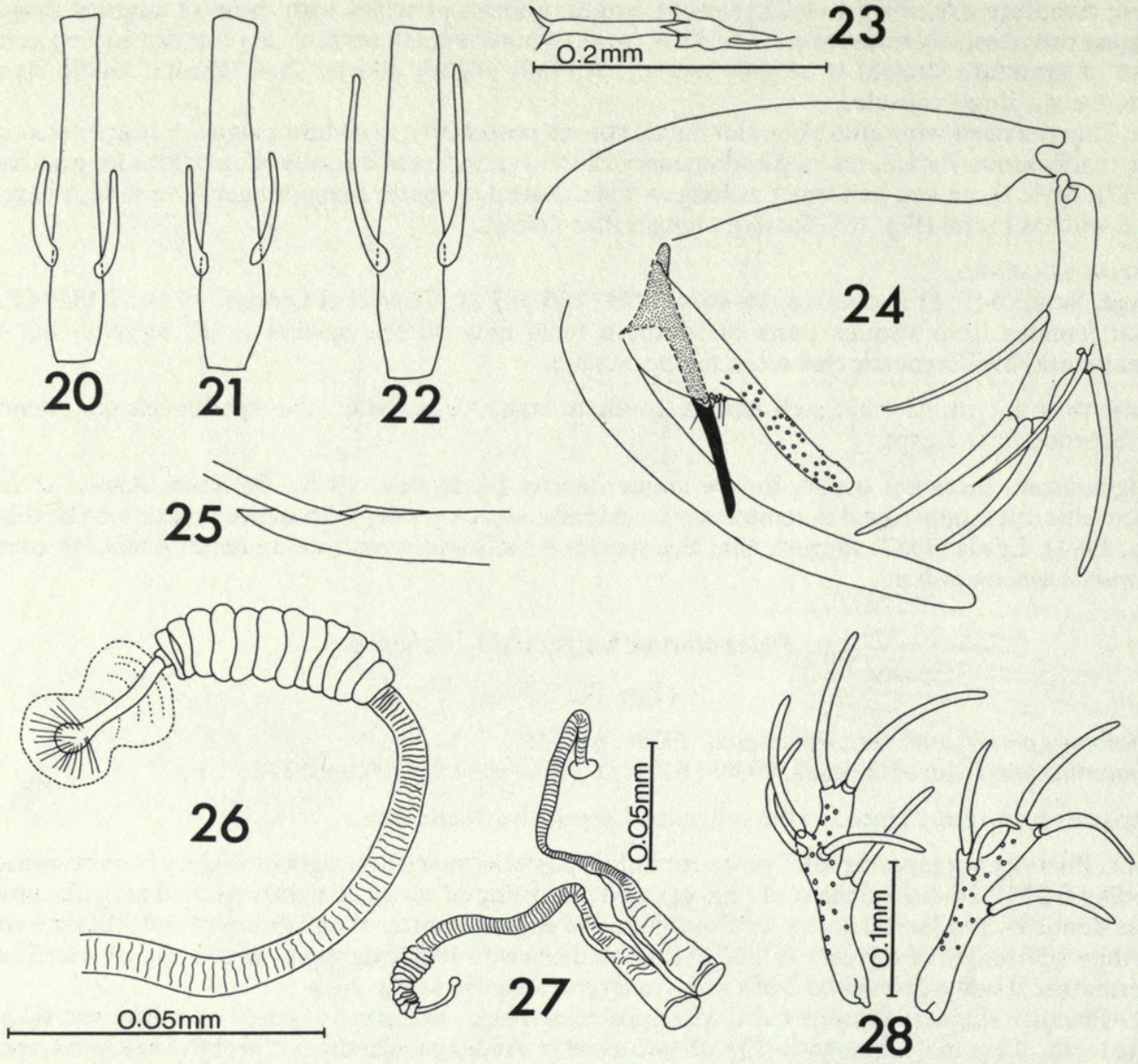
The female of this species has recently been described (Sawaf, Kassem & Said, in press) (see under *P. orientalis* for comments on identification). Some aberrant male specimens with six spines on the style instead of five were reared in culture (Fig. 28).

MATERIAL EXAMINED

Egypt. 2 ♀, Al Agamy, 15.viii.1983; 1 ♀, in poultry house, 11.x.1983 (*R.P.L.*) [used to establish colony]; 1 ♂, rodent burrow, 1 ♂, sticky trap near house, 5.x.1982.

DISTRIBUTION. Morocco, Tunisia, Libya, Egypt. Sawaf *et al.* (1984) record this species from Al Agamy, near Alexandria (Egypt), based on the identification of two males listed below (det. R.P.L.).

Until recently, *P. langeroni* was considered a very rare species known only from Morocco (Ristorcelli, 1945), Tunisia (Croset *et al.*, 1978) and Libya (Nitzulescu & Nitzulescu, 1933). In their survey of Tunisia, Croset *et al.* (1978) found this species in coastal areas only, where it was rare – in one sample of over 9600 sandflies from Fondouk-Choucha (near Tunis) there was only a single specimen of *P. langeroni*. *P. langeroni* comprised only 0·1% of 5000 sandflies collected in various parts of Tunisia over a two-year period (Chadli *et al.*, 1970*b*). Chadli *et al.* (1970*a*) collected *P. langeroni* in the town of Tunis. In Egypt this species has only been found during an epidemiological survey at a focus of visceral leishmaniasis at Al Agamy, near Alexandria. Here, *P. langeroni* constituted only 1–2% of aspirator catches made inside houses, but up to 50% of catches made with sticky traps placed in animal houses and animal burrows near houses (J. Beier, pers. comm.). The only other *Phlebotomus* species found at this focus was *P. papatasi*. Sawaf *et al.* (1984) have suggested that *P. langeroni* is the vector of visceral leishmaniasis in Al Agamy, because *P. papatasi* is a very poor vector of *Le. donovani* and *P. langeroni* is closely related to other vectors of visceral leishmaniasis (*P. orientalis* and *P. perniciosus* Newstead).



Figs 20–28 20–22, ♂, antennal segment 4 of (20) *Phlebotomus langeroni*, Egypt, Al Agamy; (21) *P. orientalis*, Sudan, Paloich District; (22) *P. orientalis*, Yemen, Taiz. 23–28, *P. langeroni*. (23) sperm pump; (24) ♂, genitalia; (25) ♂, tip of aedeagus; (26) ♀, spermatheca; (27) ♀, spermathecal ducts; (28) ♂, complementary styles, one showing additional spine. (Figs 23–28 all ex laboratory culture originating in Al Agamy, near Alexandria.)

Phlebotomus major Annandale 'Sinai form'

(Figs 32–34)

Phlebotomus major Annandale, 1910: 46.
Phlebotomus (Larroussius) major Annandale; Perfil'ev, 1966: 254.

P. major is the type-species of the subgenus *Larroussius*.

Four female specimens from Tharfet el Qidren in the southern Sinai represent a distinct form of *P. major*. The pharynx, with ridges of fine teeth, is typical of the subgenus *Larroussius*. However, the pharyngeal armature extends to the mid point of the pharynx (Fig. 32) and therefore closely resembles that of *P. major neglectus* from Italy, Malta, Albania, Yugoslavia. It differs from *neglectus* in having A3 much shorter than the labrum. Another subspecies, *P. major syriacus*, is known from the eastern Mediterranean, and recently, from northern Saudi Arabia (Lewis & Buttiker, 1982). Table 2 summarises some biometric characters of the Sinai form as well as the syntypic series of *syriacus* in the BMNH from Jerusalem and Syria. The two forms differ in the ratio length of the pharyngeal armature/length of pharynx:- 0·25 in *syriacus* and 0·5 in 'Sinai form', and the A3/labrum ratio: 0·96 in *syriacus* and 0·87 in 'Sinai form'.

The only other Middle East species with an extensive pharyngeal armature in the subgenus *Larroussius*

Table 2 Comparison of some biometric characters of *P. major* from Sinai and syntypes of *P. major syriacus* from Jerusalem and Syria.

	length of A3	A3/labrum	Pharyngeal armature: proportion of pharynx	length of pharynx
P. major 'Sinai form'	0·299 mm	0·878	0·491	0·223 mm
	n = 3	n = 3	n = 3	n = 3
P. syriacus syntypes	0·366 mm	0·966	0·258	0·215 mm
	n = 8	n = 8	n = 11	n = 11
	sd = 0·028	sd. = 0·036	sd. = 0·038	sd = 0·014

is *P. wenyoni*, which is restricted to certain areas of Iran. *P. major* 'Sinai form' can be differentiated by the shape of the pharynx and the detailed morphology of the armature. In *P. wenyoni* the teeth are all on small elliptical scales with serrated edges whereas in 'Sinai form' the teeth are more isolated and in smaller groups. This difference is especially clear in the anterior part of the pharyngeal armature.

Unfortunately, no males of *P. major* were collected in Egypt. The record of *P. major syriacus* from Saudi Arabia was based on two males and therefore the material is not directly comparable with the Sinai specimens.

P. major was divided into three subspecies by Theodor (1958), and Perfil'ev (1966) added another (*P. major krimensis*). However, the distribution of some subspecies (given in Lewis, 1982) overlaps to a considerable degree and these populations cannot therefore be considered true subspecies (see Lane & Marshall, 1981, for discussion of subspecies). Until they are taxonomically revised, probably as a species-group composed of several species, it is not prudent to name formally the distinctive southern Sinai form, particularly as only females are available.

The closely related *P. major syriacus* has been infected with *Le. donovani* (see Adler & Theodor, 1957) and is considered to be a vector of visceral leishmaniasis in the eastern Mediterranean area (Hoogstraal & Heyneman, 1969: 1185; Theodor, 1964: 480; Léger *et al.*, 1979: 20).

The occurrence of *P. major* 'Sinai form' in the mountains of the southern Sinai is consistent with the habitat-characteristic of this species-group. For example, *P. major syriacus* is only abundant at altitudes above 300 m in Greece (Léger *et al.*, 1979).

P. major has not previously been recorded from Egypt.

MATERIAL EXAMINED

Egypt. Sinai: 4 ♀, Tharfet el Qidren, 13–14.vi.1979 (*Y.B.*).

Phlebotomus orientalis Parrot

(Figs 21, 22, 29–31)

Phlebotomus (Phlebotomus) langeroni var. *orientalis* Parrot, 1936: 30 [♂♀]. Syntypes 32 ♂, 24 ♀, ETHIOPIA (IPA).

Phlebotomus orientalis Parrot; Parrot & Clastrier, 1946: 64. [Raised to species.]

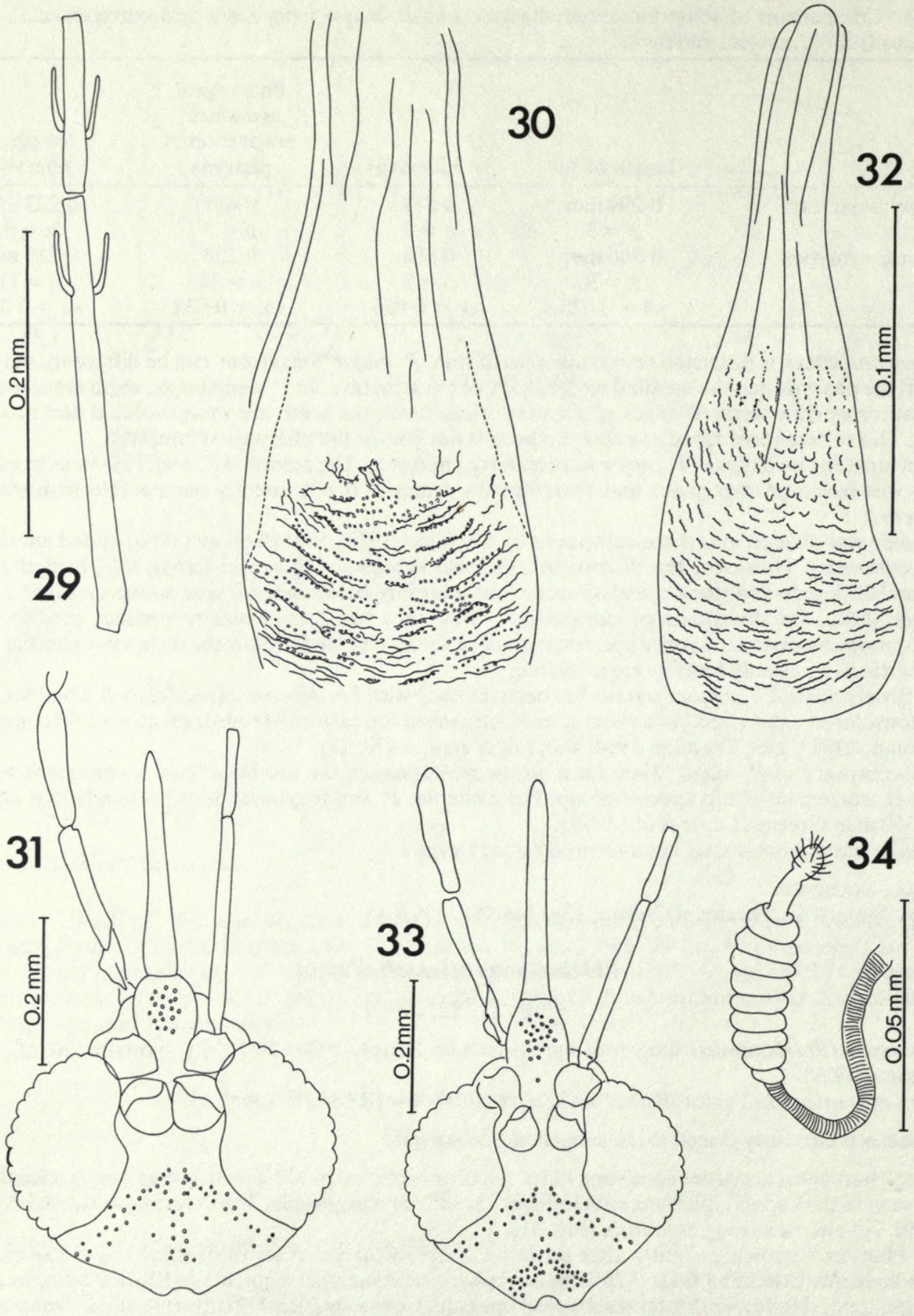
This species is currently placed in the subgenus *Larroussius*.

FEMALE. Pharyngeal armature consisting of irregular rows of nine pin-like teeth (often only the tooth bases can be seen as dark spots), pharynx with indistinct posterior margin (Fig. 30). Ascoids on A3 and A4 short (Fig. 29). A3 almost as long as labrum (Fig. 31).

MALE. Pharynx narrowing slightly after posterior bulge, armature a series of short transverse ridges of minute denticles extending 0·20–0·26 length of pharynx. Antennal segments 8–12 with a single ascoid. Aedeagus long, slender, with lateral subapical opening. Coxite slender, 5·1 times as long as wide.

Parrot & Clastrier (1946) elevated *P. langeroni orientalis* to species rank, although it continued to be treated as a subspecies of *P. langeroni* by some authors until quite recently, e.g. Lewis *et al.* (1974) and Theodor (1958). The males of *P. orientalis* and *P. langeroni* may be distinguished by the distribution of the ascoids on antennal segments 8–12 (1 per segment in *P. orientalis*, 2 in *P. langeroni*) and by subtle differences in the position of the subapical opening of the aedeagus, which is ventral in *P. langeroni* and lateral in *P. orientalis*. This aedeagal character can only be observed in perfectly mounted specimens. The females can be distinguished by the relative lengths of the ascoids on A4 (Figs 21, 22).

The male of *P. orientalis* can be distinguished from that of *P. major* by the parameres which are broad in



Figs 29–34 29–31, *Phlebotomus orientalis*. (29) ♀, antennal segments 3 and 4; (30) ♀, pharynx; (31) ♀, head. (Figs 29–31 Sinai, Tharfet el Qidren.) 32–34, *P. major*. (32) ♀, pharynx; (33) ♀, head; (34) ♀, spermatheca. (Figs 32–34 S. Sinai.)

P. orientalis but slender in *P. major*, and by the aedeagal tip which is pointed in *P. orientalis*, but blunt and rounded in *P. major*.

MATERIAL EXAMINED

Egypt. Sinai: 32 ♂, 2 ♀, Upper Wadi Nasb, 14–15.vi.1979 (*Y.B.*); 10 ♂, 9 ♀, Tharfet el Qidren, 13–14.vi.1979 (*Y.B.*).

DISTRIBUTION. Chad, Niger, Ethiopia, Kenya, Sudan, Egypt, Yemen, Saudi Arabia (SW.). This is the first record of *P. orientalis* from Egypt.

The record from the southern Sinai is the furthest north *P. orientalis* has been found. This species shows a classical East African–Arabian highland distribution, with the important exception of the lowland records from Sudan (Kirk & Lewis, 1940; Quate, 1964). In western Saudi Arabia, Buttiker & Lewis (1984) found that *P. orientalis* was predominant at altitudes above 1750 m and was absent in the lowlands.

P. orientalis is a pernicious man-biter in many parts of its range with biting rates of 108–208 per hour in Ethiopia (Ashford, 1974). It is a vector of *Le. donovani donovani* in the *Acacia-Balanites* forests of southern Sudan (Hoogstraal & Heyneman, 1969). Ashford (1974) concluded that *P. orientalis* did not transmit visceral leishmaniasis regularly in the highlands of Ethiopia (around Arbaya), although imported infections might be transmitted occasionally.

Phlebotomus papatasi (Scopoli)

(Figs 35–39)

Bibio papatasi Scopoli, 1786: 55 [♀] Type(s), ITALY (U, Pavia?).
Phlebotomus (Phlebotomus) papatasi (Scopoli) [see Lewis (1982) for complex nomenclatural history].

This species is the type-species of *Phlebotomus*.

FEMALE. Pharynx stout, narrowing after posterior bulge; armature consisting of numerous small scales with fringe of fine backward-pointing teeth (Fig. 38). A3 shorter than labrum. Spermatheca with segments (Fig. 37).

MALE. Pharynx slender, with numerous small teeth. Paramere with three lobes, dorsal lobe very much longer than broad median lobe. Coxite with small tuft of hairs on plate basally, and another clump of long hairs distally. Style long, slender, with short pointed spines: three terminal, distance between median and subapical spine less than between subapical and terminal spine (Fig. 39).

MATERIAL EXAMINED

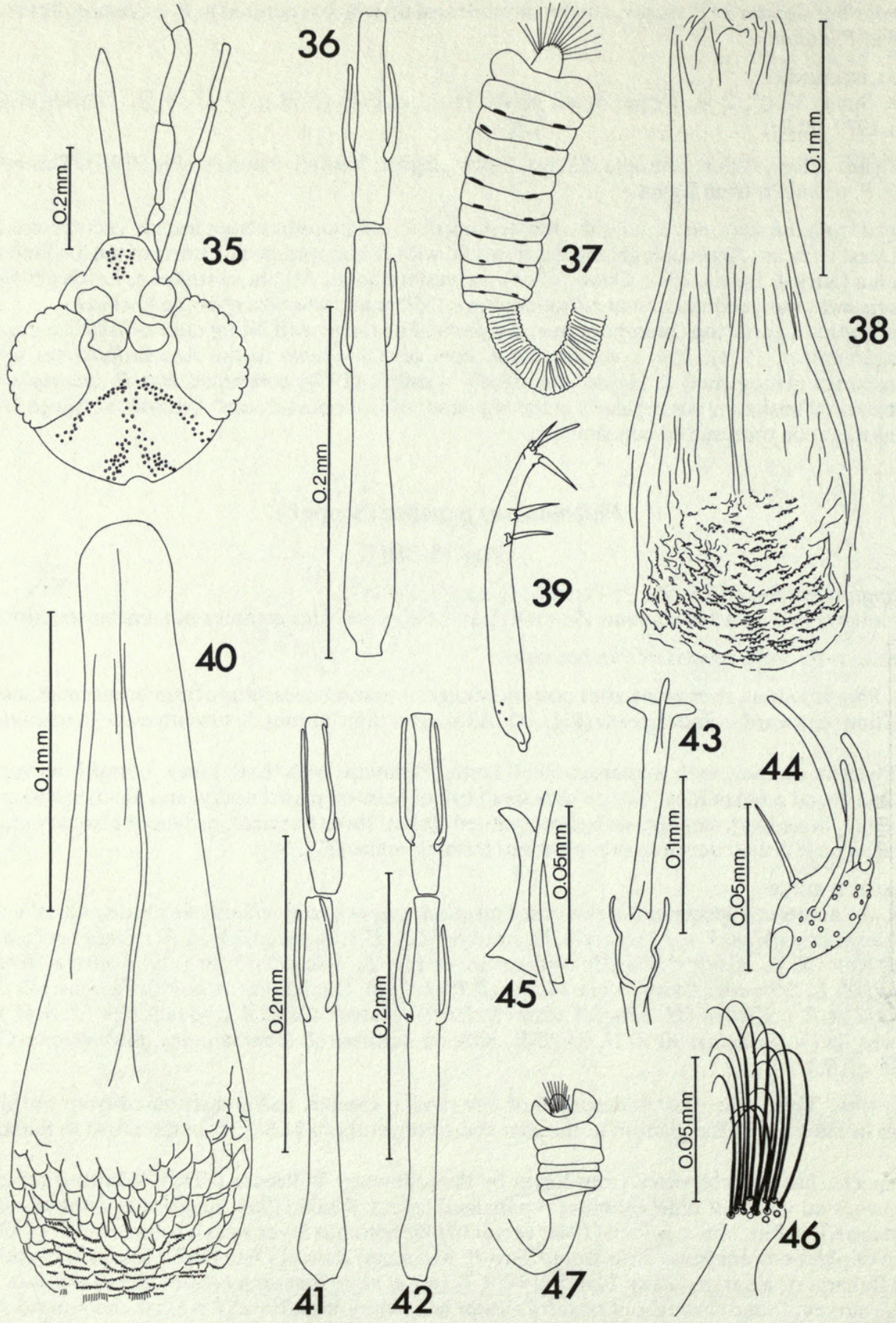
Egypt. As numerous specimens of this common species were examined only localities and collectors are given. Alexandria (*M.A.R.*); Alexandria, El Amriya (*Z.A.H.*); Bahteem (*M.A.R.*); Beni Suef (*M.A.R.*); Birqet Qarun (*R. L. Coe*); Cairo, El Amirga, caves (*M. L. Schmidt*); Cairo, El Amiriya, Apartment buildings (*M. L. Schmidt*); Cairo, Mena House (*J. Wakeling*); Dakhaliya (*M.A.R.*); Fayoum (*R. L. Coe*); Imbaba (*M.A.R.*); Khasm (*H. King*); Luxor (*S. Hirst*); Matruh (*M.A.R.*); Quahsbieh (*Z.A.H.*); Sinai, Abu Aweigila (*Y. Schlein*); 30 50′N, 34 20′E, military bunkers (*J. Zimmerman*); Siwa (*Omer-Cooper*); Tanta (*M.A.R.*).

DISTRIBUTION. This is the most widespread of any sandfly species, and is distributed from Portugal and Morocco in the west to Bangladesh in the east and from southern U.S.S.R. in the north to Sudan in the south.

This species has been reported from Egypt by the following: Willcocks (1917); Whittingham & Rook (1923: suggested vector of phlebotomus (= papataci) fever); Khalil (1934: suggested vector of cutaneous leishmaniasisi); Sabin, Philip & Paul (1944: vector of phlebotomus fever virus); Schmidt *et al.* (1960, 1971: isolation of phlebotomus fever virus from Cairo *P. papatasi*); Zein el Dine (1972: found in Dakhla Oasis but not Baharia or Kharga oases); Hafez (1977); Rifaat *et al.* (1968: no localities given); Hassan (1968*a*: extensive survey, found throughout country except non-peridomestic areas in Sinai and around Aswan); Kammah (1972: autogeny); Sawaf *et al.* (1984: Al Agamy, nr Alexandria).

During rapid field examination of samples, female *P. papatasi* may be confused with *Sergentomyia christophersi* because of the similarity in the shape and segmentation of the spermathecal capsule, and the presence of a large number of erect hair sockets on the abdominal tergites. *S. christophersi* can easily be distinguished, however, by the presence of cibarial teeth.

Schmidt & Schmidt (1963) give a detailed account of the morphological variation in a single population from a suburb of Cairo and conclude that the Egyptian *P. papatasi* bear a 'marked resemblance to



Figs 35–47 35–39, *Phlebotomus papatasi.* (35) ♀, head; (36) ♀, antennal segments 3 and 4; (37) ♀, spermatheca; (38) ♀, pharynx; (39) ♂, style. (Figs 35–39 Sinai 30° 50′N 34° 20′E.) 40–47, *P. sergenti.* (40) ♀, pharynx; (41, 42) ♀, antennal segments 3 and 4; (43) ♂, sperm pump; (44) ♂, style; (45) ♂, aedeagus; (46) ♂, basal process of coxite; (47) ♀, spermatheca. (Fig. 40 Libya, Jarian Prov.; 41 Libya, Yefran; 42 Cairo, Maadi, 43–46 Jordan, Mowaggar; 47 Egypt, Sharkeyia.)

specimens from other areas [but] several differences are apparent in the Egyptian material [which] constitute preliminary evidence for infra specific variation'.

This is probably the most studied of all sandflies because of its abundance, widespread distribution, anthropophily and peridomestic habits. It is the main vector of cutaneous leishmaniasis to man (Abonnenc, 1972: 100; Lewis, 1974*a*; Theodor, 1964; Williams & Coelho, 1978) in many parts of its range. In the Mediterranean basin and the Middle East *P. papatasi* has been proved a vector in several countries, e.g. Israel (Schlein *et al.*, 1982; Adler & Ber, 1941), and strong circumstantial evidence exists for its vectorial status in many other countries, e.g. Saudi Arabia (Nadim, Rashti & Ashi, 1979); Afghanistan (Nadim *et al.*, 1979); Iran (Adler, 1964) and North Africa (review: Dedet, 1979). It is undoubtedly the vector of cutaneous leishmaniasis in Egypt, but other species may also be involved (e.g. *P. sergenti*). *P. papatasi* has been suspected of transmitting visceral leishmaniasis in areas where no other likely vector has been found: Saudi Arabia (Lewis & Buttiker, 1980); Iraq (Abu-Hab & Azawia, 1978; Adler & Theodor, 1957; Sukkar, 1972). However, it is not an efficient vector of *Le. donovani* experimentally but might transmit it rarely (Hoogstraal & Heyneman, 1969; Zahar, 1980: 45, 53). The feeding habits of *P. papatasi* in Lower Egypt are given by Schmidt & Schmidt (1965).

Phlebotomus fever virus was isolated from wild caught *P. papatasi* collected from human dwellings in suburban Cairo (Schmidt *et al.*, 1960). This, together with the earlier work of Sabin *et al.* (1944), which clearly demonstrated that *P. papatasi* was capable of transmission after the necessary incubation, incriminated *P. papatasi* as the vector of phlebotomus fever virus in Lower Egypt.

Phlebotomus sergenti Parrot

(Figs 40–47)

Phlebotomus sergenti Parrot, 1917: 564 [♂]; Franca, 1918: 731 [♀]. Syntypes ♂, ALGERIA (IPA).

This species is currently placed in the subgenus *Paraphlebotomus* Theodor.

FEMALE. Pharynx with large scales anteriorly, some produced into long broad spines, scales becoming broader and flatter posteriorly with hind margin serrated with fine teeth (Fig. 40). Third and fourth antennal segments with slender ascoids almost reaching tip of segment (Figs 41, 42). Spermatheca with equal segments (Fig. 47).

MALE. Pharynx tapering after posterior bulge, posterior margin convex; armature series of scales with minute teeth along anterior margins. A3 slender, longer than labrum. Coxite short and stout, less than twice as long as wide. Coxite lobe slender and relatively long (Fig. 46). Surstyles longer than coxite.

MATERIAL EXAMINED

Egypt. 1 ♀, Cairo, Maadi, 7.vii.1943 (*Theodor*); 1 ♀, Sharkeyia, 1967 (*M.A.R.*); Sinai: 1 ♂, Upper Wadi Nasb, 14–15.vi.1979 (*Y.B.*); 1 ♂, Wadi Baaba, 8–9.vi.1979 (*Y.B.*).

DISTRIBUTION. Mediterranean Basin eastwards through Israel, Iraq, Iran, Afghanistan, Pakistan, India and southwards to Saudi Arabia, Yemen and Ethiopian highlands.

Theodor (1948) found *P. sergenti* around Cairo and Rifaat *et al.* (1968) record it but give no localities.

P. sergenti is a proven vector of cutaneous leishmaniasis in the U.S.S.R. (Sergiev, 1979: 206), Crete (Molyneux, 1977), Iraq and India (Abonnenc, 1972). It is a suspected vector of *Le. tropica* in many countries including Iran (Nadim & Rashti, 1971) and Yugoslavia (Lupascu *et al.*, 1977). Schlein *et al.* (1984) found promastigotes in *P. sergenti* from the Arava in Israel.

Sergentomyia adleri (Theodor)

(Fig. 48)

Phlebotomus adleri Theodor, 1933: 543 [♂♀]. Syntypes, GHANA (BMNH).

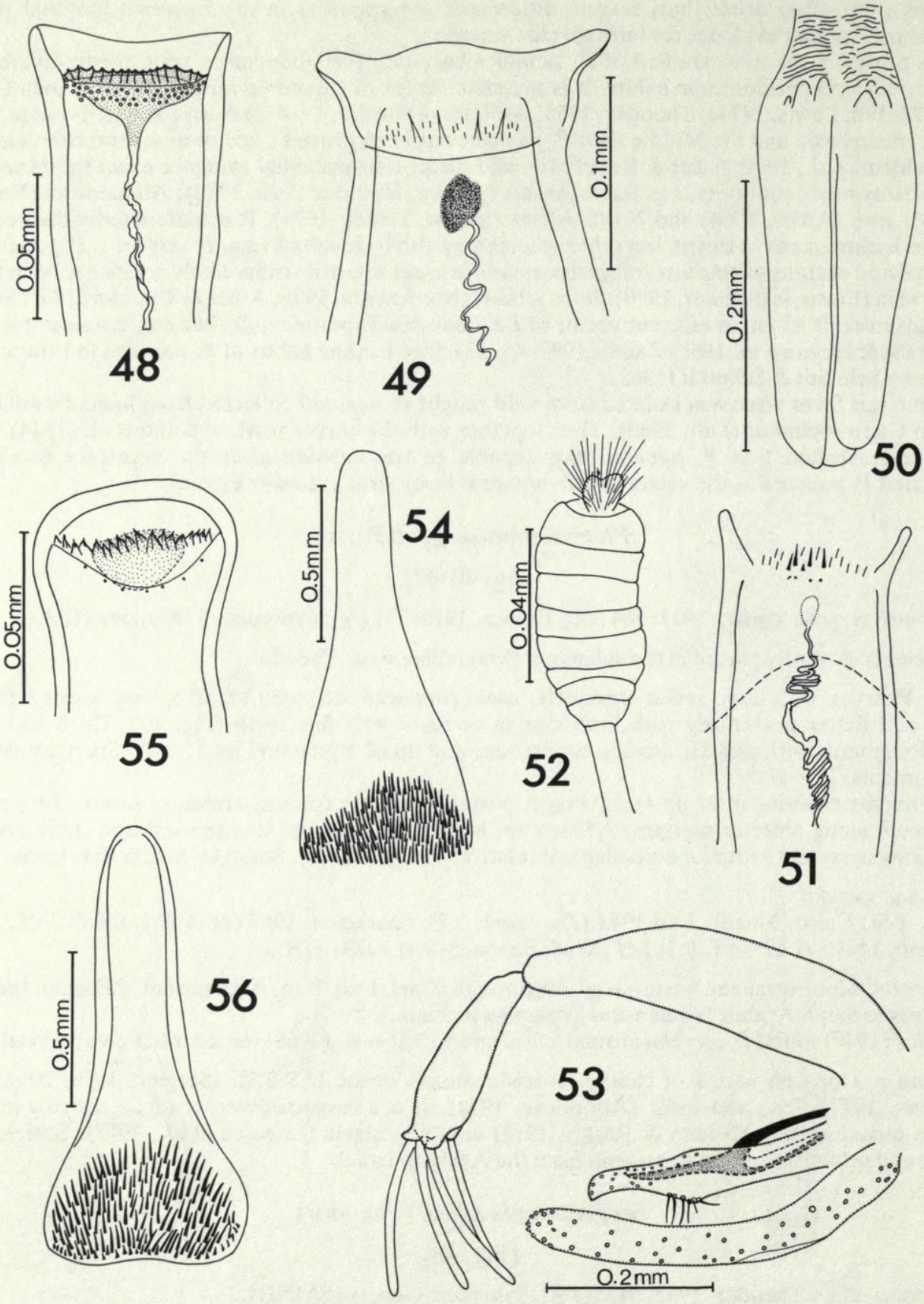
This species is currently placed in the subgenus *Sintonius* Nitzulescu.

FEMALE. Cibarium with 54 vertical teeth in three rows and 17 subequal irregularly spaced horizontal teeth; pigment patch almost as wide as cibarial armature with pronounced anterior projection. Pharynx slender, tapering slightly after posterior bulge, armature only a series of vague transverse striations.

MALE. Very similar to *S. clydei* except that cibarium has two or three rows of vertical teeth, usually 6 in each row, and horizontal teeth evenly spaced (not in groups like *S. clydei*).

MATERIAL STUDIED

Egypt. Sinai: 1 ♀, Feiran 12–13.vi.1979 (*Y.B.*).



Figs 48–56 48, *Sergentomyia adleri* ♀, cibarium, Sinai, Feiran. 49–53, *S. christophersi*. (49) ♀, cibarium; (50) ♂, pharynx; (51) ♂, cibarium; (52) ♀, spermatheca; (53) ♂, genitalia. (Figs 49–53 Aswan.) 54, 55, *S. cincta*. (54) ♀, pharynx; (55) ♀, cibarium. (Figs 54, 55 Siwa Oasis.) 56, *S. antennata* ♀, pharynx, Sinai 30° 50′N 34° 20′E.

DISTRIBUTION. Senegal, Ivory Coast, Ghana, Cameroun, Nigeria, Togo, Upper Volta, Chad, Republic of Central Africa, Sudan, Egypt, Kenya, Saudi Arabia. This is the first record from Egypt.

This species is closely related to *S. clydei* and has been considered synonymous by many authors (see discussion under *S. clydei*).

Sergentomyia antennata (Newstead)

(Figs 56–57)

Phlebotomus antennatus Newstead, 1912: 365 [♀]. Holotype ♀, GHANA (BMNH).

This species is currently placed in the subgenus *Sergentomyia*.

FEMALE. Cibarium with concave row of delicate unequal-sized teeth; pigment patch almost triangular, with anterior projection acutely angled, posterior margin broad, indented. Pharynx stout with armature of distinct teeth less than 0·20 pharynx length; posterior margin with shallow notch (Fig. 56).
MALE. Cibarium with row of about 16 irregular teeth and small spicules; some vertical teeth also present. Pharynx slender with small triangular teeth. Style stout, less than three times as long as wide; two terminal, two subterminal spines (Fig. 57).

MATERIAL EXAMINED
Egypt. Sinai: 1 ♂, 2 ♀, 30 50′N 34 20′E, 19.vii.1983, light-trap in bunkers (*J. Zimmerman*).

DISTRIBUTION. Occurs in a broad band south of the Sahara desert from Ghana through Central African Republic, East Africa, Yemen, Saudi Arabia to Kuwait. It has also been recorded from Algeria and Tunisia. This is the first record of this species from Egypt.

This is a very variable taxon and opinions differ on whether it is one or many species. The shape of the pharynx on which most differentiation is made is very variable, e.g. see Lewis & Buttiker (1982: 368).

S. antennata is commonly found outside houses associated with *P. papatasi* (Buttiker & Lewis, 1983; Lane & Al Taqi, 1983). Schlein *et al.* (1984) found 'promastigotes, possibly of reptilian leishmanial species' in 7 out of 33 *antennata* caught together at Arava (Israel).

Sergentomyia christophersi (Sinton)

(Figs 49–53)

Phlebotomus christophersi Sinton, 1927: 33 [♀]. Lectotype ♀, PAKISTAN (BMNH), designated by Lewis & Büttiker (1982: 365).

This species is currently placed in the subgenus *Sintonius*.

FEMALE. Cibarium with four or five long teeth, many small denticles visible in some specimens; small pigment patch present (Fig. 49). Pharyngeal armature with a few scale-like folds anteriorly and a series of vague ridges posteriorly. Spermathecae smooth-walled with approximately eight segments and long individual ducts (Fig. 52).
MALE. Cibarium with several long teeth and some small denticles (Fig. 51). The distinction between the large teeth and denticles is less marked in males than females. Pharynx constricted after bulge; armature a series of indistinct ridges (Fig. 50). Two apical and two subapical spines on style. Paramere simple. Surstyle longer than parameres. Aedeagus slender, tapering from base (Fig. 53).

MATERIAL EXAMINED
Egypt. Aswan: 55 ♂, 60 ♀, Elephantine Island, 3–5.x.1983, sticky traps amongst rocks harbouring numerous geckoes (*R.P.L.*).

DISTRIBUTION. Guinea, Chad, Ethiopia, Sudan, Egypt, North Yemen, Saudi Arabia, Oman, Pakistan. This is the first record of *S. christophersi* from Egypt.

This species is closely related to *S. clydei*, from which it can be distinguished by the number of cibarial teeth.

	male	female
christophersi	3–5	4
clydei	16–26	12

Sergentomyia cincta (Parrot & Martin)

(Figs 54, 55)

Phlebotomus antennatus var. *cinctus* Parrot & Martin 1944: 55 [♂♀]. Syntypes, Djibouti, Sudan (IPA), 1 ♀ syntype (BMNH).
Sergentomyia cincta (Parrot & Martin) Theodor, 1958: 38.

This species is currently placed in the subgenus *Sergentomyia*.

Female. Cibarium with concave row of 16–18 teeth, lateral teeth slightly smaller than central teeth (Fig. 55); pigment patch a rounded triangle, hind margin convex. Pharynx without distinct shoulder, hind margin straight or slightly convex, posterior teeth only slightly smaller than anterior teeth.
Male. Indistinguishable from *S. antennata*.

Material examined
Egypt. 13 ♀, Siwa Oasis, 6.viii.1935 (*Omer-Cooper*), det. O. Theodor.

Distribution. Ghana, Central African Republic, Kenya, Uganda, Sudan, Ethiopia, Djibouti, Egypt. This is the first record of *cincta* from Egypt.

This species is considered to be conscpecific with *S. antennata* by some authors (e.g. Duckhouse & Lewis, 1980), but as a distinct but closely related taxon in the *S. fallax*-group by others (Abonnenc, 1972; Theodor, 1958; Davidson, pers. comm.).

Sergentomyia clydei (Sinton)

Phlebotomus clydei Sinton, 1928*b*: 179 [♂♀]. Lectotype ♂, Pakistan (BMNH), designated by Lewis (1967: 42).

This species is currently placed in the subgenus *Sintonius*.

Female. Cibarium with row of 13–16 triangular, slender teeth; 25–37 vertical teeth in one or two rows, some teeth may be present centrally so as to produce a short third row; pigment patch triangular, broad, as wide as cibarium. Pharynx tapering markedly after bulge, no armature apparent although a few fine transverse ridges present in some specimens. Spermatheca distinctly segmented (collapsed in all specimens, therefore segment number unavailable); individual ducts rugose.

Male. Cibarium with tufts of small denticles posteriorly; pigment patch triangular, not as broad as cibarium. Pharynx more slender than in female and constriction after bulge less obvious. Abdominal tergites 5 and 6 subequal in length. Paramere with beak-like apex, style with 2 apical and 2 subapical spines. Aedeagus slender, pointed.

Material examined
Egypt. Sinai: 1 ♂, 5 ♀, Tharfet el Qidren, 13–14.vi.1979 (*Y.B.*).

Distribution. Algeria, Egypt, Mali, Senegal, Ghana, Niger, Chad, Cameroun, Sudan, Ethiopia (including Eritrea), Somalia, Kenya, Iraq, U.S.S.R. (Kazakstan, Tajikistan, Turkestan), Saudi Arabia, Kuwait, northern India. *S. clydei* has not previously been found in Egypt.

This species is recorded from southern Sinai and is likely to occur in Upper Egypt because it also is known from Wadi Halfa in Sudan, near the Egyptian–Sudanese border (Lewis & Kirk, 1954).

S. clydei is very closely related to *S. adleri* and there has been much discussion on whether they are conspecific. Quate (1964) treats them as separate species but concludes 'I suspect they eventually will be shown to be two forms of the same species'. Lewis & Buttiker (1980) also considered them as separate species and stressed the importance of females as a means of identification. Later (Lewis & Buttiker, 1982) they confirmed their earlier proposition by finding distinct specimens representing each species at a single locality (Artawiyah, Saudi Arabia). The two species are distinguished by the number of horizontal and vertical teeth on the cibarium, *S. adleri* having a higher number than *S. clydei* (summarised in Table 3). The form of *S. clydei* originally described as *latiterga* Theodor has the sixth abdominal segment much larger than the fifth (up to twice the length and width). This form was originally considered a distinct species but was subsequently synonymised by Theodor & Mesghali (1964: 297). Form *latiterga* has not been found in Egypt.

S. clydei is unusual in that it is one of several species of *Sergentomyia* which bite man (Quate, 1964), the remaining species of the genus feeding on lizards. *S. clydei* has been used to transmit experimentally *Le.*

Table 3 Differences in the number of cibarial teeth in female *S. adleri* and *S. clydei*.

	Sergentomyia clydei		*Sergentomyia adleri*	
	number of horizontal teeth	number of vertical teeth	number of horizontal teeth	number of vertical teeth
This study Sinai	14 (13–16) sd. = 1·09	31·5 (25–37) sd. = 3·7	—	—
Quate, 1964 Sudan	10–16	16–34	n.g.	45–80
Lewis, *et al.*, 1980 Saudi Arabia	12–17	26.2 (15–46)	18·8 (16–24)	43–50
Lewis, *et al.*, 1982 Saudi Arabia	12–13	16–34	22	45–80

n.g. = not given.

adleri from lizards to man, causing a transient infection and giving immunity against one form of *Le. donovani* (Garnham, 1971).

Sergentomyia fallax (Parrot)

(Figs 58–60)

Phlebotomus minutus var. *fallax* Parrot, 1921*a*: 37 [♂]. Syntypes, ALGERIA, TUNISIA (IPA).
Phlebotomus fallax (Parrot); Parrot, 1921*b*: 99. [Raised to species.]

This species is currently placed in the subgenus *Sergentomyia*.

FEMALE. Cibarium with deeply concave row of 16–23 unequal, closely packed, delicate teeth, lateral teeth larger than medial teeth, pigment patch usually ovoid, posterior margin not indented (Fig. 60). Pharynx variable in shape but typically cordiform with distinct posterior notch, posterior teeth punctiform, very much smaller than slender anterior teeth (Fig. 59). Length of A3 0·11 mm (s.d. = 0·009, range 0·083–0·113, n = 10). Spermathecae simple.
MALE. Cibarium with concave row of unequal pointed teeth; pigment patch circular or oval. Pharynx slender, narrowing posteriorly, with distinct triangular teeth. Aedeagus broad, finger-shaped. Coxite and style long and slender, style more than five times as long as wide (Fig. 58), accessory seta subterminal, distance from setal base to closest terminal spine not greater than length of accessory seta.

MATERIAL EXAMINED
Egypt. Sinai: 1 ♂, 1 ♀, Feiran, 12–13.vi.1979 (*Y.B.*); 2 ♀, Ain Higia, 9–10.vi.1979 (*Y.B.*); 2 ♂, 6 ♀, Tharfet el Qidren, 13–14.vi.1979 (*Y.B.*); 3 ♂, 9 ♀, Upper Wadi Nasb, 14–15.vi.1979 (*Y.B.*).

DISTRIBUTION. From West Africa to eastern Afghanistan, and North Africa from Algeria to Egypt. This is the first record of this species from Egypt.

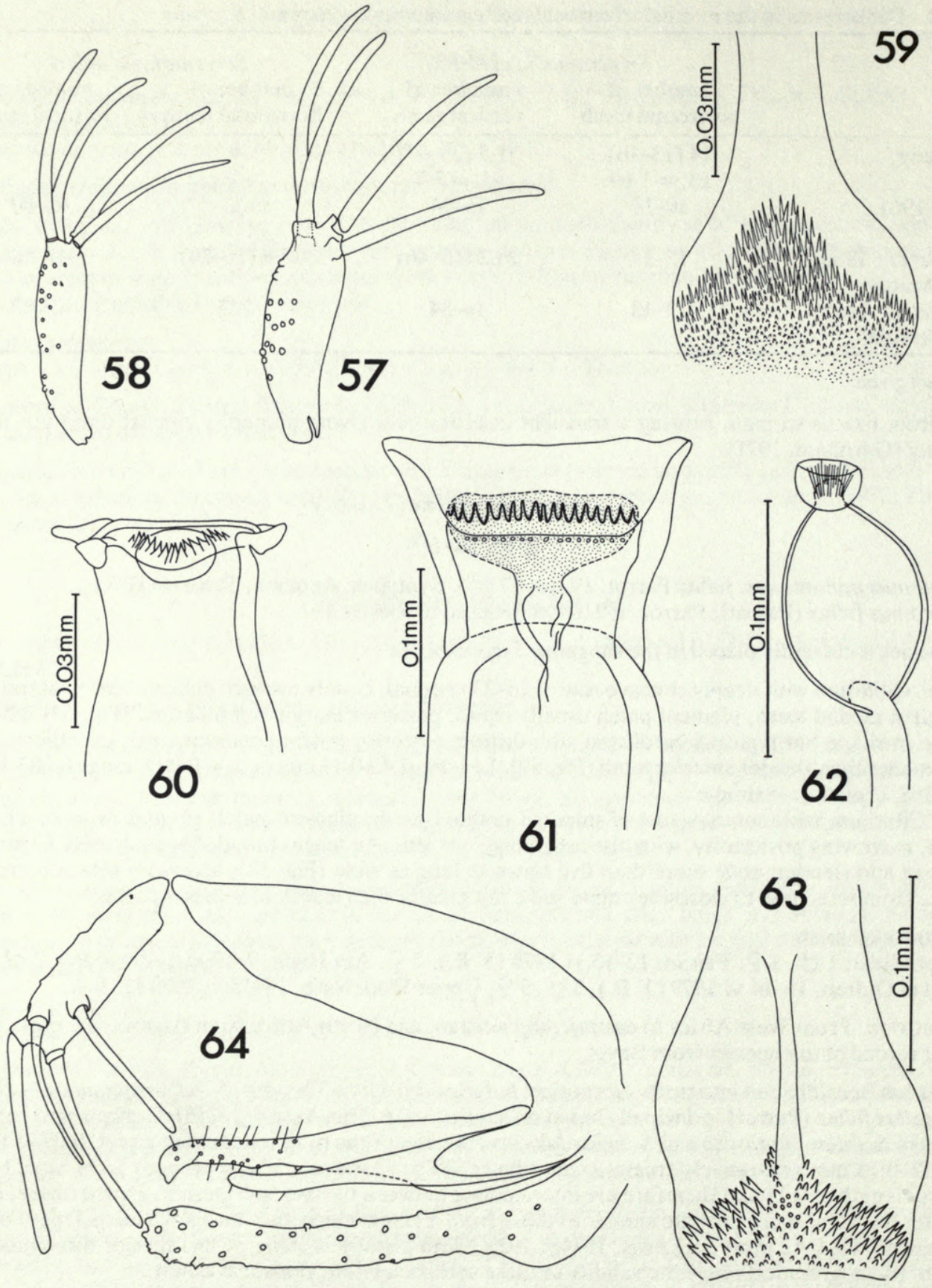
S. fallax has been divided into three subspecies: *S. fallax cypriotica* Theodor, *S. fallax afghanica* Artemiev and *S. fallax fallax* (Parrot), principally based on absolute size. Thus Lewis (1974*b*) discriminated between females of *S. fallax cypriotica* and *S. fallax fallax* on the size of the third antennal segment, 0·07–0·10 mm and 0·12–0·15 mm respectively (males cannot be reliably separated). The specimens from Sinai have a mean A3 length of 0.11 and therefore are intermediate between the two 'subspecies'. Furthermore, in this character the Sinai specimens are similar to those from Yemen which also have a A3 mean length of 0·11 mm (range 0·09–0·12 mm) (in Lewis, 1974*b*: 192). Until a study is made of this species throughout the whole of its geographical range the validity of these subspecies must remain in doubt.

Sergentomyia minuta (Rondani)

Hebotomus minuta Rondani, 1843: 265 [♂]. Type(s) ITALY (depository unknown).

This species is currently placed in the subgenus *Sergentomyia*.

FEMALE. Cibarium with a row of long, fine parallel teeth, row slightly convex posteriorly; pigment patch dark, transverse-ovoid, almost as wide as tooth row. Pharynx narrowing markedly after posterior bulge; armature of numerous individual teeth. Spermatheca simple, tubular.
MALE. Cibarium with vague row of irregular triangular teeth. Pharynx slender with ridged armature.



Figs 57–64 57, *Sergentomyia antennata* ♂, style, Sinai, 30° 50′N 34° 20′E. 58–60, *S. fallax*. (58) ♂, style, Sinai, Tharfet el Qidren; (59) ♀, pharynx; (60) ♀, cibarium. (Figs 59, 60 Sinai, Upper Wadi Nasb.) 61–64, *S. palestinensis*. (61) ♀, cibarium, Aswan; (62) ♀, spermatheca, Iraq, Jadizyah; (63) ♀, pharynx, Wadi Gaamah; (64) ♂, genitalia, Baharia Oasis.

Aedeagus finger-shaped, tapering. Style with four terminal spines, distance from accessory seta to terminal spine greater than length of seta.

MATERIAL EXAMINED

Examples of this species from Egypt have not been examined. Some specimens of 'minuta' collected by Eflatoon in 1922 are reported by Zein el Dine (1972) to be in the Egyptian Entomological Society, Cairo, but no further details are given. It is possible that these specimens were misidentified because *S. minuta* has not been collected in any sandfly surveys since. However, as *S. minuta* occurs around most of the Mediterranean Basin it is equally possible that this species will be found in the more humid areas of coastal Lower Egypt.

DISTRIBUTION. Portugal, Spain, France, Italy, Malta, Yugoslavia, Greece, Cyprus, Tunisia, Algeria, Morocco, Egypt (?).

Two subspecies have been described: *S. minuta minuta* from continental Europe, with a mean cibarial tooth number of 40; and *S. minuta parroti* (Adler & Theodor, 1926) from North Africa, with 70 teeth (Theodor, 1958; Rioux & Golvan, 1968). Recent work by Belazzoug *et al.* (1982) in different ecological zones of Algeria has shown that the number of cibarial teeth varies according to certain climatic factors (mainly humidity).

Sergentomyia palestinensis (Adler & Theodor)

(Figs 61–64)

Phlebotomus palestinensis Adler & Theodor, 1926: 64. Holotype ♀, PALESTINE (BMNH).
Phlebotomus lewisi Parrot 1948: 125. [Synonymised by Lewis & Büttiker, 1982: 370.]

This species is currently placed in the subgenus *Parrotomyia* Theodor.

FEMALE. Cibarium with straight row of 18–19 strong, straight, subequal horizontal teeth and a single row of vertical teeth; pigment patch broad, occupying most of cibarium width and with flattish posterior margin; cornua large (Fig. 61). Pharynx broad with distinct radiating teeth posteriorly (Fig. 63). Spermatheca tubular, capsule with thickened walls; collar surrounding spermathecal head well developed and often pigmented (Fig. 62).
MALE. Cibarium with straight row of 16 delicate horizontal teeth and a single row of vertical teeth. Pharynx with only slight constriction after post-medial bulge; armature with series of weakly developed scales posteriorly. Parameres simple, almost as long as surstyles, with hooked tips (Fig. 64).

MATERIAL EXAMINED

Egypt. 1 ♀, Aswan, Elephantine Island, sticky trap amongst rock by riverine vegetation, 3–5.x.1983 (*R.P.L.*); 1 ♀, 5 ♂, Baharia Oasis, 15.v.–7.viii.1971 (*K.Z.D.*); 2 ♀, Dakhla Oasis, Rashda, 17.viii.1971 (*K.Z.D.*); 2 ♀, Sinai, Tharfet el Qidren, 13–14.vi.1979 (*Y.B.*).

DISTRIBUTION. Egypt, Israel, Iraq, Iran, Saudi Arabia, Pakistan, Sudan, Ethiopia. Zein el Dine (1972) recorded this species from Dakhla and Baharia oases.

This species may be separated from other species of the subgenus *Parrotomyia* by the shape and number of pharyngeal teeth in both sexes, and by the shape of the spermathecal capsule and collar in the female.

Sergentomyia schwetzi (Adler, Theodor & Parrot)

(Fig. 65–67)

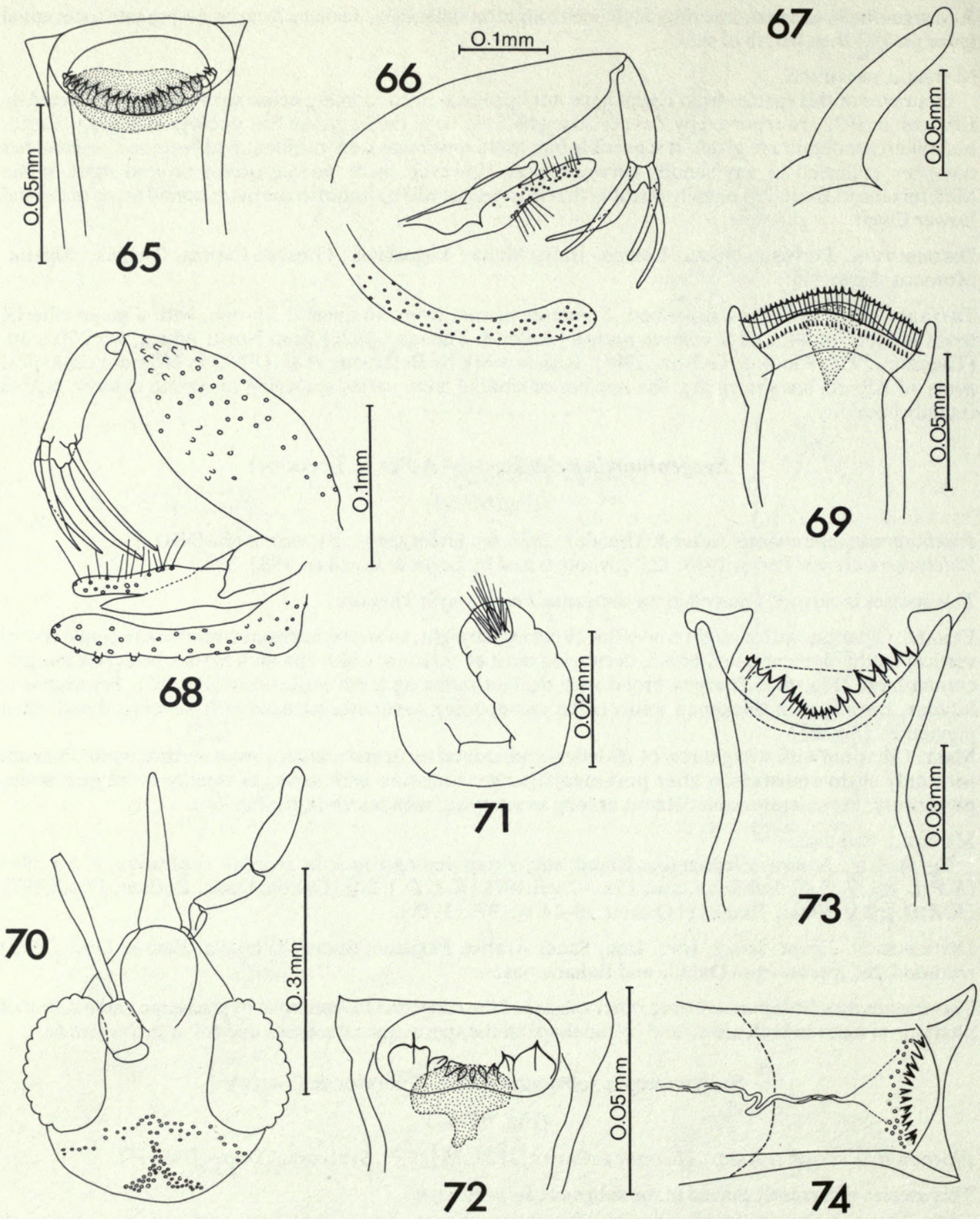
Phlebotomus schwetzi Adler, Theodor & Parrot, 1929: 75 [♂♀]. Syntypes, CONGO (BMNH).

This species is currently placed in the subgenus *Sergentomyia*.

FEMALE. Cibarium with 13–22 horizontal teeth, lateral teeth larger and broader than central (Fig. 65). Pharynx narrowing posteriorly with an armature of broad scales. Spermatheca simple, tubular and smooth-walled.
MALE. Cibarium with concave row of large irregular teeth. Aedeagus finger-like with gentle ventral curve (Fig. 67); style with two apical and two subapical spines at about 0·75 length of style (Fig. 66).

MATERIAL EXAMINED

Egypt. 1 ♀, Aswan, Elephantine Island, 3–5.x.1983, sticky trap (RPL).



Figs 65–74 65–67, *Sergentomyia schwetzi*. (65) ♀, cibarium, Aswan; (66) ♂, genitalia; (67) ♂, aedeagus. (Figs 66, 67 S. Sinai.) 68, 69, *S. squamipleuris*. (68) ♂, genitalia, Cairo; (69) ♀, cibarium, Kuwait. 70–72, *S. taizi*. (70) ♀, head; (71) ♀, spermatheca; (72) ♀, cibarium. (Figs 70–72 Sinai, Mt Katherine.) 73, *S. theodori* ♀, cibarium, Gaza. 74, *S. tiberiadis*. ♂, cibarium. (Fig 74, Aswan.)

DISTRIBUTION. Widespread in Africa, Yemen, Saudi Arabia. This is the first record of this species from Egypt.

Sergentomyia squamipleuris (Newstead)

(Figs 68–69)

Phlebotomus squamipleuris Newstead, 1912: 366 [♀]. Syntypes, SUDAN (BMNH).

This species is currently placed in the subgenus *Grassomyia* Theodor.

FEMALE. Cibarium with convex row of fine, parallel horizontal teeth; undulating row of vertical teeth; pigment patch small, tapering anteriorly; broad, chitinised, transverse band present (Fig. 69). Pharynx tapering abruptly posteriorly, with rows of angular teeth. Spermatheca single capsule with dense covering of fine ductules.
MALE. Cibarium with slightly convex row of minute triangular teeth; faint pigment patch present, almost circular. Pharynx narrow, tapering posteriorly. Coxite broad, style with two spines terminal, two subterminal. Paramere thick, bluntly rounded. Aedeagus tapering gently from base to three-quarters of length, then tapering abruptly (Fig. 68), dorsal margin concave. Surstyles short and thick, as long as coxite.

MATERIAL EXAMINED
Egypt. 1 ♂, Cairo, 1.xi.1910 (*Wakeling*); 1 ♀, Aswan, xi.1969 (*M.A.R.*).

DISTRIBUTION. Most of Africa (including Egypt), Israel, Iraq, Iran, Saudi Arabia, Kuwait. Khalil (1934) found this species in Sharqia Governate and Rifaat *et al.* (1968) recorded it but gave no localities.

Sergentomyia taizi (Lewis)

(Figs 70–73)

Sergentomyia (Sergentomyia) taizi Lewis, 1974*b*: 193 [♂♀]. Holotype ♀, YEMEN (BMNH).

This species is currently placed in the subgenus *Sergentomyia*.

FEMALE. Cibarium with nine teeth, two outer teeth broad, scale-like. Pigment patch dark, less than half width of cibarium, with rectangular anterior projection (Fig. 72). Pharynx with numerous fine transverse ridges posteriorly, bearing small distinct teeth. In holotype, pharynx tapers posteriorly but not in Sinai specimens (possibly artefact of preparation). Spermatheca broad, tubular, with apical knob in depression (Fig. 71).
MALE. Cibarium with concave row of teeth, outer teeth large, scale-like. Style with all spines terminal.

MATERIAL EXAMINED
Egypt. 1 ♀, Sinai, St Katherina, 15–16.vi.1979 (*Y.B.*).

DISTRIBUTION. Yemen, SW. Saudi Arabia, Egypt. This is the first record of this species from Egypt.

This species was described from the mountainous areas of Yemen and only subsequently found in the continguous mountain chain in Asir (SW. Saudi Arabia).

Sergentomyia theodori (Parrot)

(Fig. 73)

Phlebotomus minutus (Rondani) sensu Adler & Theodor, 1926: 403 [♂♀]. Misidentification.
Phlebotomus (Prophlebotomus) theodori Parrot, 1942: 322. Syntypes, PALESTINE: Jericho (BMNH).

This species is currently placed in the subgenus *Sergentomyia*.

FEMALE. Cibarium with 20–22 sharply pointed horizontal teeth in concave row, lateral teeth at least twice as long as central teeth (Fig. 73); pigment patch broad, almost as wide as cibarium and approximately rectangular. Pharynx triangular, posterior margin concave or notched; anterior teeth long and slender, posterior teeth appear shorter as they are usually viewed at an acute angle.
MALE. Cibarium with concave row of pointed teeth, lateral teeth much longer than tightly packed medial teeth. Pharynx narrowing after posterior bulge (lamp-glass shaped), with fine teeth. Style 4–5 times as long as wide; accessory seta further from apex than length of seta.

MATERIAL EXAMINED

Egypt. 2 ♂, 4 ♀, Gaza, vii.1940 (*O. Theodor*).

DISTRIBUTION. Yugoslavia, Turkey, Lebanon, Syria, Israel, Cyprus, Egypt, Iraq, Iran, Pakistan, N. India, Afghanistan. This is the first record of this species from Egypt.

Sergentomyia tiberiadis (Adler, Theodor & Lourie)

(Figs 74–77)

Phlebotomus tiberiadis Adler, Theodor & Lourie, 1930: 537 [♂♀]. Lectotype ♀, PALESTINE (BMNH), designated by Lewis & Büttiker (1982: 367).

This species is currently placed in the subgenus *Sintonius*.

FEMALE. Head narrow. Cibarium with straight row of about 16 strong, curved, closely packed horizontal teeth; these characteristic teeth may appear straight in some poorly mounted specimens; two or three rows of distinct vertical teeth; pigment patch broad, almost as wide as tooth row (Fig. 77). Pharynx slender with barely discernible armature in form of transverse striations. Spermatheca with 6–8 segments.

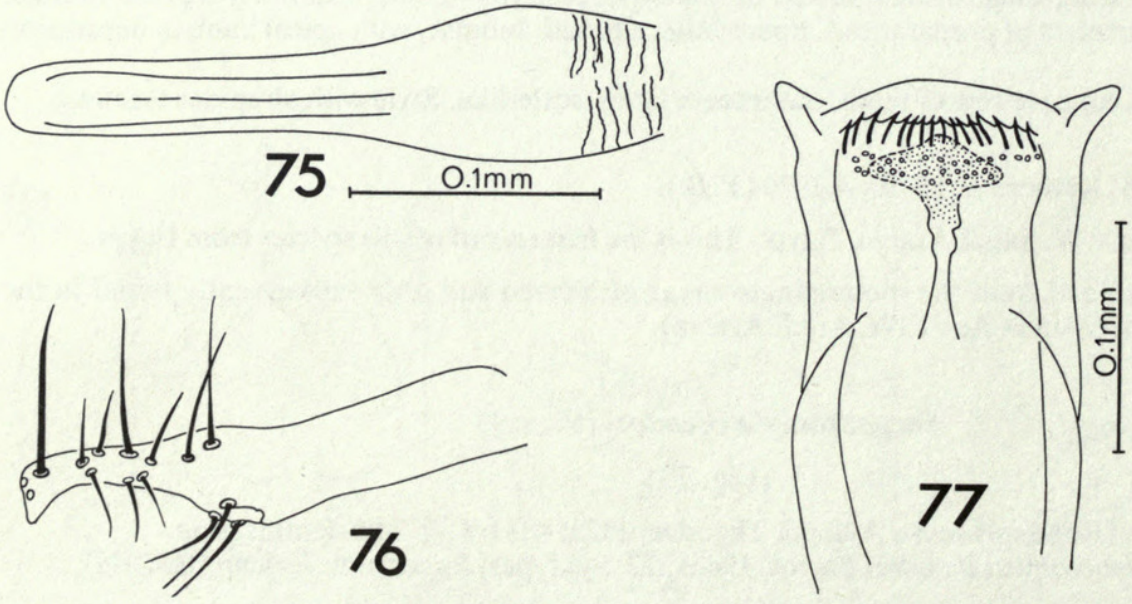
MALE. Cibarium with a row of 12–14 curved horizontal teeth and one or two rows of vertical teeth (Fig. 74); pigment patch vague, almost as wide as tooth row. Pharynx slender, gently narrowing after bulge; armature a series of indistinct ridges (Fig. 75). Paramere with distinct beak apically (Fig. 76). Style with two apical, two subapical spines. Aedeagus slender, tapering from base.

MATERIAL EXAMINED

Egypt: 1 ♂, Aswan Governate, Aswan, Elephantine Island, 3–5.x.1983, sticky traps amongst rocks (*R.P.L.*); 2 ♂, Aswan, xi.1967 (*M.A.R.*); 2 ♂, Luxor, 8.xi.1966 (*Z.A.H.*).

DISTRIBUTION. Egypt, Israel, Djibouti, Ethiopia, South & North Yemen, Sudan. Rifaat *et al.* (1968) record this species from Egypt but give no specific locality.

This species is easily distinguished from *S. christophersi* and *S. clydei* by the shape and number of cibarial teeth in the male and female. The Oriental subspecies *S. tiberiadis pakistanica* Artemiev & Saf'yanova differs from the nominate subspecies in the spermathecal capsule which narrows towards the tip and has more segments (9–12), and the lower mean number of cibarial teeth (13 compared to 17–18). The subspecies *pakistanica* is restricted to Pakistan and Afghanistan.



Figs 75–77 *Sergentomyia tiberiadis*. 75, ♂, pharynx; 76, paramere; 77, ♀, cibarium. (Aswan.)

Faunal associations

Based on the distributions of sandflies collected in Egypt and described above, the fauna can be divided into three distinct elements. Each element has affinities to faunas in areas outside Egypt and these are discussed below and compared to the distribution of other insects.

Elements of the Egyptian sandfly fauna

Each of the three faunal elements is composed of a characteristic, although not mutually exclusive, group of species. The areas occupied by these three faunal elements are:

Mediterranean/Lower Egypt element: coastal Egypt, Siwa Oasis, the Delta and Nile valley as far south as Asyut, and northern Sinai.

Upper Egypt: Nile valley to Lake Nasser and the oases of Bahariya, Farafra, Dakhla and Kharga.

S. Sinai: the mountain system from Gebel el Igma southwards to Sharm el Sheikh.

The fauna of the mountainous southern Sinai is clearly distinct from that of northern Sinai, which has a typical lowland Middle Eastern fauna composed of *P. papatasi* and *S. antennata*.

The species representing each of the three faunal elements are listed on pages 4–5. All are restricted to their component areas except *P. papatasi, P. sergenti* and *S. palestinensis*, which are widespread in distribution. *P. papatasi* is the only species found predominantly in peridomestic habitats.

Clearly, this division of the fauna into three elements is greatly influenced by the distribution of collecting sites, and at present it is not possible to delimit precisely each area. For example, the Upper Egypt component is based on collecting around Aswan and in the Kharga and Dakhla oases, but the extent to which the species of this area penetrate northwards along the narrow riverine vegetation to Beni Suef and Faiyum in Lower Egypt is unknown. The faunas of Upper and Lower Egypt (including northern Sinai) are more similar (i.e. have more species in common) to each other than either is to the southern Sinai fauna, presumably because of the Nilotic connection suggested above, and the presence of high mountains in southern Sinai and associated habitats not available in the rest of Egypt. Several geographically important areas need to be surveyed to complete the faunistic picture of Egyptian sandflies, particularly the remote wadi systems of the southern Sinai and Upper Egypt, the oases of Siwa and Farafra, and the Red Sea Hills.

The largest and most diverse faunal component in Egypt is that of the southern Sinai, with 12 species (6 *Phlebotomus*, 6 *Sergentomyia*) compared to the six (1 *Phlebotomus*, 5 *Sergentomyia*) found in Upper Egypt and eight (3 *Phlebotomus*, 5 *Sergentomyia*) in the Mediterranean/Lower Egypt component.

It is not clear which environmental factors have the greatest effect on the distribution of different sandfly species, although it is clear that some species have a marked association with a particular habitat. Vegetation affects sandfly distribution indirectly through its effect on the hosts of sandflies, which can be either carnivores (dogs, foxes etc.), herbivores (rodents) or man and domestic animals (goats, poultry). However, the presence of some plants may be important as sources of sugar meals for the adults. The shade provided by vegetation probably has a minimal direct effect on sandfly distribution as sandflies rarely use plants as resting sites (e.g. tree holes) in arid regions, although vegetation structure clearly has an effect on some sandfly hosts. Temperature has some rôle in governing distribution because some species found in the high mountains of the southern Sinai (e.g. Gebel Katherina which rises to 2637 m) are exposed, during the winter snowfall, to low temperatures which would be fatal to other species.

Association of Egyptian fauna with neighbouring areas

Throughout this discussion, the affinity of the different elements of the Egyptian fauna with the faunas of neighbouring areas is measured by the number of species they share. Figs 78–80

summarise the proportion of each faunal element found in seven neighbouring areas. Several factors affect these estimates of affinity, including the number of species in a faunal element, differences in the taxonomic status of a species (e.g. *S. cintus* is treated as a distinct species here but as a synonym by some authors) and differences in sampling (some areas are better known than others). Hence, such estimates, like so many others which take no account of relative abundance of species or the range of habitats available in an area, can only be used to give a general impression of the affinity of faunas.

The Southern Sinai is known as an area of endemicity in some groups, e.g. Lepidoptera and Orthoptera, but it does not have any endemic sandflies. However, the Sinai populations of some species show subtle morphological differences from populations in other parts of their range, e.g. *P. orientalis* and *P. major*. More refined taxonomic techniques may demonstrate substantial differences. the lack of endemicity in sandflies may be because the group is well adapted, even common, in arid areas and therefore the deserts of the region do not pose a very significant barrier to dispersal and introgression of populations as they do in most other groups of insects.

The sandfly fauna of the southern Sinai shows a marked affinity with the fauna of the Arabian Peninsula (see Lewis & Buttiker, 1982), particularly Asir, Yemen (*in* Lewis, 1974*b*) and, to a lesser but still significant extent, to the highlands of eastern Africa (Table 4; Fig. 80). The mountains of the southern Sinai represent an isolated part of a tongue of the Afrotropical Region extending northwards to the end of the Rift Valley System in northern Israel (Upper Galilee). The principal species indicating this association are *P. arabicus, P. orientalis, P. kazeruni, S. taizi* and *S. adleri*, which dominate the fauna of south-west of the Arabian Peninsula and are closely related to species in the Afrotropical Region. The absence of the common Palaearctic *P. papatasi* further supports this association and the conclusion that sandflies of these highland areas are a distinct part of the Afrotropical fauna and not a relict intrusion of the Palaearctic fauna. *S. taizi* has only been found in the mountains of Yemen (near Ta'izz) and at the top of Gebel Katherina. Unlike parts of the sandfly fauna of the Arabian Peninsula, the Sinai fauna does not contain any Oriental species, although some species are east European/west Asian (*P. alexandri, P. kazeruni*). Therefore the southern Sinai does not constitute part of the Triad Zone as defined by Lewis & Büttiker (1980).

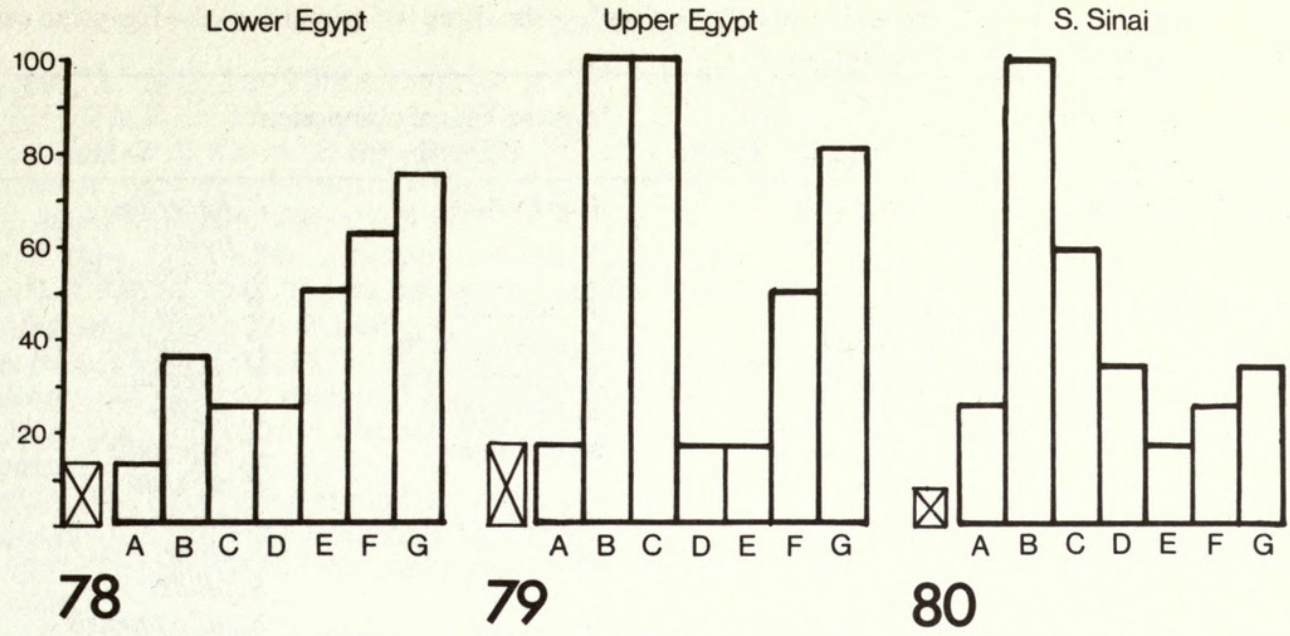
The sandfly fauna of Upper Egypt has affinities with both the Arabian peninsula and the Sahel of Africa, through species such as *S. christophersi, S. clydei, S. adleri, S. schwetzi* and *S. tiberiadis* (Table 4; Fig. 79). *P. papatasi* is not typically African and its presence in Upper Egypt is part of a southernly extension of its range along the Nile Valley as far as northern Sudan.

Sandflies of Lower Egypt and the northern Sinai are typical of the North African and eastern Mediterranean faunas (Table 4; Fig. 78). The rarity of *P. langeroni* has already been noted (p. 11). Its presence in Egypt indicates that it may be widely distributed along the North African coast, perhaps in association with outcrops of limestone which are such a feature of the area in Egypt where it is comparatively common. *S. squamipleuris* is a member of a species group widely distributed along a band south of the Sahara, through the Arabian Peninsula and into northern India. Its presence in Lower Egypt represents a northerly extension of its range, in contrast to that postulated above for other species (e.g. *P. papatasi*). *S. squamipleuris* is more rigidly confined to the riverine vegetation along the Nile than are many other sandflies, where it feeds on amphibians.

Distribution of insects other than sandflies

The comparison of distribution patterns of sandflies with those of other biting flies (Simuliidae, Ceratopogonidae and Culicidae) is germane to understanding sandfly faunal associations, because these other flies also are influenced by the search for hosts. However, other biting flies are restricted environmentally by the need for free water (running water in Simuliidae) for the development of the immature stages.

The mosquito *Culex sinaiticus* Kirkpatrick was thought to be confined to southern Sinai, but was later found in Eritrea and northern Sudan (Red Sea coast around Port Sudan and in central Sudan) (Lewis, 1956), although it has not been found elsewhere in Egypt. A similar situation is found in *Culex arbieeni* de Meillon which is known from southern Sinai and the upper slopes of



Figs 78–80 Histograms showing the percentage of the species from Lower Egypt (78), Upper Egypt (79) and southern Sinai (80) which also occur in neighbouring areas.
A = east Saudi Arabia + Iran; B = south-west Saudi Arabia + Yemen + Ethiopia; C = Sudan; D = Sahel; E = north Africa; F = Israel; G = east Mediterranean. X = one species as percentage of total number in faunal element.

the Marra mountains in west Sudan (Lewis, 1954). In the Simuliidae, only two species are known from Egypt. *Simulium griseicolle* Becker which breeds in large rivers in Africa, has only been found once in Egypt, at Aswan, its type-locality. The second species, *Simulium ruficorne* Macquart, has a very wide distribution throughout the savannah areas of Africa (south of the Sahara), North Africa, Spain and African islands. It is not clear whether it is an Afrotropical or Palaearctic species but it probably represents a species complex. Specimens of *S. ruficorne* from Feiran Oasis in southern Sinai are similar in their pupal gill structure (Crosskey, pers. comm.) to specimens from Israel and the Hejaz. Unfortunately very little is known of the Egyptian Ceratopogonidae, particularly *Culicoides*, but the known fauna, based on collecting in the Delta, is Palaearctic. Thus the faunal associations of other biting flies are broadly concordant with those of the Egyptian sandflies, showing connections between Sinai and the Afrotropical Region, and Lower Egypt and the Palaearctic Region.

As noted above, southern Sinai is a known area of endemicity in other insect orders. For example, Uvarov (1929) studied a small collection of Orthoptera from southern Sinai and drew the following conclusions: 'in general composition the known fauna of the Sinai peninsula is clearly a local division of the Palaearctic eremian fauna . . . it possesses certain features of its own [endemics]. The Sinai peninsula must be regarded as one of the dry mountainous centres where an ancient Mediterranean fauna survives, where the present eremian fauna was born and developed and from where it spread over the whole great desert belts . . . the Sinai fauna has a close similarity, perhaps an intimate relation to that of Arabia' [although at the time the latter fauna was very poorly known].

In a comprehensive account of the biogeography of Arabian butterflies, Larsen (1984) makes relatively little comment on the Egyptian fauna other than that it is typical of the 'Palaearctic eremic zone'. However, there are several endemic species of butterflies in the southern Sinai massif.

In conclusion, the sandfly fauna of Egypt is exceptional, compared to the sandfly fauna of other countries, in being so clearly divided into Afrotropical and Palaearctic elements. Whether Egypt and surrounding areas have always been a point of faunal exchange of sandflies between the two zoogeographic regions, with the Nile valley and the mountains of the Red Sea coast and Sinai acting as major dispersal routes, is not clear. Lewis (1982) has suggested that the genus *Phlebotomus* is Palaearctic in origin and subsequently extended southwards into Africa during the pluvial periods, presumably through the Nile and Rift valleys. However, the Sahara desert

Table 4 Comparison of the species shared between each of the three components of the Egyptian sandfly fauna and the faunas of neighbouring areas.

Neighbouring area	Egyptian faunal component		
	Lower Egypt	Upper Egypt	S. Sinai
E. Saudi Arabia/Iran	*P. papatasi*	*P. papatasi*	*P. kazeruni* *S. fallax* *S. christophersi*
SW. Saudi Arabia/Yemen/ Ethiopia	*P. papatasi* *P. sergenti* *S. cincta*	*P. papatasi* *S. christophersi* *S. palestinensis* *S. schwetzi* *S. tiberiadis*	*P. arabicus* *P. alexandri* *P. kazeruni* *P. major* *P. orientalis* *P. sergenti* *S. adleri* *S. clydei* *S. fallax* *S. palestinensis* *S. schwetzi* *S. taizi*
Sudan	*P. papatasi* *S. cincta*	*P. papatasi* *S. christophersi* *S. palestinensis* *S. schwetzi* *S. tiberiadis*	*P. orientalis* *S. adleri* *S. christophersi* *S. clydei* *S. fallax* *S. palestinensis* *S. schwetzi*
Sahel	*S. antennata*	*S. schwetzi*	*P. orientalis* *S. adleri* *S. clydei* *S. schwetzi*
North Africa	*P. langeroni* *P. papatasi* *P. sergenti* *S. minuta*	*P. papatasi*	*P. alexandri* *S. fallax*
Israel	*P. papatasi* *P. sergenti* *S. theodori* *S. antennata*	*P. papatasi* *S. palestinensis* *S. tiberiadis*	*P. alexandri* *P. sergenti* *S. fallax*
E. Mediterranean	*P. papatasi* *P. sergenti* *S. theodori* *S. antennata* *S. squamipleuris* *S. minuta*	*P. papatasi* *S. palestinensis* *S. squamipleuris* *S. tiberiadis*	*P. alexandri* *P. sergenti* *S. fallax* *S. palestinensis*

has not always been such a barrier to dispersal and possibly, in an arid-adapted group such as the sandflies, substantial dispersal may have taken place either through or around the Sahara. A more comprehensive study of sandflies throughout the whole of the Eremic Zone (Morocco to Afghanistan) is required to answer these questions fully.

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Invalid names are in *italics*; principal references are in **bold**.