

The Palaearctic species of Curtonotidae (Diptera: Schizophora), with special reference to the fauna of Israel

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Abstract

Species of the family Curtonotidae occurring in the Palaearctic Region are reviewed. Diagnoses of the family Curtonotidae and the genus *Curtonotum* MACQUART based on adults are presented. The two species of *Curtonotum* now known to occur in the region, viz. *C. anus* (MEIGEN) and *C. simile* TSACAS, are keyed and figured, and confirmatory characters are provided to separate them. The species-group associations of both are discussed, as is the zoogeographic significance of their occurrence in Israel. A distribution map is provided for that country, and *C. anus* is recorded from Pakistan in the Oriental Region for the first time.

Key words: *Curtonotum*, Curtonotidae, Ephydroidea, Palaearctic, key, Israel.

Introduction

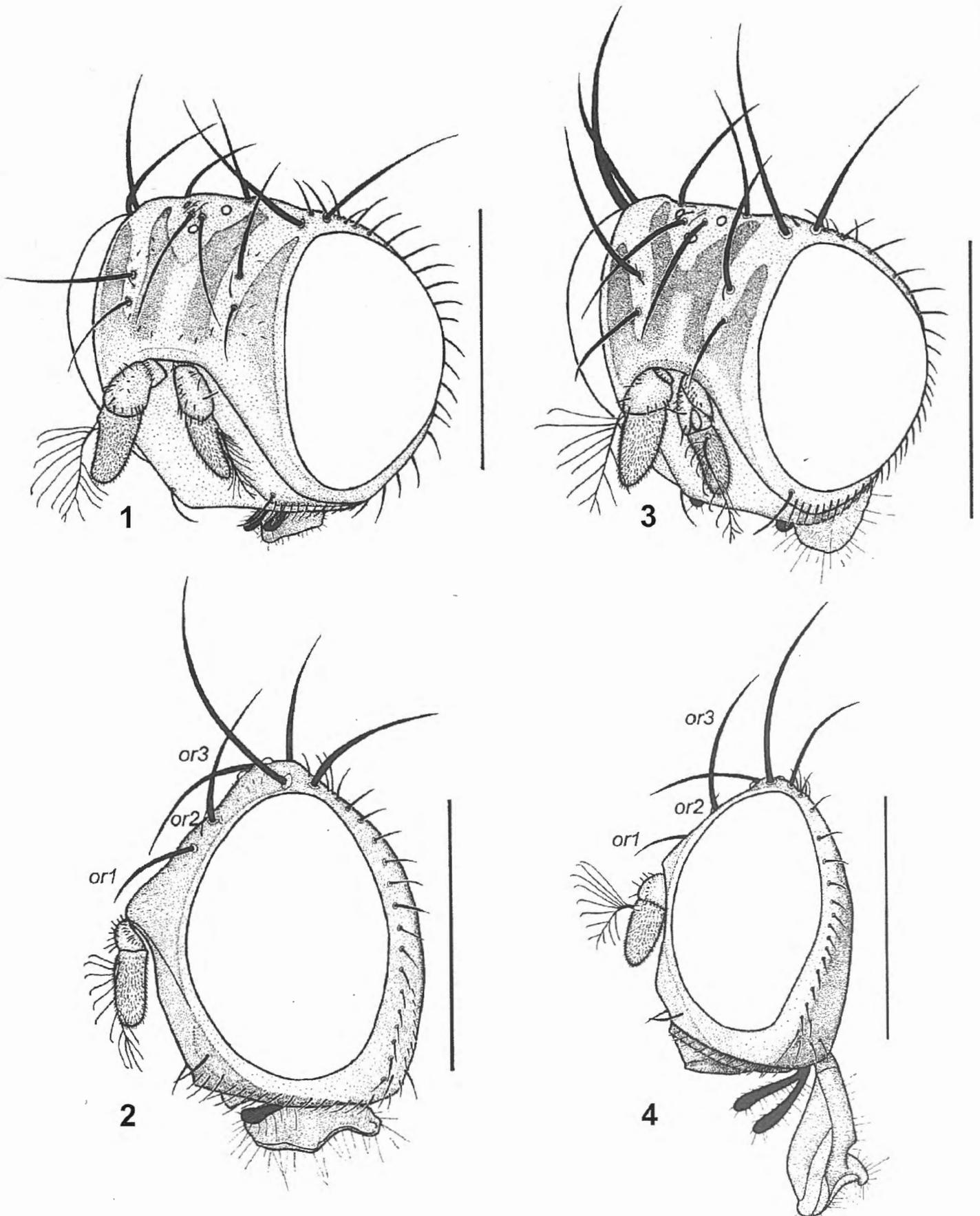
The acalyprate family Curtonotidae comprises three genera worldwide: *Curtonotum* MACQUART, 1844, which occurs in all zoogeographic regions, excepting the Australasian/Oceanian Region, *Axinota* VAN DER WULP, 1886, occurring in the Oriental, Australasian/Oceanian Regions and Madagascar, and *Cyrtona* SÉGUY, 1938, which is restricted to the continental Afrotropical Region. These genera are most speciose in the tropical and subtropical regions of the world, *Curtonotum* being the only genus recorded thus far from the Palaearctic Region.

Species of the family have been assigned to various families in the past, including the Diastatidae, Drosophilidae, Ephydriidae, Heleomyzidae and Opomyzidae (as Geomyzidae) (MCALPINE 1987 for review), but contemporary workers appear unanimous in regarding the Curtonotidae as a monophyletic group with familial rank (e.g. GRIFFITHS 1972; HENNIG 1958, 1971; MCALPINE 1989). The family is now placed in the Ephydroidea, along with the families Camillidae, Diastatidae, Drosophilidae and Ephydriidae.

The Ephydroidea is a reasonably well-supported monophyletic group, being the least controversial taxon ranked as a 'superfamily' in the acalyprate flies (GRIFFITHS 1972; HENNIG 1958, 1971; MCALPINE 1989; MEIER *et al.* 1997). A recent study of the immature stages of three species of *Curtonotum* has supported suggestions that the Curtonotidae is the sister group to the remainder of the Ephydroidea and is probably most closely-related to the Camillidae, with which it shares numerous larval features (KIRK-SPRIGGS submitted).

Only a single compression fossil has been reported, *Curtonotum* †*gigas* THEOBALD, 1937 (EVENHUIS 2006), but a recent review has established that this fossil does not represent a species of Curtonotidae and is now regarded as *insertae sedis* (KIRK-SPRIGGS 2007). Amber fossils are yet to be discovered.

The biology of the family is poorly known, and the immature stages and biology are only known for three species of the genus *Curtonotum* (GREATHEAD 1958; KIRK-SPRIGGS submitted; MEIER *et al.* 1997). Adults of African species frequently roost in the burrows of mammals, especially those of aardvark, warthog and porcupine, and other shaded situations such as hollow trees, overhangs in dry riverbeds and beneath bushes and shrubs (MEIER *et al.* 1997; TSACAS 1977 for review). There is no evidence of any direct association with these mammals or their dung, and adults probably roost in such situations to avoid daytime heat. Evidence from the Nearctic species, *C. helvum* (LOEW, 1862a), and African species of the genus indicates that they are probably crepuscular or nocturnal (KIRK-SPRIGGS submitted; MEIER *et al.* 1997). The biology and immature stages of the genera *Axinota* and *Cyrtona* remain entirely unknown, although at least one undescribed species of *Cyrtona* from Zimbabwe is known to be oviviviparous, retaining the larvae in a brood pouch prior to larviposition (POLLOCK 1996). Species of *Curtonotum* and *Axinota* are, however, oviparous.



Figs 1-4 — Head. 1-2 — *Curtonotum anus* (MEIGEN) (Murtaza Abad, Pakistan) 1. fronto-lateral view; 2. lateral view [right *or3* and left inner vertical setae bent anteriorly]. Figs 3-4 — *C. simile* TSACAS (Assab, Eritrea) 2. fronto-lateral view; 3. lateral view. Scale bars = 1 mm.

Two desert species of *Curtonotum* are known to be associated with the egg pods of Acrididae (Orthoptera) in Africa and the Middle East, namely *C. sahelense* TSACAS, 1977 and *C. simile* TSACAS, 1977 (see below), their larvae developing in damaged egg pods as scavengers (GREATHEAD 1958; KIRK-SPRIGGS submitted), and a larva of *C. helvum* was also reared on grasshopper egg pods in the laboratory (MEIER *et al.* 1997). The Palaeartic species, *Curtonotum anus* (MEIGEN, 1830), is prone to the attack of Laboulbeniales (Ascomycetes) parasitic on Diptera (ROSSI 1993).

Until recently only a single species of the genus *Curtonotum*, *C. anus*, was known to occur in the Palaeartic Region, and the majority of workers have used DUDA (1934) and later PAPP (1984) for the identification of the species. FREIDBERG (1988) recorded the family Curtonotidae for the first time from Israel, citing two species from that country, the European *C. anus* and a second species that was then suspected to be undescribed. FREIDBERG noted that the distribution of the two species in Israel was parapatric, with *C. anus* being more northern, and the second species more southern. Later László PAPP (HNHM) identified Israeli specimens of the second species as *C. simile* (as *C. similis*), representing a second confirmed species of Curtonotidae for the Palaeartic Region. He noted the occurrence of the species in that region in the 'Manual of Palaeartic Diptera' (PAPP 1998).

These two species are the only species of Curtonotidae which are known to occur in more than one zoogeographical region: *C. anus* in the Palaeartic and Oriental Regions (here recorded for the first time from Pakistan), and *C. simile* in the Palaeartic and Afrotropical Regions.

The distribution of these two species in Israel is significant as they typically demonstrate the unique zoogeographic position of Israel as a 'crossroads' between several zoogeographical regions (FURTH 1975; POR 1975). Central Israel comprises both the southernmost locality known for the predominantly European *C. anus* and the northernmost locality for the Afrotropical *C. simile*.

This paper provides a key to the species of *Curtonotum* known to occur in the Palaeartic Region and presents previously under-appreciated characters for the separation of the two species.

Material and Methods

Figures 1–6 were prepared from images captured with a Leica E24U binocular microscope with a built-in

digital camera. These were traced and the details added by hand. Male sternites, male terminalia and female abdomens were macerated in 10% potassium hydroxide (KOH) for five minutes, then transferred to alcohol with a few drops of glacial acetic acid, and were viewed and drawn in a blob of heated and set glycerol jelly. Figures 7–20 were prepared using a Wild M5-94286 binocular microscope with a *camera lucida* attachment. Images were enlarged and traced, and details added by hand. These figures were digitised as 600 dpi TIFF files and were edited, arranged into plates and labelled using the program Corel Draw Version 11. All figures were prepared from dry-pinned specimens. Scale bars were added using a Zeiss 0.01 mm graticule slide.

Bilaterally symmetrical structures are described in the singular. Type label data are quoted exactly as they appear. A division slash (/) denotes the commencement of a new line, two division slashes (//) data on a further label. Significant supplementary or qualifying information is presented in square brackets when considered necessary. Information on label colour, etc. is provided only for holotypes.

'Fig.' or 'Figs' as cited in the text refers to figures cited in this paper; 'fig.' or 'figs' to figures in other publications.

Terminology of the external morphology follows, for the most part, that of the interactive *Anatomical Atlas of Flies* (YEATES *et al.* 2004). For head setae not defined in that work, terminology follows BARRACLOUGH (1995: 100), and abbreviations for fronto-orbital setae follow TSACAS (1977: 148). The terminology of male and female terminalia follows MARSHALL *et al.* (in press) and SINCLAIR (2000).

Abbreviations used in the text and on the figures: *bp* = basiphallus; *ce* = cercus; *dp* = distiphallus; *ea* = ejaculatory apodeme; *ep* = epandrium; *or1* = anterior proclinate orbital seta; *or2* = medial reclinate orbital seta; *or3* = posterior reclinate orbital seta; *pg* = postgonite; *ph* = phallapodeme; *S10* = abdominal sternite 10; *S4–S6* = abdominal sternites 4–6; *S5–S8* = abdominal sternites 5–8; *sp* = spermathecae; *ss* = surstylus; *T5–T8* = abdominal tergites 5–8.

Material used in the study was obtained from the following institutions (curators are named in parenthesis):

- BMNH: Natural History Museum, London, United Kingdom (Nigel WYATT)
- HNHM: Hungarian Natural History Museum, Budapest, Hungary (Mihály FÖLDVÁRI)
- MNHN: Muséum national d'Histoire naturelle, Paris, France (Christophe DAUGERON)
- MZLU: Museum of Zoology, Lund University, Lund,

Sweden (ROY DANIELSSON)

NMW: Naturhistorisches Museum Wien, Vienna, Austria (Peter SEHNAL)

NMWC: National Museum and Gallery of Wales, Cardiff, United Kingdom (John DEEMING, Mark PAVETT)

TAU: Tel Aviv University, Tel Aviv, Israel (Amnon FREIDBERG)

ZMHB: Museum für Naturkunde der Humboldt-Universität, Berlin, Germany (Joachim ZIEGLER)

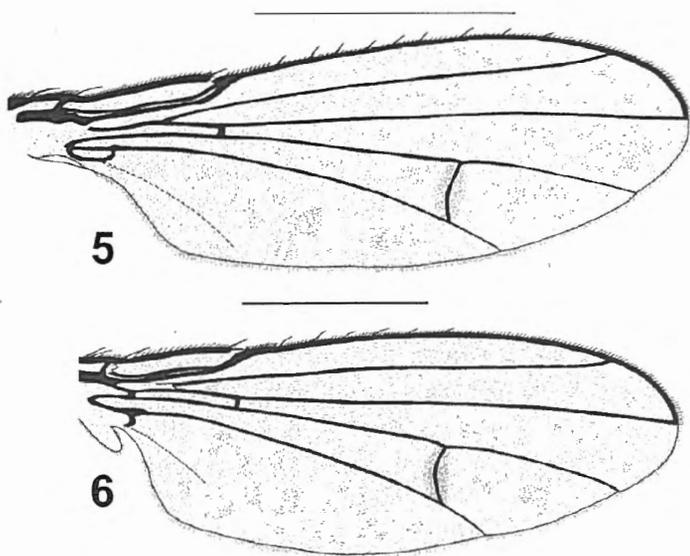
ZMUC: Zoological Museum, University of Copenhagen, Denmark (Jan PEDERSEN, Thomas PAPE)

Systematics

Family: **Curtonotidae** DUDA, 1924

Adults of the family Curtonotidae can be diagnosed as follows (based on MARSHALL *et al.* (in press), with amendments). *Curtonotum* is the only genus recorded as occurring in the Palaearctic Region and a diagnosis of that genus is presented below.

DIAGNOSIS: Small to medium-sized (4–10 mm), distinctively robust flies, with a hump-backed, drosophilid- or heleomyzid-like form, usually greyish to yellow, often with spots, strips or irrorations on the



Figs 5-6 — Wing. 5 — *Curtonotum anus* (MEIGEN) (Murtaza Abad, Pakistan). Fig. 6 — *C. simile* TSACAS (Assab, Eritrea). Scale bars: 5 = 2 mm; 6 = 1 mm.

thorax and pigment patterns on the abdomen. Arista plumose, with long dorsal and ventral rays; rays varying in number. Wing pigmentation varying from hyaline to lightly fumose (especially on *r-m* and *dm-cu* crossveins), or boldly patterned; subcosta complete, cell *cup* present, cells *dm* and *bm* confluent, and costa (*c*) with humeral and subcostal breaks. Abdomen with aedeagus enlarged, C-shaped, distiphallus anteroventrally-directed; two spermathecae present.

GENUS: *Curtonotum* MACQUART, 1844: 193 (350)

Type-species: *Musca gibba* FABRICIUS, 1805 (preoccupied, = *Curtonotum taeniatum* HENDEL, 1913), by original designation)

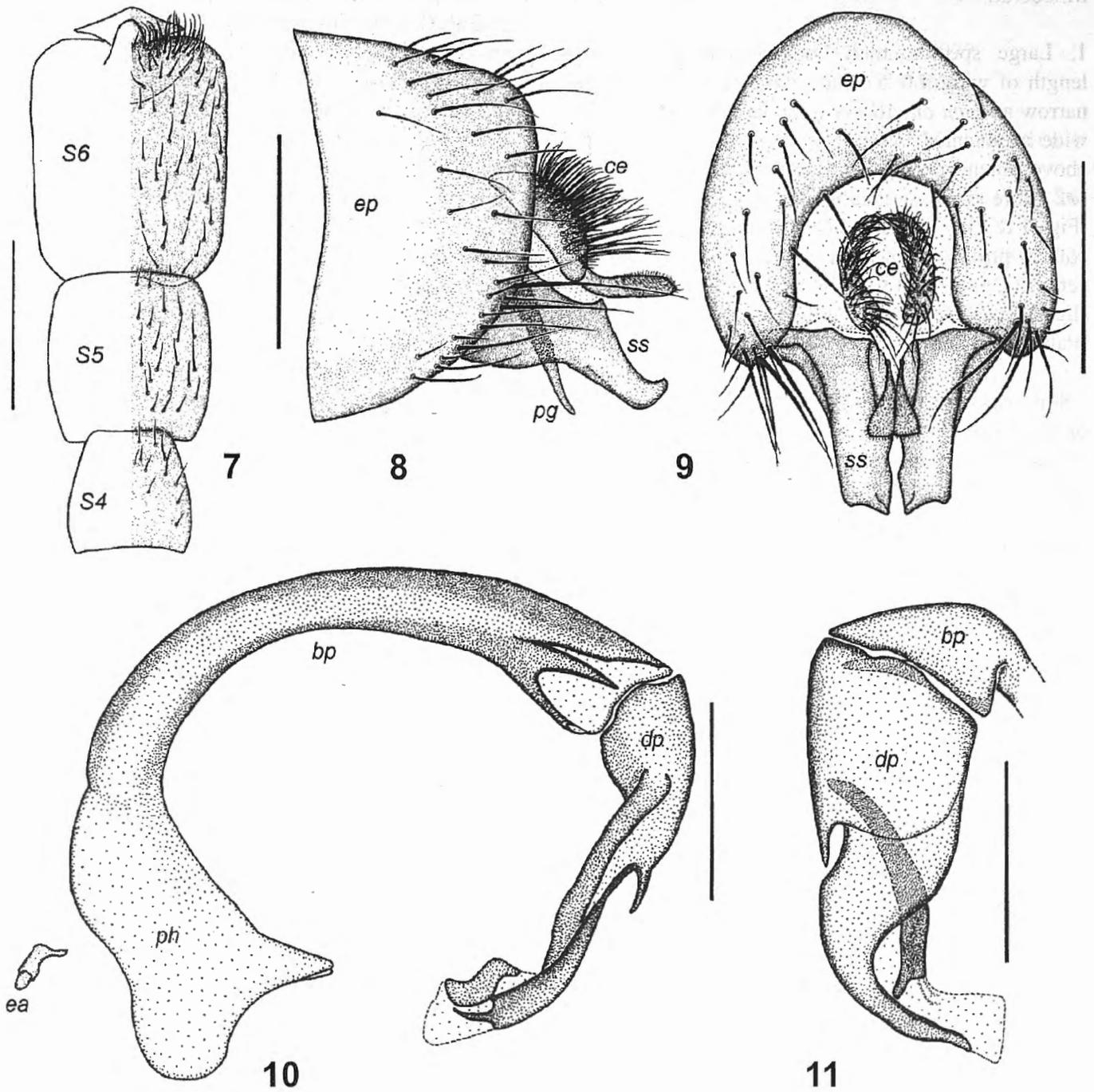
= *Cyrtonotum* AGASSIZ, 1847: 108, 114 (unjustified emendation of *Curtonotum*)

= *Diplocentra* LOEW, 1862b: 13 ([unnecessary] replacement name for *Curtonotum* MACQUART)

= *Parapsinota* DUDA, 1924: 177 (Type-species: *Drosophila angustipennis* DE MEIJERE, 1911, by monotypy)

The genus *Curtonotum* can be diagnosed as follows (based on TSACAS (1977), with amendments):

DIAGNOSIS: *Head* (Figs 1–4): with two pairs of long, prominent fronto-orbital setae, the anterior pair (*or1*) proclinate, the posterior pair (*or3*) reclinate, with a minute reclinate seta (*or2*) positioned between them, close to base of *or3*; frons wide in both sexes. *Thorax:* Scutum more-or-less hump-backed in appearance, with a pair of strong dorsocentral setae and one pair of acrostichal setae; anepisternum with 2–3 long setae and some short setae; one very long katepisternal seta accompanied by a short anterior one. *Scutellum:* entirely covered in setulae, with two pairs of strong marginal setae. *Wing* (Figs 5 & 6): greyish to grey-brown infusate, *dm-cu* crossvein usually markedly infusate; costa (*c*) with humeral and subcostal breaks, and with a variable number of prominent costal spines beyond R_1 longer and stronger than adjacent vestiture. *Legs:* all tibiae with preapical dorsal setae; forefemur with row of short, but strong spinules posteroventrally along distal half or third, variable in number. *Abdomen:* long, cylindrical, generally pale in colour with brown spots or T-shaped inverted lateral markings. Basiphallus and distiphallus fused and asymmetrical. Spermathecae flattened, short and obclavate with a folded or rugose surface or long, tubular and studded with protuberances.



Figs 7-11 — *Curtonotum anus* (MEIGEN) Male (Park HaYarden, Israel) 7. abdominal sternites 4-6; 8. epandrium, lateral view; 9. same, posterior view; 10. phallus, lateral view; 11. junction between basiphallus and distiphallus, anterior view. Abbreviations: *bp* = basiphallus; *ce* = cercus; *dp* = distiphallus; *ea* = ejaculatory apodeme; *ep* = epandrium; *pg* = postgonite; *ph* = phallapodeme; *ss* = surstylus; *S4-S6* = abdominal sternites 4-6. Scale bars: 7 = 0.6 mm; 8-11 = 0.3 mm.

Key to the Palaearctic species of *Curtonotum*
MACQUART

1. Large species, total body length 4.5–7.5 mm, length of wing 4.0–6.5 mm; wing (Fig. 5) with alula narrow and *dm-cu* crossvein moderately straight; frons wide at antennal bases (Fig. 1), projecting anteriorly above antennae (Fig. 2), sub-parallel sided (Fig. 1); *or2* more or less equidistant between *or1* and *or3* (Figs 1 & 2); ♂ sternite 6 (Fig. 7, *S6*) developed into a conical protuberance flanked by semi-erect setulae; ♀ cercus (Figs 17 & 18, *ce*) with strong, erect and blunt, slightly posteriorly-directed spines on dorsal surface (Palaearctic and Oriental Regions) *C. anus* (MEIGEN)
- Small species, total body length 3.5–6.5 mm, length of wing 3.0–5.0 mm; wing (Fig. 6) with alula slightly expanded and *dm-cu* crossvein moderately curved; frons at antennal bases narrow and constricted (Fig. 3), not projecting anteriorly (Fig. 4), *or2* more closely approximated to base of *or3* (Figs 3 & 4); ♂ sternite 6 (Fig. 12, *S6*) simple, with indented dove-tailed insertion; ♀ cercus (Figs 19 & 20, *ce*) simple with fine erect setae on dorsal surface (Afrotropical and Palaearctic Regions) *C. simile* TSACAS

Curtonotum anus (MEIGEN, 1830)
(Figs 1 & 2, 5, 7–11, 17 & 18)

Diastata anus MEIGEN, 1830: 95 (Type locality: not provided)

= *gibbum* (PERRIS, 1839: 50) (*Helomyza*) (Type locality: 'Circa Mont-de-Marsan (Landes)' [France].

= *perrisi* SCHINER, 1864: 23 (*Curtonotum*, as *perrisii*, new name for *gibbum* (PERRIS 1839) not FABRICIUS 1805)

Curtonotum anus (MEIGEN): DUDA 1934, figs 1–4

Curtonotum anus (MEIGEN): PAPP 1984

Curtonotum anus (MEIGEN): PAPP 1998, figs 1–9

CONFIRMATORY CHARACTERS: Male sternite 6 (Fig. 7, *S6*) expanded laterally, subparallel-sided, with apical conical extension medially and irregular rows of overlapping long, fine setulae laterally, sternite 5 (*S5*) sub-quadrate, narrower than *S6*, sternite 4 (*S4*) narrowed from basal third, markedly narrower than *S5* apically; ♂ terminalia, epandrium (Figs 8 & 9, *ep*) long, evenly curved in profile, with three or four strong, parallel, anteriorly-directed setae inserted along ventral margin and some weaker setae interspersed; surstylus (Figs 8 & 9, *ss*) short and broad, parallel, curved dorsally and slightly notched apically (often visible in undissected

specimens); cercus (Figs 8 & 9, *ce*) with prominent setose projection curved dorsally, sub-triangular and divided (in posterior view); postgonite (Fig. 8, *pg*) short and prong-like, projecting from mid-length of surstylus; phallus (Figs 10 & 11) short, robust and broad, heavily sclerotised, with phallapodeme (*ph*) and basiphallus (*bp*) fused, forming a continuous arched, C-shaped structure, distiphallus (*dp*) extremely broad and robust (in posterior view), with characteristic apical shape as illustrated, ejaculatory apodeme (Fig. 10, *ea*) apparently sub-divided and short, with basal extension.

Female abdomen (Figs 17 & 18) with tergites and sternites heavily sclerotised, *S5* (in ventral view) long and narrow, *S6* (in ventral view) relatively long, narrowed basally, expanded apically, *S7* sub-quadrate, cercus (*ce*) comprising pseudacanthophorite (FREIDBERG & BESCHOVSKI 1996), bearing a series of short, blunt, overlapping, slightly posteriorly-directed spines (those towards apex larger and more pointed in some specimens), *S8* in form of ventrally-directed, semi-circular, hirsute process, 'stem' (termed 'apodeme of hypoproct' by PAPP (1998)) clearly visible through cuticle, *S10* in form of a short blunt, hirsute process, spermathecae (Fig. 17, *sp*) elongate, narrowed basally, with bluntly pointed apex.

DIFFERENTIAL DIAGNOSIS: This species is most closely related to the Nearctic species, *C. helvum*, also included in the *anus* species-group (see 'Discussion' below). It is separable on the structure of the male and female terminalia (MCALPINE 1987: 1008, figs 2 & 3).

TYPE MATERIAL EXAMINED: *Diastata anus* MEIGEN, 1830. Holotype male, [ITALY] "*Helomyza / anus* Mn / Italia [handwritten; faded yellow card] // *Curtonotum* ♂ / *anus* (MEIGEN, 1830) / det. A.H. Kirk-Spriggs 2007 [printed]" (ZMUC). Direct-pinned, in good condition, not dissected.

Curtonotum perrisi SCHINER, 1864. Holotype female, "*Perisii* Schi. [handwritten] // Schiner / 1869 [printed] // Type [printed on red card]; *C. anus* Mg / ♀ d. Duda // *Curtonotum* ♀ / *anus* (MEIGEN, 1830) / det. A.H. Kirk-Spriggs 2007 [printed]" (NMW). Direct-pinned. Condition: good: cracked along lateral margins of thorax.

OTHER MATERIAL EXAMINED: [FRANCE]: 1♀, Cavaliere [=Cavaliere-dur-Mer, 43°10'00"N, 06°31'60"E] (Var.), VI [19]06, Muséum Paris, France, Var. Dr. VILLENEUVE, *Curtonotum perrisi* Schin = *anus* Meig., det. Dr. VILLENEUVE (MNHN). [GREECE]: 1♀, Ile Thasos,

Aghia Marina [=Ayia Irini, 37°58'00"N, 24°28'60"E], 20.VIII.[19]61, Coll. L. TSACAS, Muséum Paris; 1♀, Rovies ile Eubeé Endroit humide Sous les Oliviers Littoral, 4.X.1957, Coll. L. TSACAS, *Cyrtotonotum anus* Meig. L. TSACAS det. [19]58, Muséum Paris (both MNHN); 1♀, Graecia, Samos, Ampelos [37°48'04"N, 26°48'12"E], 22.VI.[19]32, *Curtonotum anus* Meig. (NMW). **ISRAEL**: 2♂♂, 4♀♀, Park HaYarden [32°54.5'N, 35°37.5'E], 14.VI.1982, A. FREIDBERG; 1♂; 3♀♀, same, except: 16.VI.1982; 9♂♂, 6♀♀, same, except: 17.VI.1982; 14♂♂, 10♀♀, same, except: 18.VI.1982; 4♂♂, 1♀, same, except: 20.VI.1982; 5♂♂, 14♀♀, same, except: 24.VI.1982 [1♂, 1♀, HNHM]; 3♂♂, 1♀, same, except: 30.IX.1982; 1♀, same, except: 25.VII.1983, I. NUSSBAUM; 1♂, same, except: 27.IV.1984, A. FREIDBERG; 1♀, same, except: 27.IV.1984, I. YAROM; 1♂, same, except: 7.V.1987, A. FREIDBERG; 1♀, same, except: 7.V.1987, F. KAPLAN; 1♂, 3♀♀, same, except: 5.VIII.1988, A. FREIDBERG; 2♂♂, same except: 7.V.1997, A. FREIDBERG; 1♂, Tel Aviv [32°06'N, 34°49'E], 3.XI.1977, A. FREIDBERG, feeding on honeydew of aphids on *Phragmites* (all TAU). **[ITALY]**: 1♀, 13.VIII.[18]88, Handl., Tirolia, Sarche [=Sarche di Calavino, 46°02'60"N, 10°56'60"E], *C. anus* Mg. ♀ d. DUDA (NMW). **PAKISTAN**: 1♂, PAKISTAN: Hunza District, Murtaza Abad, 2220 m, 36°16'41"N, 74°35'53"E, 27.VII.2000, swept, coll. D.J. MANN (det. J. DEEMING, NMWC.). **[ROMANIA]**: 1♀, 46565 Ungureni [ca. 47°32'60"N, 23°56'60"E], Museum Paris, Th. BECKER 1902, *Diastata anus* Mg., det. BECKER (MNHN). **TURKEY**: 3♂♂, 2♀♀, Isparta, Kovada [ca. 36°54'45"N, 30°41'23"E], stream oak & *Platanus* woods 7.VII.1997, M.J. EBEJER (HNHM).

DISTRIBUTION: Palaeartic Region: Albania, Austria, France, Greece, Hungary, Israel, Italy, Moravia, Romania, Russia, Serbia, Slovakia, Turkey; Oriental Region: Pakistan.

BIOLOGY: DUDA (1934) notes that adults rest in shaded and cool situations beneath plants and have a laboured heleomyzid-like flight. A specimen (cited above) was collected in damp areas, beneath olive trees on the seashore in Greece. The numerous specimens collected at Park HaYarden (Israel) were almost all swept from the shady and muddy shore of the Jordan River within a range of 0.5–1 m from the waterline. The biology and larval habits of the species remain entirely unknown. Its closest relative, the Nearctic species, *C. helvum*, has been reared from grasshopper egg pods in the laboratory (MEIER *et al.* 1997), and given our current knowledge of the larval habits of two African species of

the genus, such a larval association can not be ruled out for this species.

Curtonotum simile TSACAS, 1977
(Figs 3 & 4, 6, 12–16, 19 & 20)

Curtonotum similis: TSACAS, 1977: 165, figs 10a–b (Type locality: Arabia)

Cyrtotonotum cuthbertsoni DUDA: GREATHEAD 1958: 36, figs 1–6, misidentification

Curtonotum simile TSACAS: WIRTH & TSACAS 1980: 672

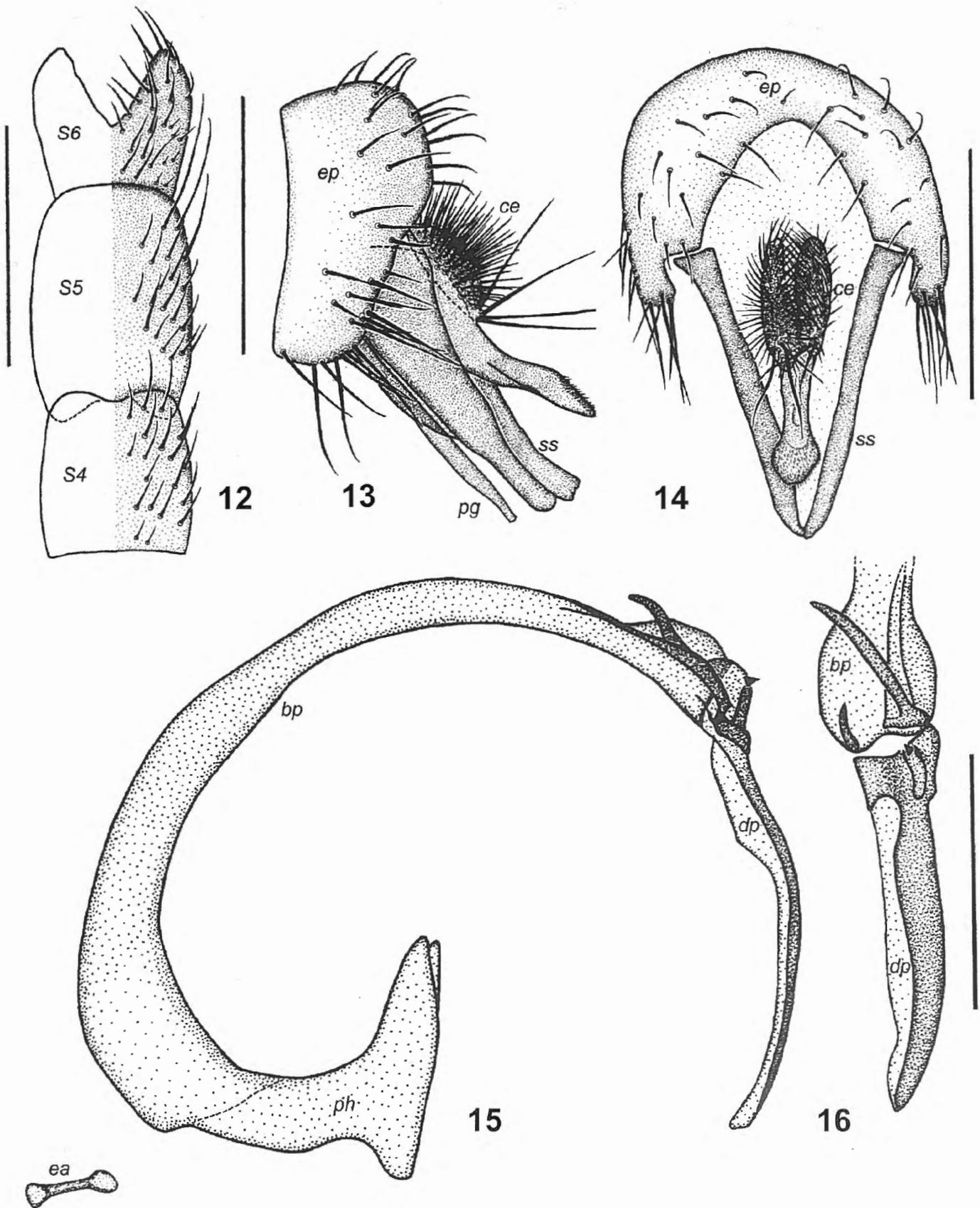
Curtonotum sp.: PAPP 1998, figs 10–12

Curtonotum simile: TSACAS: KIRK-SPRIGGS submitted, figs 13–19, 24, 25, 31, 35–37

CONFIRMATORY CHARACTERS: Male sternite 6 (Fig. 12, *S6*) equal in width to *S5* at widest point, with deep apical V-shaped insertion (dove-tailed), sternites 5 (*S5*) elongate, narrower basally and apically, sternite 4 (*S4*) as wide as *S5*, but shorter; male terminalia, epandrium (Figs 13 & 14, *ep*) short, indented in ventral half (in lateral view), surstyli (*ss*) longer in proportion to epandrium, with group of strong, but irregular posteriorly-directed setae inserted along ventral margin and some weaker setulae interspersed; surstylus (Figs 13 & 14, *ss*) long and narrow, paired surstyli widely spaced, not curved dorsally and not notched apically; cercus (Figs 13 & 14, *ce*) with setulose projection partially curved dorsally, apically bulbous and undivided (in posterior view); postgonite (Fig. 13, *pg*) long and narrow, running parallel to surstyli; phallus (Figs 15 & 16) long and narrow, moderately sclerotised, with phallapodeme (*ph*) and basiphallus (*bp*) fused, forming a continuous arched, C-shaped structure, basiphallus (*bp*) with a strong, posteriorly-directed spine and short blunt spine (in posterior view), distiphallus (*dp*) with basal area strongly excavated laterally, ejaculatory apodeme (Fig. 15, *ea*) dumbbell-shaped.

Female abdomen (Figs 19 & 20) with tergites and sternites weakly sclerotised, *S5* (in ventral view) short and sub-quadrate, *S6* (in ventral view) markedly short, expanded laterally, with shallow anterior incision, *S7* sub-quadrate, cercus (*ce*) clothed in erect setae on dorsal surface, *S8* in form of ventrally-directed, circular, hirsute process, with laterally expanded lobes (in ventral view), 'stem' (termed 'apodeme of hypoproct' by PAPP (1998)) not visible through cuticle, *S10* in form of a short blunt, hirsute process, spermathecae (Fig. 19, *sp*) short and broad basally, with bluntly pointed apex.

DIFFERENTIAL DIAGNOSIS: This species is most closely related to the Afrotropical species, *C. sahelense* TSACAS,



Figs 12-16 — *Curtonotum simile* TSACAS Male (Assab, Eritrea) **12.** abdominal sternites 4-6; **13.** epandrium, lateral view; **14.** same, posterior view; **15.** phallus, lateral view; **16.** junction between basiphallus and distiphallus, anterior view. Abbreviations: *bp* = basiphallus; *ce* = cercus; *dp* = distiphallus; *ea* = ejaculatory apodeme; *ep* = epandrium; *pg* = postgonite; *ph* = phallapodeme; *ss* = surstylus; *S4-S6* = abdominal sternites 4-6. Scale bars: 12 = 0.6 mm; 13-16 = 0.3 mm.

1977, also included in the *cuthbertsoni* species-group (see 'Discussion' below). The two species are virtually indistinguishable on external characters, but the male is distinguishable on the shape of the cercus (TSACAS 1977: 162, fig. 8a) and on the shape of the base of the distiphallus, which in *C. sahelense* has an additional short sub-medial spur and lacks the strong basilateral excavation of *C. simile* (TSACAS 1977: 162, fig. 8e).

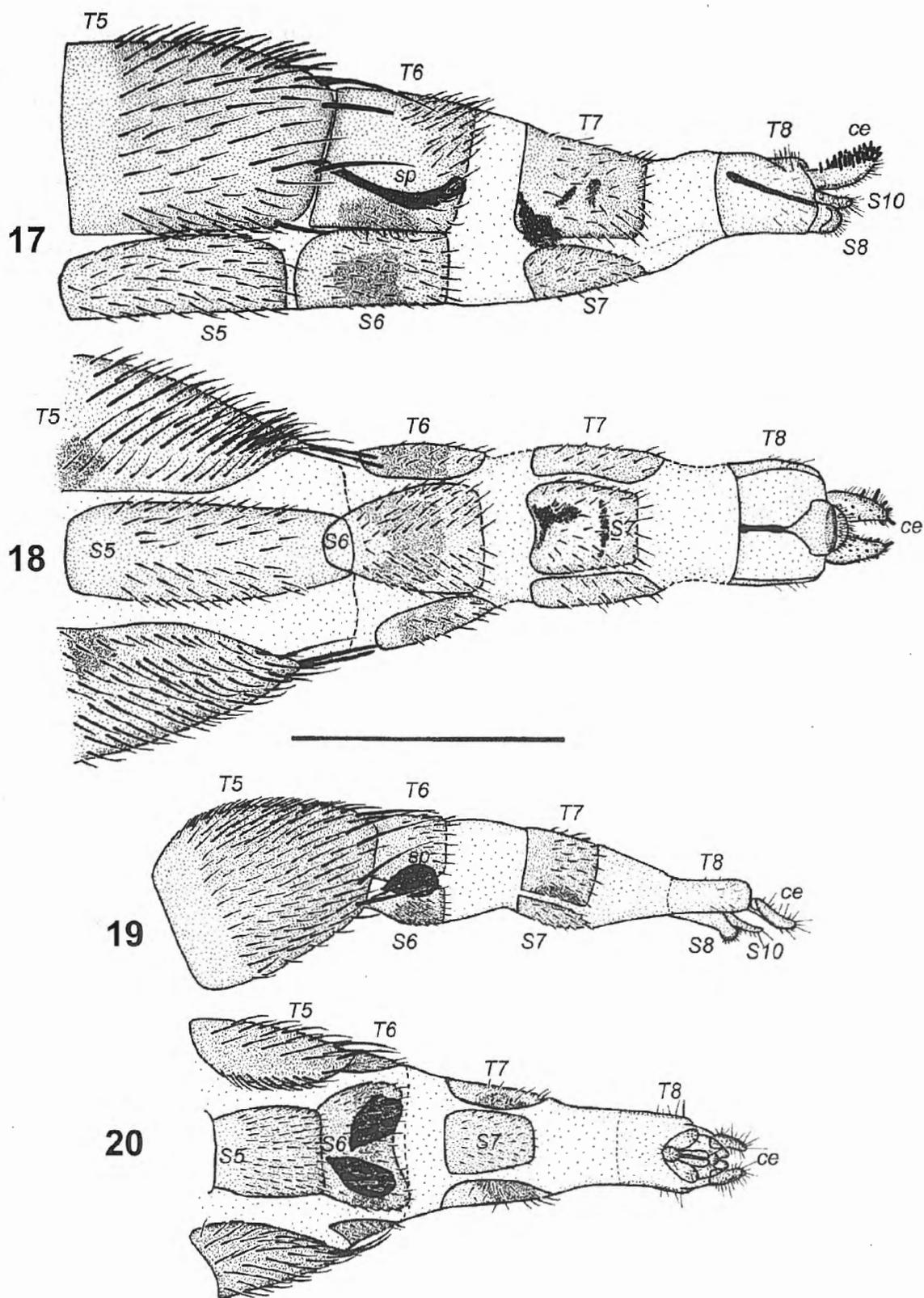
TYPE MATERIAL EXAMINED: Holotype male, **YEMEN**: "Type [paper disc with red border] // **ARABIA**: / S. Othman [=Shaykh 'Uthmān, 12°53'N, 44°58'E] / 17.III.1895 / C.G. Nurse. / B.M.1934–8. [handwritten & printed] // S. Othman / Nr Aden / 17.III.95 [handwritten on white paper] // Genitalia vial / replaced / A.H. Kirk-Spriggs 2006 [printed] // **CURTONOTUM** / *similis* n.sp. / Holotype / L. TSACAS DET. 1976 [handwritten & printed on white card] // *Curtonotum* ♂ / *simile* Tsacas, 1977 / det. A.H. Kirk-Spriggs 2006 [printed]" (BMNH). Paratype: ♂, same data as holotype, except: "Para- / type // **CURTONOTUM** / *similis* n.sp. / Paratype / L. TSACAS DET. 1976" (BMNH). Paratype ♂, same labels, except no label 'Para- / type': "*Curtonotum* / *anus* Meig. / 3♂♂ / det. J.C. Deeming 1965 // **MUSÉUM PARIS**" (MNHN).

OTHER MATERIAL EXAMINED: **ERITREA**: 1♂, 1♀, Eritrea, Ailet egg field [=Ailet, 15°34'N, 39°09'E (GREATHEAD 1958: 38)], em. 20.I.1956, D.J. GREATHEAD, Natural Resources Institute coll. BMNH(E) 1997–28 [with associated damaged puparia] (BMNH); 1♀, 15 mls N. Massawa [Emberemi, 15°46'N, 39°22'E (GREATHEAD 1958: 38)], Eritrea, 21.II.[19]54, Natural Resources Institute coll. BMNH(E) 1997–28 (BMNH); 8♂♂, 10♀♀, Africa or. Katona, Assab [13°5'30"N, 42°44'22"E], [1]907. V–VI (HNHM); 1♀, same data, except: Zool. Mus. Berlin (ZMHB); 10♂♂, 10♀♀, same except: [1]907. VII (HNHM). **ISRAEL**: 1♀, Nahal Perat [W. Kelt] [31°51'N, 35°25'E], 25.III.1975, A. FREIDBERG, *Curtonotum similis* TSACAS, det L. PAPP, 1994; 1♂, Qalya [31°45'N, 35°28'E], 28.IX.1995, A. FREIDBERG; 1♂, Arava Valley, Moshav Hazeva, Wadi Shahak, between agricultural fields, el. -110 m, Sharkey Malaise trap, 30°46.33'N, 35°16.32'E [GPS], 22.III.1995, M. IRWIN; 1♂, Hazeva Field School, 30°46'N, 35°15'E, Malaise trap, 4.X.1997, S. PLOTKIN; 1♀, Nahal Hiyon, Rt. 40 [30°12'N, 35°01'E], near Ne'ot Smadar, 13.X.1997, A. FREIDBERG; 1♀, Ne'ot Smadar [30°03'N, 35°01'E], 21.VI.1995, A. FREIDBERG; 11♂♂, 10♀♀, same except: 7.VIII.1995, A. FREIDBERG; 1♂, same except: 7.viii.1995, I. YAROM; 7♂♂, 11♀♀, same except: 17.VIII.1995, A.

FREIDBERG; 16♂♂, 23♀♀, same except: 20.IX.1995; 26♂♂, 25♀♀, same except: 10.X.1995; 2♂♂, 2♀♀, same except: 2.viii.1995, I. YAROM; 1♂, 3♀♀, same except: 29.VIII.1995, A. FREIDBERG; 1♀, same except: 13.X.1996; 1♂, Samar, 21.VII.1982, Sh. Alterman [29°50'N, 35°01'E], *Curtonotum similis* TSACAS, det. L. PAPP, 1994; 1♂, 1♀, Elifaz [29°47'N, 35°01'E], sewage, 5.IV.1997, A. FREIDBERG; 1♂, [Park] Timna' [29°47'N, 35°00'E], gate, 3.IV.1997, A. FREIDBERG; 1♀, [10 km south to] Elat, Taba, 29°29'N, 34°55'E, 7.V.2002, A. FREIDBERG (all TAU). **OMAN**: 1♀, Oman: Batinah, Şohār, [24°23'N, 56°45'E], 5.XII.1992, J.C. DEEMING, at light, NMW.Z.1981–001; 2♂♂, 3♀♀, Oman: Muscat, Al Khuwair, [23°37'N, 58°38'E], X.1990, J.C. DEEMING, NMW.Z.1981–001; 1♂, same except: 3–4.I.1988, M. EBEJER, NMW.Z.1985–032; 2♂♂, 1♀, same except, 31.XII.1987; 1♂, same except: 20.I.1988; 1♀, same except: 5–9.I.1988; 1♂, same except: 4–5.I.1988, *Curtonotum* sp. nr. *similis* TSACAS (distiphallus lacking reclinate basal spine) det. J.C. DEEMING 1990; 1♂, Oman: Muscat, Wattayeh [23°37'N, 58°38'E], 17–20.IV.1988, M.D. GALLAGHER, *Curtonotum similis* TSACAS, det. J.C. DEEMING '93, NMW.Z.1981–001; 2♀♀, Oman: Muscat, Al Khuwair, [23°37'N, 58°38'E], 27–30.IV.1997, M.D. GALLAGHER (all NMWC); 1♂, Oman, Qurm Hotel garden [23°36'N, 58°31'E], 5.IV.[19]85, PAÖ (MZLU). **UNITED ARAB EMIRATES**: 1♀, Oman, Ras al-Kheima [=U.A.E.: Ra's al Khaymah, 25°47'28"N, 55°56'34"E], 10.VI.[19]57, G. POPOV, from pod of *Acrotylus* sp. No. 18, Natural Resources Institute coll. BMNH(E) 1997–28 (BMNH) [with associated puparium]; 3♂♂, U.A.E., Al-Ajban [24°36'N, 55°01'E], 1–8.IV.2006, A. VAN HARTEN, Malaise trap; 6♂♂, 1♀, U.A.E., Sharjah Desert Park [25°17'N, 55°42'E], 30.IV–31.V.2005, A. VAN HARTEN, light trap (all NMWC). **YEMEN**: 1♀, Arabien, 54539, Zool. Mus. Berlin (ZMHB); 1♂, 1♀, Yemen, Ta'izz [13°35'N, 44°02'E], VIII.1999, A. VAN HARTEN & A. AWAD, light trap; 2♀♀, Yemen, 12 Km NW of Manakhah [15°05'N, 43°42'E], 5.V–17.VI.2002, A. VAN HARTEN, Malaise trap (all NMNW).

DISTRIBUTION: Palaeartic: Israel, Oman, United Arab Emirates; Afrotropical: Eritrea, Yemen.

BIOLOGY: Adults have been taken at light in Oman, the United Arab Emirates and Yemen, indicating crepuscular or nocturnal adult activity. Reared from the damaged egg pods of *Schistocerca gregaria* (FORSKAL) in Eritrea (GREATHEAD 1958, as *Cy. cuthbertsoni*) and of *Acrotylus* sp. in Oman (see above). GREATHEAD (1958) found adult flies in Eritrea on dung, dead locusts and



Figs 17-20 — *Curtonotum anus* (MEIGEN) Female abdomen (Park HaYarden, Israel) **17.** lateral view; **18.** ventral view. Figs 19-20 — *C. simile* TSACAS Female abdomen (Ne'ot Smadar, Israel) **19.** lateral view; **20.** ventral view. Abbreviations: *ce* = cercus; *S10* = abdominal sternite 10; *S5*-*S8* = abdominal sternites 5-8; *sp* = spermathecae; *T5*-*T8* = abdominal tergites 5-8. Scale bar = 1 mm.

sand wetted by camel urine. Larvae occurred on locust egg pods crushed and exposed during the sampling of egg fields, generally in the top layers of eggs, usually more than 10 larvae per pod. A mush of decaying eggs was produced by their feeding action, and pupariation took place in this mush, or in soil within one inch of the remains of the pod. GREATHEAD concluded that larval development was completed in two days (probably in error) and that the period from pupariation to eclosion was 23–25 days (KIRK-SPRIGGS submitted). The numerous specimens collected in Ne'ot Smadar (Israel) were almost all swept from the irrigated moist soil of the cultivated herb field of the kibbutz.

Discussion

The rather extreme differences between *C. anus* and *C. simile*, especially in respect to the structure of the male and female terminalia, are not surprising, given that the two species belong to two entirely different and geographically distinct species-groups. *Curtonotum anus*, on the one hand, is the nominate species of an *anus* species-group, which includes the closely-related Nearctic species, *C. helvum*, and apparently all 19 Neotropical species of the genus (J. Klymko pers. comm. 2006). The group is in need of clear definition, but the short, robust structure of the male phallus with a defined apical, sclerotised portion of the distiphallus and the spinose cercus of the female (pseudacanthophorite) appear to be key features (figures in MARSHALL *et al.* in press; McALPINE 1987). *Curtonotum simile*, on the other hand, belongs to the *cuthbertsoni* species-group (*sensu* TSACAS 1977), which also includes the Afrotropical species *C. angolense* TSACAS, 1977, *C. campsiphallum* TSACAS, 1977, *C. cuthbertsoni* DUDA, 1935, *C. platyphallum* TSACAS, 1977, *C. quinquevittatum* CURRAN, 1933, *C. sahelense* TSACAS, 1977, *C. sao* TSACAS, 1977, *C. simile* TSACAS, 1977, the seven endemic named species from Madagascar (TSACAS 1974), plus the Oriental species, *C. arenatum* (OSTENSACKEN, 1882), *C. ceylonense* DELFINADO, 1969 and *C. maai* DELFINADO, 1969 (DELFINADO 1969). TSACAS (1977) further divided the *cuthbertsoni* species-group into a *quinquevittatum* complex and a *cuthbertsoni* complex, species of the latter being defined as having the epandrium posteroventrally with a tuft of long setae and the base of the distiphallus bearing a double or single tooth or long spine. To this latter group he ascribed the species *C. cuthbertsoni*, *C. sahelense* and *C. simile*.

The sister species of *C. simile* is the Afrotropical

species, *C. sahelense*, and the geographical distribution of these two species is worthy of note. *Curtonotum sahelense* is today virtually restricted to the Sahel transitional zone between the Sahara Desert and the savannas of equatorial Africa and occurs in all countries that fall within that zone (Gambia, Senegal, Mali, Niger, Nigeria, Chad and Sudan) (KIRK-SPRIGGS in prep.). The Sahara is a very young desert which developed in the Pliocene and became hyper-arid in the Pleistocene, prior to which it was a vast savanna which extended much closer to the shores of the Mediterranean (KIRK-SPRIGGS & STUCKENBERG submitted; SCHUSTER *et al.* 2006). It is tempting to postulate that the ancestral species of *C. sahelense* was a savanna-inhabiting species that evolved in the transitional zone that developed as the Sahara became more arid and the savanna receded southwards. *Curtonotum simile* occurs in Eritrea on the continental African landmass and the Arabian Peninsula northwards to Israel. The Ethiopian Highlands, which began to rise in the Tertiary (*ca.* 75 MYA), form a rugged mass of mountains in Ethiopia, Eritrea and northern Somalia in north-eastern Africa, reaching altitudes of 1500–4600 m.a.s.l. Although these highlands appear to act as a barrier between the parapatric distribution of these two species today the climatic conditions which prevailed, even comparatively recently, were considerably wetter, and these highlands may not have acted as the barrier to dispersal they appear today. Given that these two species are relatively young in evolutionary terms it is also unlikely that the Tertiary uplift of these highlands could have led to the cladogenesis of the two species. Clearly some barrier existed in the past which led to this, but it remains an intriguing open question. Additional sampling, especially in Sudan and Egypt along the Red Sea may shed light on the problem.

The distributions of *C. anus* and *C. simile* in Israel (Fig. 21) are of particular significance, given the known transitional nature of this country between the Afrotropical, Palaeartic and Oriental zoogeographic Regions. Numerous specimens of *C. anus* have been collected from Park HaYarden [32°54.5'N, 35°37.5'E], on the shore of the Jordan River (north-eastern Israel), on many occasions, and a single specimen was collected in Tel Aviv (32°06'N, 34°49'E), on the shore of the Yarqon River (Central Israel). The former locality, at -200 m, near Lake Kinneret (=Sea of Galilee), is a very hot and humid subtropical location. The latter locality is close to the Mediterranean shore and enjoys a more temperate climate. *Curtonotum simile* has been collected in several localities in Israel along a stretch of approximately 250 km of the Great Rift Valley, from

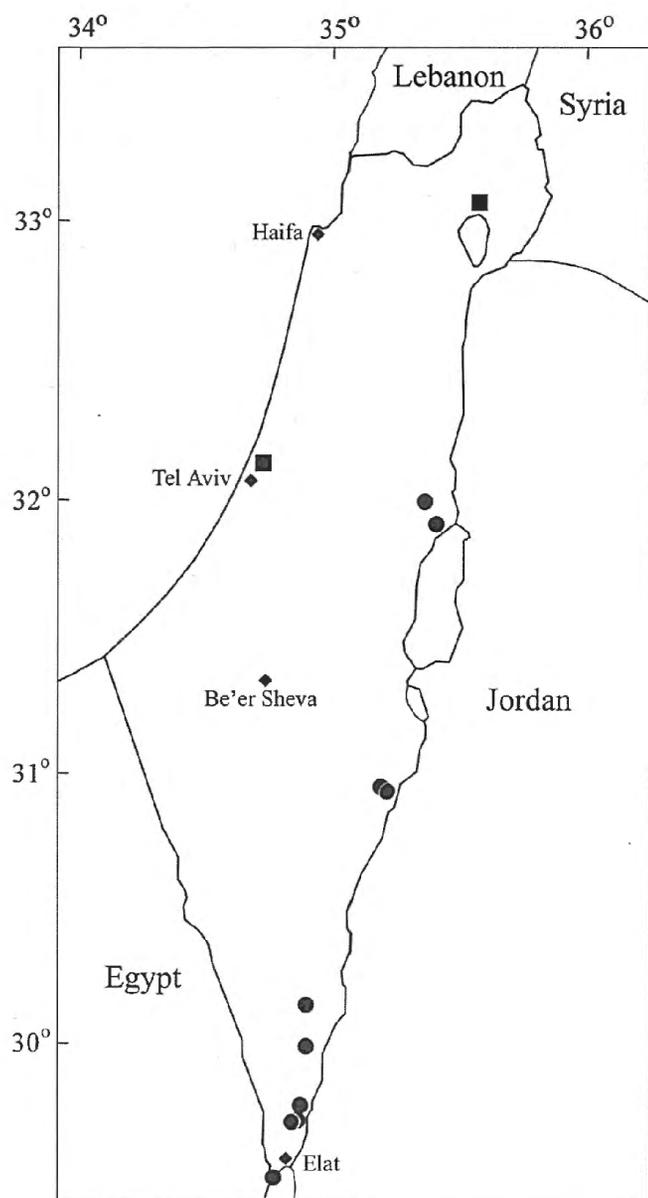


Fig. 21 — Distribution of *Curtonotum anus* (MEIGEN) (squares) and *C. simile* TSACAS (circles) in Israel.

Jericho and its environs in the north ($31^{\circ}51'N$, $35^{\circ}25'E$) to beyond Elat, on the coast of the Red Sea. Although the latitudinal gap between Tel Aviv and Jericho is only 15 minutes, the aerial distance between the two localities is about 70 km. Due to its specific topography, climatological variability and historical biogeography this gap is significant, and no overlap between the two species is expected throughout its length. The gap between Jericho and Park HaYarden, although longer, is more gradual, and it would therefore be interesting to better survey the Jordan River gorge between the Dead Sea and Lake Kinnereth to determine whether these two

species occur sympatrically there.

Most specimens of *C. simile* were collected in the irrigated and lush herb fields of Kibbutz Ne'ot Smadar, by sweeping herbs and also low above the ground. The remaining specimens were chiefly collected in wet or irrigated localities. This indicates that although the entire stretch is a desert habitat, flies were confined to oases or 'pseudo-oases' (we have coined the latter term for artificial, irrigated biotopes in the desert). The collection of both species, on or near ground-level, coupled with the presence of pseudacanthophorites in *C. anus*, is an indication that eggs are laid into the upper layer of (moist) soil, where the larval development probably takes place. This is in accordance with what has been speculated for other Diptera possessing this organ (FREIDBERG & BESCHOVSKI, 1996). Although an association with grasshopper egg pods cannot be ruled out, at least in the locality of Park HaYarden, these insects are uncommon, especially near water.

Collecting records for *C. anus* in Israel include all the months from April to November except October, and only April to September in Park HaYarden. Records for *C. simile* include all months from March to October, indicating that these species have a long adult activity period centred around the summer months. No flies were collected in the autumn, winter or early spring months. Although no attempt was made to screen population sizes, the collection records indicate two possible peaks for *C. anus* (around June and September), and a possible prolonged peak (August to October) for *C. simile*. Both species probably have at least two, and perhaps more, generations per year.

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