First host record and description of female *Halictophagus calcaratus* Pasteels (Strepsiptera: Insecta) from South Africa

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The strepsipteran, *Halictophagus calcaratus*, was described from South Africa by Pasteels in 1958, but no host record/s or females were included. Here we record that *H. calcaratus* parasitizes the cicadellid, *Molopopterus theae* Theron 1978, an important pest of the commercially produced shrub, *Aspalathus linearis* (Fabaceae), from which 'Rooibos' tea is produced. We provide a redescription of the male and a description of the female and the male cephalotheca. A checklist of South African Strepsiptera is included.

Key words: *Halictophagus*, host, *Molopopterus theae*, Rooibos tea, South Africa.

INTRODUCTION

The present composition of *Halictophagus* (Strepsiptera) from South Africa includes two species: *Halictophagus calcaratus* Pasteels 1958 and *H. irwini* Riek 1975. Worldwide, however, more than 70 species are known endoparasites of mainly hemipteran hosts with a notable number of associations in the Cicadellidae. The leafhopper, *Molopopterus theae* Theron 1978, is indigenous to South Africa and a serious pest of the 'Rooibos' tea bush (red bush) *Aspalathus linearis* (Burm.f.) Dahlgren 1963 (Fabaceae) (Theron 1978; Annecke & Moran 1982). This shrub occurs naturally in the Fynbos biome of the greater Cederberg mountain region of the Western Cape Province of South Africa (Fig. 1A) (Van Rooyen *et al.* 1999). The needle-like leaves are harvested and oxidised before being steeped in hot water to produce a herbal tea with characteristic reddish-brown or amber colour (hence the name 'red bush' tea). Commercial production commenced in the early 1930s with c. 50 000 ha currently under production.

Research was initiated by the South African Agricultural Research Council, Small Grain Institute (ARC-SGI) on the development of an integrated pest management programme (IPM) against the most injurious insect pests of *A. linearis*, including *M. theae*. Emphasis within this IPM approach is largely directed towards the establishment of an environmentally sound strategy with limited use of chemical insecticides. Extensive surveys were undertaken to characterise the complex of natural enemies associated with *M. theae*, as well as two other principal insect pests, namely a

looper (*Isturgia exerraria* Prout 1925) (Lepidoptera: Geometridae) and clearwing moth, *Monopetalotaxis candescens* (Felder & Felder 1874) (Lepidoptera: Sesiidae).

The objectives of the present paper are to record *M. theae* as host of *H. calcaratus* and to provide a redescription of the male and a first description of the female and the male cephalotheca. Notes on the morphology and phenology of *M. theae* are included as background information on this unique association reported here for the first time.

MATERIAL AND METHODS

Host phenology and morphology

Two-weekly surveys were conducted over a period of about three years (June 2000 – April 2003) during which 10 plants (two year old) were randomly selected and individually covered with a (solid) plastic cage, 1 m × 1 m × 1 m. A plastic sheet was introduced into each enclosure directly under the plant and all insects were collected by means of fumigation. Dead insects were shipped to ARC-SGI and sorted/counted using a stereo microscope at ×20 magnification. Identification of *M. theae* was based on the description by Theron (1978). Briefly, adult *M. theae* are typically wedge-shaped varying from 3.08–3.2 mm in length (Theron 1978). Both adult males and females have a predominantly yellow appearance with characteristic dark spot on either side of the wings (Fig. 1B). Eggs are deposited inside the needle-like leaves from which the nymphs emerge (Fig. 1C); progressing through five instar stages (Fig. 1D).

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Fig. 1. A, Two-year-old plantation of *Aspalathus linearis*; B, Adult *Molopopterus theae* feeding on needle-like leaf of *Aspalathus linearis*; C, hatching of first instar nymph (left); D, final instar nymph. Photographs: J.L. Hatting.

RESULTS

Bimonthly survey data revealed *M. theae* activity throughout the year, although highest populations typically occurred during the hot summer period from December to April (Fig. 2). Natural enemies found associated with *M. theae* during the course of this study include the entomopathogenic fungus *Beauveria bassiana* (Balsamo) Vuillemin 1912 (Ascomycota: Hypocreales), the predatory mite *Namadia floreata* Smith Meyer & Ueckermann 1987 (Acari: Anystidae), an unidentified hump-backed fly (Diptera: Phoridae) and the strepsipteran *Halictophagus calcaratus*, reported here (Fig. 3). *Halictophagus calcaratus* was described by Pasteels in 1958 but no host records or females were included. Here we record that *H. calcaratus* parasitizes the cicadellid *M. theae* and provide a redescription of the male and a description of the female and the male cephalotheca. A checklist of South African Strepsiptera is provided in Appendix A.

Redescription

Halictophagus calcaratus Pasteels

Only two species of the male of *Halictophagus* have been described from South Africa: *H. calcaratus* Pasteels 1958 and *H. irwini* Riek 1975. *Halictophagus irwini* differs from *H. calcaratus* by its smaller size (0.75 mm) and the base of antennomeres III and IV are longer than wide so that the flabella are distinctly separated. Maxillary palps are three times longer than the basal segment and taper to a rounded point in *H. irwini*, the palps are slightly over twice the length in *H. calcaratus* and do not taper. In females the brood canal is sub-rounded in *H. irwini* whereas in *H. calcaratus* it is narrow and elongated.

Adult male

Total length. 1.14 mm.

Head. Palpi of maxilla over twice the length of basal segment (palpi = 0.07 mm; basal segment = 0.03 mm). Mandibles short (0.04 mm) (Fig. 4D).

Fig. 2. Average number of *Molopterus theae* (all stages) per plant over three seasons.

Antennae. Seven-segmented. Antennomere III plus flabellum = 0.20 mm, antennomere IV plus flabellum = 0.18 mm, antennomere V plus flabellum = 0.14 mm, antennomere VI plus flabellum = 0.11 mm, antennomere VII plus flabellum = 0.14 mm (Fig. 4D,E).

Thorax. Prescutum length = 0.16 mm, scutellum = 0.05 mm, postlumbium narrow, length = 0.07 mm; postnotum length = 0.22 mm (Fig. 4D,F).

Metathoracic wing. R₂ diffused and wide, R₃ short, R₄ extending to mid-wing, MA half the length of CuA₁.

Cephalotheca of the male pupa (Fig. 4A,B). Width = 0.38 mm, length = 0.26 mm. Rudiments of ommatidia are represented by small thickenings of the sclerite on either side of the cephalotheca. Antennal rudiments represent the scapus and pedicellus. Paired mandibles with a single spine

Fig. 3. Stylized *Molopterus theae* with protruding male puparium (arrow) of *Halictophagus calcaratus*. Photograph: J.L. Hatting.

Fig. 4. *Halictophagus calcaratus* male. **A**, SEM of cephalotheca of pupa; **B**, cephalotheca (length = 0.26 mm); **C**, mandible on cephalotheca with a single spine; **D**, SEM of male emerging from *Molopopterus theae*; **E**, ventral and **F**, dorsal view (head width = 0.33 mm). Photographs: J. Kathirithamby (B, E, F) and M. Shaw (A, C, D).

(Fig. 4C) and elongated maxilla appear just on either side of the eyes (Fig. 4B), with a mouth-opening between. The clypeus is the raised region in the centre of the cephalotheca. Vertex and occipital sutures are found on the dorsal region of the cap.

Female cephalothorax. The cephalothorax is almost

black, length = 0.16 mm, broadest width = 0.14 mm, with a narrow brood canal opening with a projection on the upper margin (length = 0.05 mm; narrowest width = 0.10 mm) (Fig. 5).

Molecular analysis of this species places it in the family Halictophagidae (D. McMahon *et al.*, in prep.).

Fig. 5. *Halictophagus calcaratus* female. SEM of cephalothorax. Brood canal opening (arrow). Photograph: M. Shaw.

Voucher specimens

SOUTH AFRICA, *Western Cape Province*: 1 adult ♂, 1 ♂ cephalotheca, 1 ♀ cephalothorax, Clanwilliam, Ysterfontein farm, 32°9'S 18°46'E, 25.xi.2008, J.L. Hatting, Hope Entomological Collections, Oxford

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APPENDIX A

STREPSIPTERA OF SOUTH AFRICA

Family Stylopidae Kirby, 1813: 100

Genus *Xenos* Rossius, 1793: 49

Xenos stuckenbergi Pasteels, 1956

Host: *Polistes marginalis* Pal. (Hymenoptera: Vespidae)

Distribution: KwaZulu-Natal Province

University Museum of Natural History, Oxford; 1♂, 1♀ cephalothorax, *idem*, South African National Collection of Insects (SANC), Pretoria. Accession number AcP 9503.

DISCUSSION

The host range of *H. calcaratus* seemingly extends beyond *M. theae* given the initial collection thereof in Pretoria (Gauteng Province; Pasteels 1958), a locality situated >1000 km from the Clanwilliam site (Western Cape Province). Also, the *M. theae*–*A. linearis* association is unique to the Cederberg region (Western Cape Fynbos biome) of South Africa without any *A. linearis* occurring naturally or being cultivated in any of the other eight provinces. The prevalence of *H. calcaratus* among populations of *M. theae* may exceed 50% parasitism (Hatting, pers. Obs.).

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Genus *Halictoxenos* Pierce, 1908: 82

Halictoxenos annecke Pasteels, 1958

♀: unknown

Host: unknown

Distribution: Pretoria: Gauteng Province

Family Halictophagidae Perkins, 1905

Subfamily Halictophaginae Perkins, 1905

Genus *Halictophagus* Dale (in Curtis 1832)

Halictophagus calcaratus Pasteels, 1958

Distribution: Pretoria: Gauteng Province

Host: *Molopopterus theae* Theron (Homoptera: Cicadellidae)

Distribution: Clanwilliam: Western Cape Province

Halictophagus irwini Riek, 1975

Host: *Dalbulus distans* Linnavuori (Homoptera: Cicadellidae)

Distribution: Karkloof, KwaZulu-Natal Province

Family Elenchidae Perkins, 1905

Subfamily Elenchinae Perkins, 1905

Genus *Elenchus* Curtis 1831

Elenchus falcipennis Luna de Carvalho, 1956

♀: unknown

Distribution: Pretoria: Gauteng Province

Host: *Nilaparvata angolensis* Synave (Homoptera: Delphacidae)

Distribution: Angola, S. Africa (former Transvaal Province)

Family Myrmecolacidae Saunders, 1892

Genus *Stichotrema* Hofeneder 1910

Stichotrema robertsoni Kathirithamby 1991

♀: unknown

Host: *Phaeidole* sp.

Distribution: Natal