Females of *Mitophyllus arcuatus* Holloway and *M. irroratus* Parry are not readily separated by morphology (Coleoptera: Lucanidae)

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Abstract
The lucanid *Mitophyllus arcuatus* Holloway was recently described by Holloway (2007) having been previously considered as a form of *M. irroratus* Parry. Males of *M. arcuatus* and *M. irroratus* can be readily separated by the shape of the mandibles but differences between females are more subtle. *Mitophyllus* females from Bay of Plenty kiwifruit orchards could not be separated into *M. arcuatus* and *M. irroratus* based on selected morphometrics (measurements of the mandible basal projection and the spermathecal duct) and on other traits in a key and notes by Holloway (2007). Where no males are collected from the same locality, some caution is needed in assigning females to species.

Keywords: mandible, distribution, Bay of Plenty, allopatry

Introduction
The lucanid *Mitophyllus arcuatus* Holloway was recently described by Holloway (2007), having been previously considered as a form of *M. irroratus* Parry. Males of *M. arcuatus* and *M. irroratus* can be readily separated by the shape of their mandibles (Fig. 1); however females appear very similar. In a key to *Mitophyllus* females Holloway (2007) separated *M. arcuatus* and *M. irroratus* by the colour of the mandibles (black in *M. arcuatus*, dark reddish-brown in *M. irroratus*) and the shape of the mandible basal projection (inconspicuous and obtuse-angled in *M. arcuatus*, conspicuous and acute-angled in *M. irroratus*). Other traits separating the species given in the description of *M. arcuatus* and other notes by Holloway(2007) are the slope of the outer surface of the supra-antennal brow, the symmetry of the 3rd and 4th funicle segments, the length and

breadth of the spermathecal duct and the strength of the bursal sclerite. Here I report on the diagnosis of individuals keyed to couplet 8 (either *M. arcuatus* or *M. irroratus*) of the key to species of *Mitophyllus* females given in Holloway (2007).

Methods

Female *M. arcuatus/irroratus* were collected in window-pane type traps on commercial kiwifruit orchards during Jan-Mar 2009 and from the Plant and Food Research kiwifruit orchard at Te Puke in the summers of 2007-08 and-2008-09 (Fig. 2). Male *M. arcuatus* and *M. irroratus* were also collected in the same traps at some sites. Males have an apparently mutually-exclusive distribution in Bay of Plenty kiwifruit orchards consistent with the observation by Holloway (2007) that *M. arcuatus* and *M. irroratus* have not been collected from the same locality. Adult male M. *arcuatus* occur in kiwifruit orchards in the Te Puke area while male *M. irroratus* occur outside the Te Puke area (Fig. 2). The Te Puke area is defined as an area bounded on the east by SH33, on the west by the Papamoa Hills, on the north by the coastline, and on the south by the geographical extent of kiwifruit orchards.

Females from the Te Puke area (n = 40) and outside of the Te Puke area (n = 17) were compared qualitatively for differences in mandible colour, the slope of the outer surface of the supra-antennal brow, the symmetry of the 3rd and 4th funicle segments and the strength of the bursal sclerite. Females were also compared quantitatively for the plane angle formed by the distal end of the mandible basal projection (inconspicuous and obtuse-angled in *M. arcuatus*, conspicuous and acute-angled in *M. irroratus*) (Fig. 3) and for the length:width ratio of the spermathecal duct (Fig. 4). The spermathecal duct is long and slender in *M. arcuatus* but shorter and broader in *M. irroratus* (Holloway 2007), suggesting that a ratio of length:width may be discriminatory.

Plane angle for both mandible base projections per individual was measured on images using ImageJ (Rasband 2012). Mean plane angle for Te Puke females (n = 40) was compared with that for females from outside of the Te Puke area (n = 17) with a two-sample t-test at $P<0.05$ using Genstat Release 9.1 [(PC/Windows XP) copyright 2006, Lawes Agricultural Trust Rothamsted Experimental Station)]. The length:width ratio of the spermathecal duct was compared for 10 females from the Te Puke area and outside of the Te Puke area. Abdomens were removed from female beetles

and placed in 10% NaOH for 30 minutes at ca. 50°C, then rinsed in distilled water and the genitalia removed. Measurements of the length and width of the spermathecal duct were made using ImageJ (Rasband 2012). The mean ratio of length:width for the two groups was compared by two-sample t-test at $P<0.05$ using Genstat Release 9.1 [(PC/Windows XP) copyright 2006, Lawes Agricultural Trust Rothamsted Experimental Station)].

Results and Discussion

Females from the Te Puke area and outside the Te Puke area could not confidently be separated on the basis of mandible colour, the slope of the outer surface of the supra-antennal brow or the symmetry of the 3rd and 4th funicle segments. There were no differences in the plane angle of the mandible basal projection between females from Te Puke (mean ± standard deviation = 102.9 ± 11.0°) and outside of Te Puke (101.2 ± 11.8°) ($P>0.05$). Most females had obtusely angled mandible basal projections (>95°). One female from outside the Te Puke area and two from the Te Puke area had acute-angled mandible basal projections (<75°). Females could not be separated by the length and width of the spermathecal duct. The mean ratio of length:width was not different for 10 females from the Te Puke area and 10 from outside the Te Puke area ($P>0.05$). The bursal sclerite was not observed to be different in strength for each of the two groups of 10 dissected females. Rather than being disc-shaped as could be inferred from illustrations in Holloway (2007), the sclerotized area is cupuliform at the distal end of the shortest bursa copulatrix arm with an extension on one side. The spermathecal duct enters the bursa copulatrix at the edge of the cupuliform area (Fig. 4).

As *M. arcuatus* and *M. irroratus* may have a mutually-exclusive distribution there is some confidence in assigning females to *M. arcuatus* and *M. irroratus* when they are collected in association with males. However where no males are collected, some caution is needed in assigning females to species.

References

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Rasband WS 2012. ImageJ. U. S. National Institutes of Health, Bethesda, Maryland, USA, http://imagej.nih.gov/ij/.

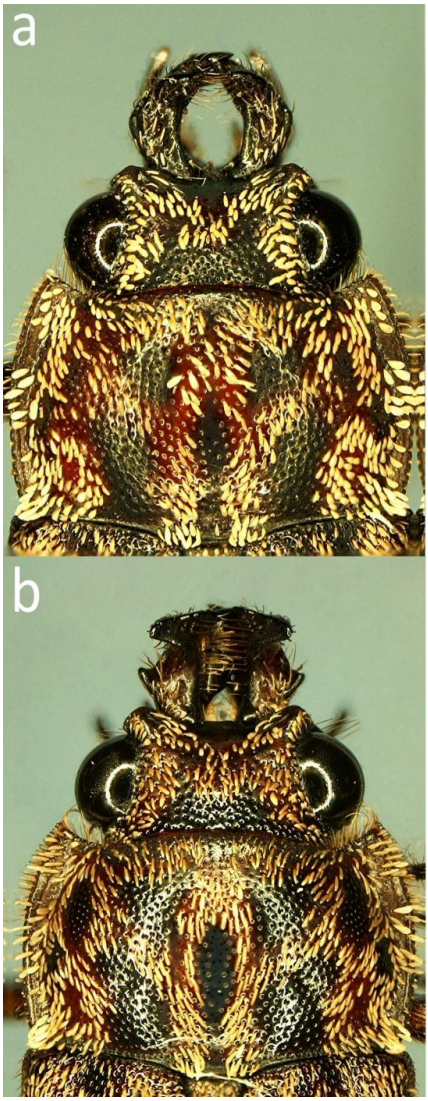

Fig. 1. Head and pronotum of male (a) *Mitophyllus arcuatus* and (b) *M. irroratus* illustrating differently- shaped mandibles.

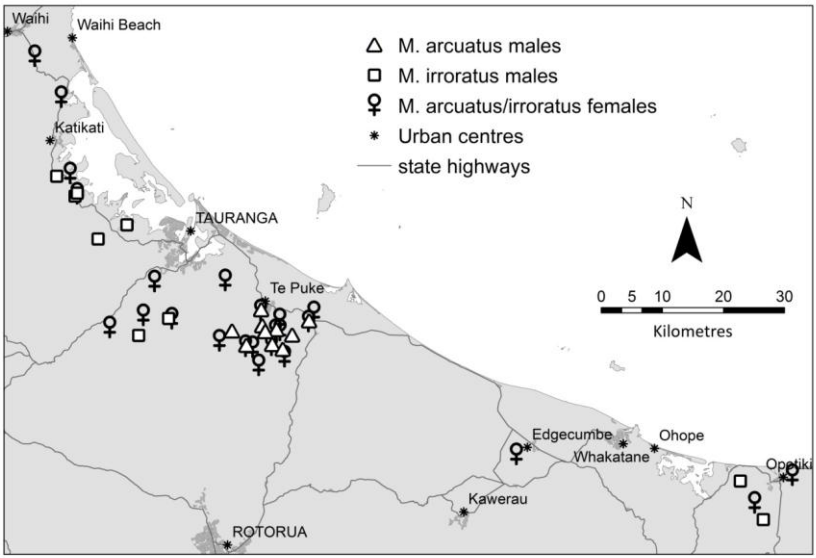

Fig. 2. Distribution of male *Mitophyllus arcuatus* and *M. irroratus* and of indeterminate *M. arcuatus*/*irroratus* females on kiwifruit orchards in the Bay of Plenty. Data are from a survey of invertebrates on commercial kiwifruit orchards using window-pane type traps from January-March 2009.

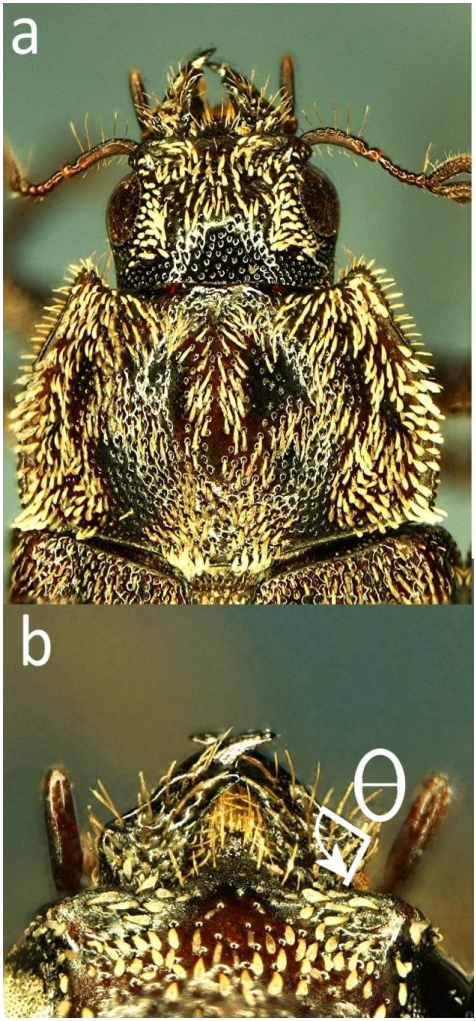

Fig. 3. Head and pronotum of female (a) *Mitophyllus arcuatus/irroratus*. (b) Mandibles and plane angle (θ) of mandible basal projection measured to separate females of *Mitophyllus arcuatus* and *M.irroratus*

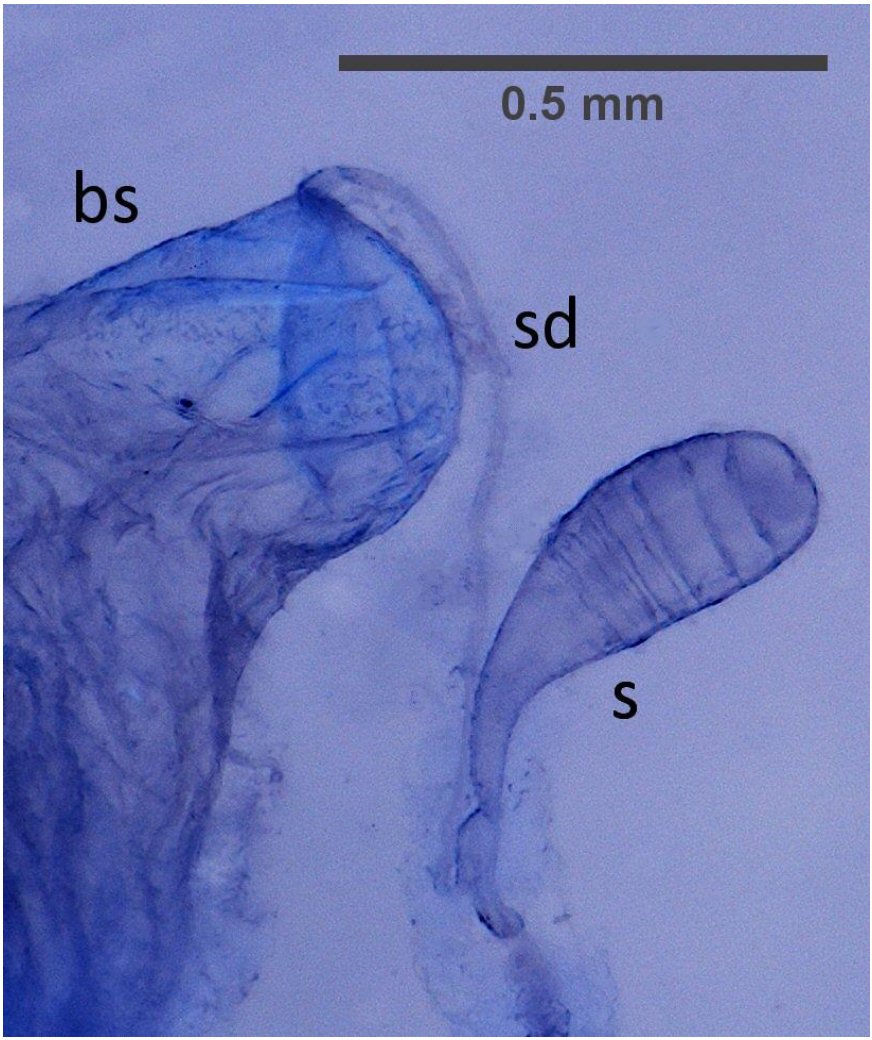

Fig. 4. Detail of the genitalia of a *Mitophyllus arcuatus*/*irroratus* female showing bursal sclerite (bs), spermathecal duct (sd) and spermatheca (s).