



Recent occurrence of *Aphanogmus dictynna* (Waterston) (Hymenoptera: Ceraphronidae) in Kenya — an important hyperparasitoid of the coffee berry borer *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae)

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Abstract

The ceraphronid wasp *Aphanogmus dictynna* (Waterston) was recently recorded in error as an undescribed species of *Aphanogmus*. This species is a primary parasitoid on larvae and cocoons of the bethylid *Prorops nasuta* Waterston, and probably a second bethylid species, *Cephalonomia stephanoderis* Betrem. Both bethylids are primary parasitoids, and important biological control agents, of larvae and pupae of the coffee berry borer *Hypothenemus hampei* (Ferrari). New host and distribution records are provided for *A. dictynna*, as well as a diagnosis and comments on its taxonomic relationships.

Key words: Coffee pests, biocontrol, biological control, hyperparasitism, superparasitism, secondary parasitoid

Introduction

The coffee berry borer *Hypothenemus hampei* (Ferrari) is the most important pest of coffee worldwide (Brun *et al.*, 1995; Damon, 2000; Jaramillo *et al.*, 2006). *Hypothenemus hampei* is native to Africa, but has since spread to coffee-growing regions of Asia and the Americas. Both larvae and adults damage coffee berries, and crop losses can reach 80%, with estimated global crop losses estimated at US\$ 300–500 million (Global Invasive Species Programme, 2008; Vega *et al.*, 2002). Crop losses have been estimated to reduce earnings for more than 20 million rural families globally (Vega *et al.*, 2003). Le Pelley (1968) provides a detailed review of the biology of *H. hampei*, including earlier attempts at its biological control. Chemical control is considered ineffectual, and an integrated approach that includes a combination of fungal pathogens and parasitoid wasps is currently advocated (Global Invasive Species Programme, 2008). In addition to the tetrastichine eulophid parasitoid *Phymastichus coffea* LaSalle, two bethylid wasps *Prorops nasuta* Waterston and *Cephalonomia stephanoderis* Betrem, are the biological control agents of *H. hampei* used currently. *Cephalonomia hyalinipennis* Ashmead is known to attack *H. hampei* under natural conditions in Mexico (Pérez-Lachaud & Hardy, 2001).

Extensive surveys undertaken by the International Centre for Insect Physiology and Ecology (ICIPE), of *P. nasuta* on *H. hampei*, undertaken in Western Kenya from 2006 to 2008, revealed high levels of parasitism by an *Aphanogmus* species. Initially recorded as a new species of *Aphanogmus* (Jaramillo & Vega, 2009) this species has since been identified as *A. dictynna* (Waterston). *Aphanogmus dictynna* was recorded originally (as *Calliceras dictynna*) from Uganda in association with *P. nasuta* and *H. hampei* (Waterston, 1923).

The hyperparasitoid was sent for identification to the United States Department of Agriculture's Systematic Entomology Laboratory in Washington D.C., where the first author originally identified it as a *Ceraphron* species; following consultation with Andy Deans (North Carolina State University), the correct

genus for these wasps was determined to be *Aphanogmus*. The second author was later able to identify it as *A. dictynna*, a member of the *Aphanogmus hakonensis* species complex (Polaszek & Dessart, 1996). All species in this complex, for which the biology is known, are hyperparasitoids. A closely related species, *Aphanogmus manilae* (Ashmead), has been reared from a bethylid cocoon (Polaszek & Dessart, 1996). Because of its potential impact on current biocontrol efforts using *C. stephanoderis* and *P. nasuta*, we list these new records below and provide a diagnosis of *A. dictynna* to aid in its recognition.

Images for figures were obtained using techniques summarized in Buffington and Gates (2009). Several specimens were gold-coated for microphotography with a Hitachi S2500 scanning electron microscope at 15Kv. Male genitalia preparations were made using the technique described by Polaszek & Kimani (1990). Morphological terminology follows Polaszek & Dessart (1996). Repositories for specimens are the International Center for Insect Physiology and Ecology (ICIPE), the Natural History Museum, London (NHM) and the National Museum of Natural History, Smithsonian Institution, Washington DC (USNM).

Taxonomy

Aphanogmus dictynna (Waterston)

(Fig 1–10)

Calliceras dictynna Waterston, 1923: 116–118.

Ceraphron dictynna (Waterston); Risbec, 1950: 552 (misspelling)

Ceraphron dictynnus (Waterston); Masner, 1965: 12.

Aphanogmus dictynna (Waterston); Dessart, 1971: 99; Johnson & Musetti, 2004: 14.

Aphanogmus sp. Jaramillo & Vega, 2009: 114.

Redescription. Female (Fig 1) body length: 0.82–1.00 mm. Colour: Dark brown, head almost black. Scape and pedicel yellow, remaining antennomeres mid brown. Hind coxae pale in striking contrast to the metapleura and metasoma. Hind trochanters slightly darker than coxae and all femora and tibiae mid brown, much paler than mesosoma. Terminal metasomal terga paler than preceding ones. Tarsi pale. Wings hyaline.

Morphology: Head globose. In dorsal view, maximum head width 1.3x head length at midpoint; maximum head width 1.5x maximum head length. Head in frontal view with antennal scrobes united into a single frontal depression. Sculpture of depression transverse, and distinct from fine reticulate sculpture of remaining frons (Fig. 2). Ocelli in an equilateral triangle, lateral ocelli equidistant from each other and from compound eye orbits. Anterior ocellus with a small depression in front, containing a minute fovea. A shallow groove extending from stemmaticum to occiput. Antennae (Fig. 3A) 10-segmented, without a distinct clava (club) unless F10, being more than 2x the length of F9, is considered as a 1-segmented clava..

Mesosoma strongly flattened laterally (Fig. 4). In dorsal view appearing much narrower than head; maximum width of mesosoma 0.7x maximum head width. A single shallow median groove extending the length of the mesoscutum. Notauli and parapsidal lines absent. Mesoscutellum (scutellum) elongate-oval in dorsal view, laterally with striate carinae (Figs 4, 5) characteristic of the *A. hakonensis* complex. Dorsellum present, unsculptured. Propodeum with a row of 8–9 deep foveae on each side. Mesosoma in lateral view (Fig. 5) with fused meso- and metapleura with strong carinae fading posteriorly to an area of reticulate sculpture. Wing (Fig. 10) with radial vein elongate and smoothly curving.

Metasoma in dorsal view with T1 occupying more than 0.5 of its total length; with a strong transverse carina anteriorly (Fig. 7). Anterior T1 laterally with reticulate patches of sculpture each with about 6 setae, otherwise T1 completely smooth, unsculptured, with no longitudinal carinae. T3–T5 with reticulate sculpture anteriorly. S1 laterally, centrally with a reticulate patch of sculpture bearing about 10 setae, ventrally more densely setose.

Male (Figs 6, 8–10) body length: 0.65–1.00 mm. Colour as female, except antennal scape and pedicel as dark as remainder of antenna. Morphology as in female except for the moniliform antennae (Fig. 3b) and

genitalia characters. Genitalia with the parameres (Fig. 6) very strongly lobed externally, the lobes bearing long setae apically. Parameres less than half the length of the entire genital capsule, though approaching half the length in some individuals. Digiti large and conspicuous, as long as apical section of parameres, with three teeth. Aedeagus with tip blunt.

Material examined: Holotype ♀ UGANDA: Najunga, 24.v.[19]21 H. Hargreaves coll. Presented by Imperial Bureau of Entomology. TYPE 9.121 (NHM, on a single slide). Paratypes 4♀1♂ same data as Holotype; 3♀1♂ on slides, 1♀ card mounted. 1♀1♂ KENYA: ex *Cephalonomia stephanoderis* on *Hypothenemus hampei* F. Infante, CIBC, ii.1982 (NHM); 25♀25♂, KENYA: Kisii District, Western Kenya; 00°25'S, 34°28'E, 1510m, Jarmillo & Vega, July, 2008 [ex *Prorops nasuta*; specimens taken from rearing facility at ICIPE in Nairobi by first author] ICIPE, NHM USNM).

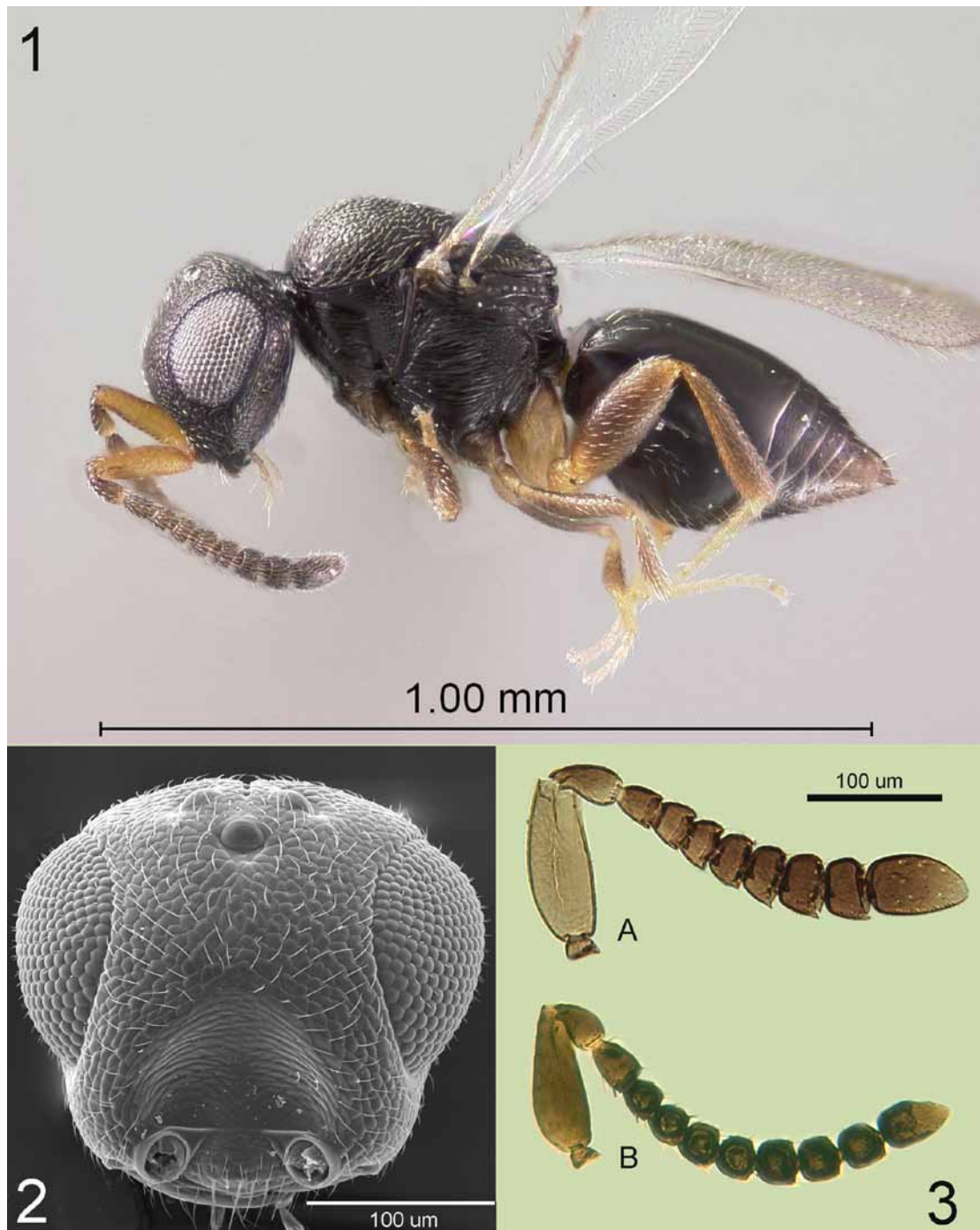


FIGURE 1–3. Female, lateral habitus; 2. Female, head in frontal view; 3. Antennae: A. Female; B. Male.

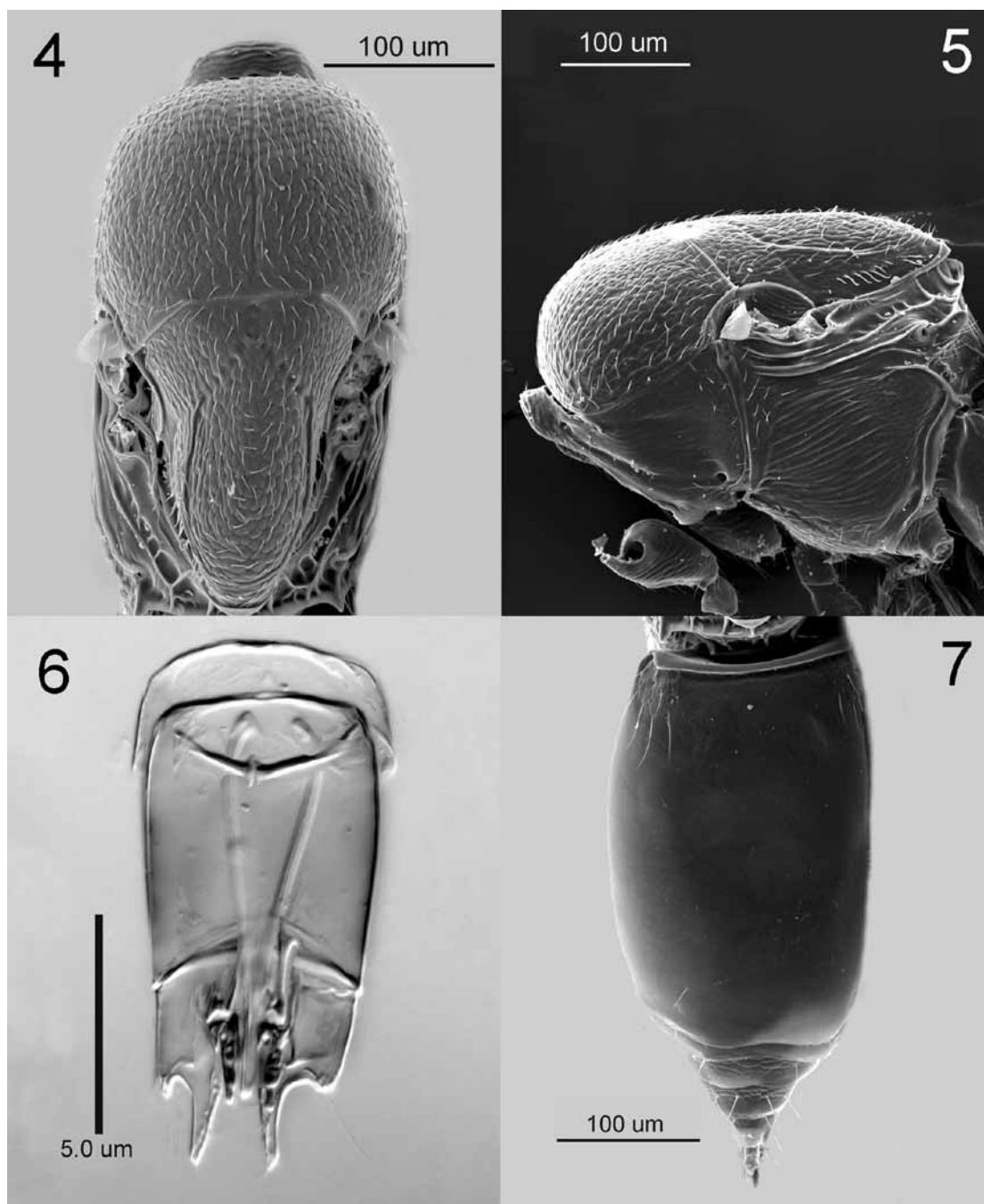


FIGURE 4–7. 4. Female, dorsal mesosoma; 5. Female, lateral mesosoma; 6. Male, genitalia; 7. Female, dorsal metasoma.

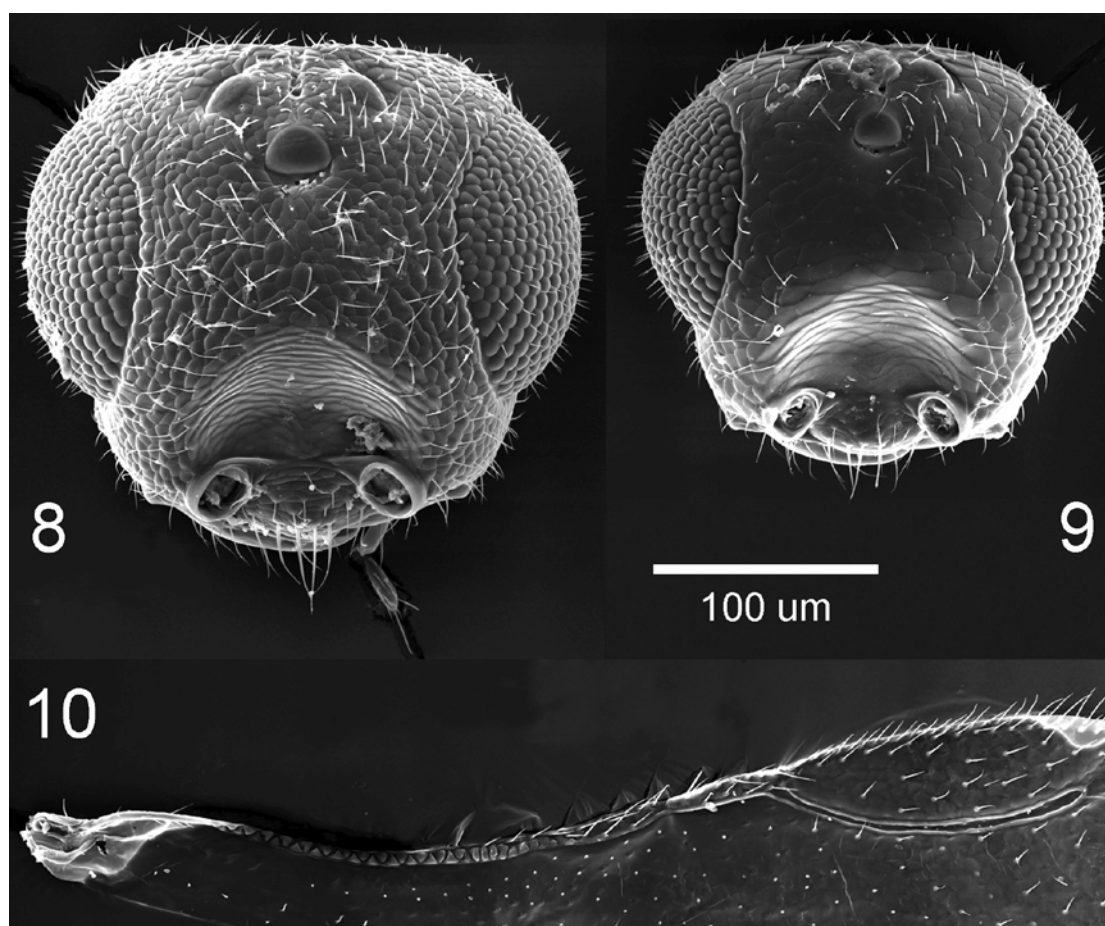
Comments. One male examined in the recently collected Kenyan material was substantially smaller (about 75% body length) than the others studied. Its small size appears to have a marked effect on head sculpture, especially of the frons (see Figs 8 & 9). Reticulate sculpture in the smaller individual was less rugose, with the cells much larger in relation to overall head size. Other aspects of morphology, including genitalia, suggest strongly that this is a size effect and not indicative of a different species.

Scanning electron micrographs of the fore wing base (Fig. 10) reveal the structure of the basal marginal vein to be composed of successive inverted triangular elements. We have not observed this before, although it may be widespread in Ceraphronidae.

Among the described species of *Aphanogmus*, *A. dictynna* appears to be most similar morphologically to *A. manilae*, an extremely common and polyphagous species occurring from India to eastern Australia, and most often reared as a hyperparasitoid of pest Lepidoptera larvae. It can be separated morphologically from *A. manilae* by the following combination of characters: i) female antennae of *A. manilae* with a distinct 3-segmented clava, at least as distinguished by being dark brown in distinct contrast to the remaining antennomeres; ii) all legs pale yellow; iii) A9 of female antenna quadrate (transverse in *A. dictynna*); iv) head only slightly wider than mesosoma in dorsal view (1.2x; - 1.5x wider in *A. dictynna*); v) posterior meso+metapleuron without reticulate area; vi) T1 of metasoma with many longitudinal carinae basally.

Biologically, *A. manilae* is most commonly associated with braconids, especially microgastrines, but has once been reared from the cocoons of a *Goniozus* species (Bethylinidae: Bethylinae) (Polaszek & Dessart, 1996).

Aphanogmus dictynna appears also to be morphologically very similar to another species known from bethylids, *A. goniozi* Dessart (Dessart, 1988) a species described from females only. Examination of the type series of *A. goniozi* reveals that it differs from *A. dictynna* in exactly the characters listed above for *A. manilae*, to which *A. goniozi* is apparently even more similar morphologically.



FIGURES 8–10. 8 & 9. Males, heads in frontal view; 10. Male, fore wing venation. (at same scale of magnification).

Discussion

Previous studies of the *Aphanogmus hakonensis* complex, and of other economically important *Aphanogmus* species (Polaszek & LaSalle, 1994; Polaszek & Dessart, 1996) have stressed the importance of the male genitalia as a species-level informative character in this genus, even to the point where other aspects of

morphology were dismissed as uninformative, especially those of females. The present study shows that species that are very clearly distinct based on external morphology (including colour), and possibly biological and biogeographical considerations, can have very similar male genitalia. This suggests that species having the *hakonensis*-type of male genitalia (Polaszek & Dessart, 1996) potentially represent a complex within a complex. Careful consideration of both genitalia and external morphology appear to be essential for future taxonomic studies of this genus, probably supplemented by molecular sequence data.

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