

Description and identification of white grubs (Coleoptera: Scarabaeidae) that attack pineapple crops in South Africa

T.J. Smith¹, G.J. Petty² & M.H. Villet¹

¹Department of Zoology and Entomology, Rhodes University, Grahamstown, 6140 South Africa

²Institute for Tropical and Subtropical Crops, Private Bag X1, Bathurst, 6166 South Africa

Larvae of five species of scarabaeid beetles, *Asthenopholis subfasciata* Blanchard, *Trochalus politus* Moser, *Macrophylla ciliata* Herbst, *Congela valida* Péringuey and *Adoretus ictericus* Burmeister, and adults of a sixth species, *Heteronychus arator* (Fabricius), cause considerable economic damage to the root systems of pineapple plants. The biologies of the species differ, making reliable identification essential. Since no convenient method is available to identify them, both field and laboratory keys are provided for the identification of third instar larvae of the six species, and detailed, illustrated descriptions for confirming their identifications.

Key words: larvae, pests, pineapples, systematics, agriculture.

INTRODUCTION

The larvae of several scarabaeid beetles (Coleoptera: Scarabaeidae), commonly called white grubs, are often serious agricultural pests. One of the crops that they attack is pineapples, of which more than 20 000 ha is cultivated in South Africa, yielding about 180 000 tonnes of fruit per annum. White grubs are responsible for a large part of the damage to the roots of pineapple plants, and infestations of 20 grubs per plant are sufficient to reduce the root system, leading to stunting, wilting and yellowing of the plant (Petty 1976, 1977, 1978; Le Roux 1992). In addition, adults of the scarabaeid beetle *Heteronychus arator* (Fabricius) damage the stems of pineapples, leading to fungal infections and lower yields (Le Roux 1992).

Accurate identification is important for the management of pest species, as it provides the necessary information to adapt control methods to the biologies of these species (Danks 1988). Although the adults of white grubs are easily identified, little work has been done on the identification of their larvae in South Africa (Oberholzer 1959; Sweeney 1967; Petty 1976, 1977, 1978). At least nine species of white grub occur in pineapple crops in the Eastern Cape Province, but due to difficulties in their identification it is not known whether all of these cause major damage to pineapples. In this paper we describe the third instar larvae of *Asthenopholis subfasciata* Blanchard, *Trochalus politus* Moser, *Macrophylla ciliata* Herbst and *Congela valida* Péringuey (all Melolonthinae),

Adoretus ictericus Burmeister (Rutelinae), and *H. arator* (Dynastinae), all of which are pests of pineapples (Petty 1976, 1977, 1978; Le Roux 1992). Keys are provided for the rapid identification of these larvae in the field and for more rigorous identification in the laboratory. Specimens should also be compared with the illustrated descriptions to ensure that they do not belong to a species not included here.

MATERIAL AND METHODS

Larvae of *H. arator*, *A. subfasciata*, *T. politus*, *M. ciliata*, *C. valida* and *A. ictericus* were reared to adulthood by G.J.P. at the Pineapple Research Station, East London, and identified by staff of the National Collection of Insects, Pretoria (SANC). Specimens of larvae and adults are held at the Pineapple Research Station, Bathurst Experimental Farm, and adult specimens are deposited in SANC. Third instar larvae were macerated in 10 % potassium hydroxide to remove soft tissue, and drawn using a Wild M5 stereomicroscope and *camera lucida*. Anatomical terminology follows Ritcher (1966).

Characters of the head capsule and the mouthparts are generally the most reliable characters for determining species of scarabaeid larvae (Ritcher 1966; Scholtz 1993). In particular, the number of notches on the left and right mandibles (Figs 7–12), the presence or absence of a stridulatory area on the ventral surface of the mandibles (Fig. 13) and

the number and position of the heli on the epipharynx (Figs 16–21) are useful. While the number and arrangement of setae on the head capsule may also be taxonomically significant (Figs 1–6), it is not always reliable for identification because setae can break off as the larva moves through the soil (Scholtz & Peck 1990). Raster patterns are most useful for field diagnosis because they are reasonably easy to see without dissection or strong magnification.

Field key to third instar larvae

1. Anal opening a single transverse slit 2
— Anal opening Y-shaped 5
2. Raster beneath last abdominal segment with palidia (distinct, medial rows of setae termed pali) (e.g. Figs 23, 27) 3
— Raster without palidia (e.g. Figs 22, 24) 4
3. Palidia forming an elongated oval-shape (Fig. 27). *Asthenopholis subfasciata* Blanchard
— Palidia in two parallel rows (Fig. 23) *Adoretus ictericus* Burmeister
4. Anal opening straight; raster with few short, scattered, hamate setae on tegilla (the anterior setose area) (Fig. 22) *Heteronychus arator* (Fabricius)
— Anal opening curved; semicircular tegilla covered with many sharp, hamate setae, which are longest closer to the anal opening and shorter further away (Fig. 24) *Macrophylla ciliata* Herbst
5. Raster beneath last abdominal segment without palidia (distinct, medial rows of setae termed pali); tegilla (setose anterior area) of raster small, covered with short setae arranged in a fairly ordered pattern (Fig. 25) *Congela valida* Péringuey
— Raster with palidia that form an arc (Fig. 26); tegilla larger, covered with scattered setae *Trochalus politus* Moser

Laboratory key to third instar larvae

1. Plegmatium on each lateral margin of epipharynx absent (Figs 16, 17); stridulatory area present on ventral surface of each mandible (Fig. 13) 2
— Plegmatium present (Figs 18, 19, 20, 21); stridulatory area absent from mandibles 3
2. Dorsolateral edge of maxillary stipes with a row of flattened, claw-shaped stridulatory

teeth; mala with one large uncus at tip and two smaller, blunt unci situated below it; right mandible with a single notch on the scissorial area; raster with septula; palidia on raster in two parallel rows

- *Adoretus ictericus* Burmeister
- Dorsolateral edge of stipes with a row of blunt, truncate stridulatory teeth; mala with one large uncus and three smaller ones, surrounded by thick setae; right mandible without notch; septula of raster absent; palidia absent
. *Heteronychus arator* (Fabricius)
3. Plegmatium on lateral margins of epipharynx very prominent (Figs 18, 21) 4
— Plegmatium relatively weakly developed (Figs 19, 20) 5
 4. Raster lacking a septula; palidia absent; maxillary galea with a single, hooked uncus, surrounded by many long, thin setae; maxillary lacinia with four unci, surrounded by setae; haptomerum of epipharynx with 10 large heli surrounding a clump of 16 small heli
. *Macrophylla ciliata* Herbst
— Raster with an elongated, oval septula; galea with single uncus, surrounded by thick setae; lacinia with three unci, surrounded by many long, thick setae; haptomerum with 13–16 short, stout heli, bigger towards anterior end
. *Asthenopholis subfasciata* Blanchard
 5. Dorsolateral edge of maxillary stipes with a row of blunt, truncate stridulatory teeth; raster without palidia; epipharynx without epizygum and zygum; right mandible with a single notch in the scissorial area
. *Congela valida* Péringuey
— Dorsolateral edge of stipes with row of pointed stridulatory teeth; palidia forming an arc; epizygum and zygum present; right mandible without notch . . . *Trochalus politus* Moser

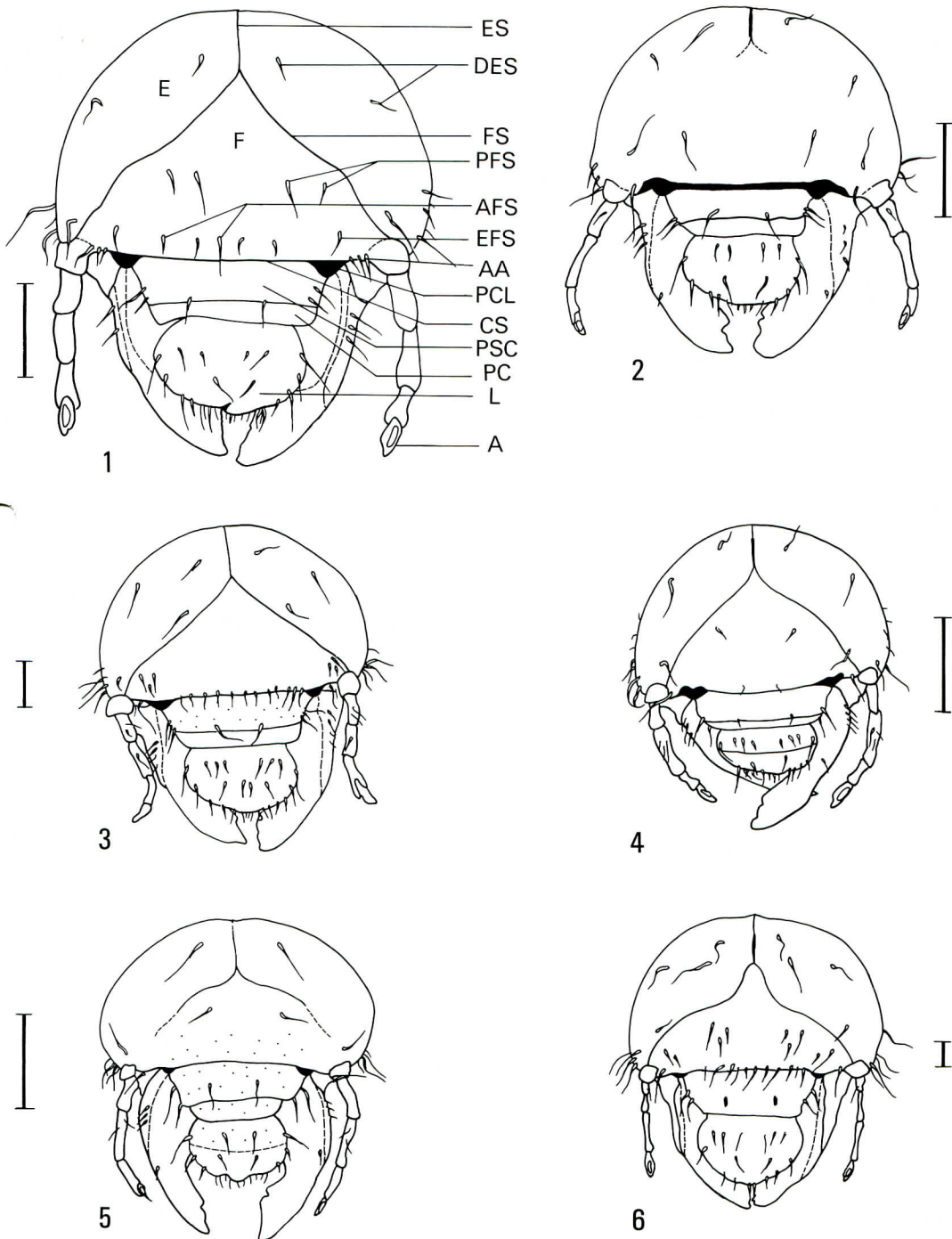
Family Scarabaeidae

Subfamily Dynastinae

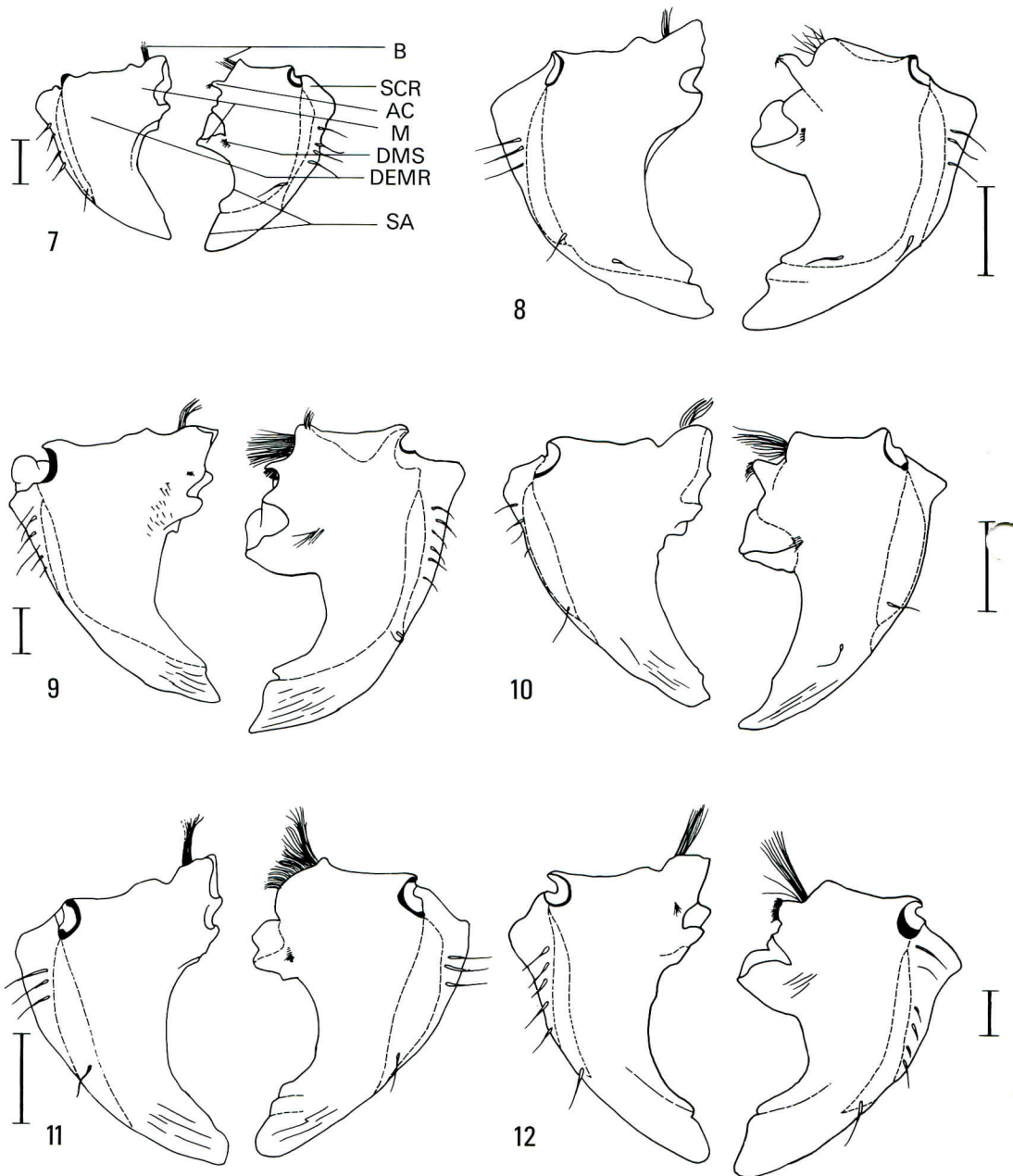
Heteronychus arator (Fabricius), Figs 1, 7, 13, 14, 15, 16, 22

Description

Body. Cylindrical, typically scarabaeiform, average body length 30 mm, average head width



Figs 1-6. Head capsules of third instar larvae. 1, *Heteronychus arator*; 2, *Adoretus ictericus*; 3, *Asthenopholis subfasciata*; 4, *Congela valida*; 5, *Trochalus politus*; 6, *Macrophylla ciliata*. A = antenna; AA = anterofrontal angle; AFS = anterior frontal setae; CS = clypeofrontal suture; DES = dorsoepicranial setae; E = epicranium; EFS = exterior frontal seta; ES = epicranial suture; F = frons; FS = frontal suture; L = labrum; PC = preclypeus; PCL = precoila; PFS = posterior frontal seta; PSC = postclypeus. Scale bars = 1 mm.

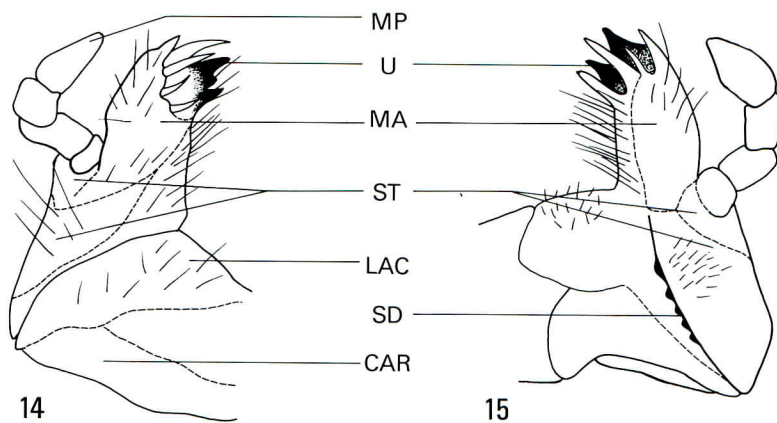
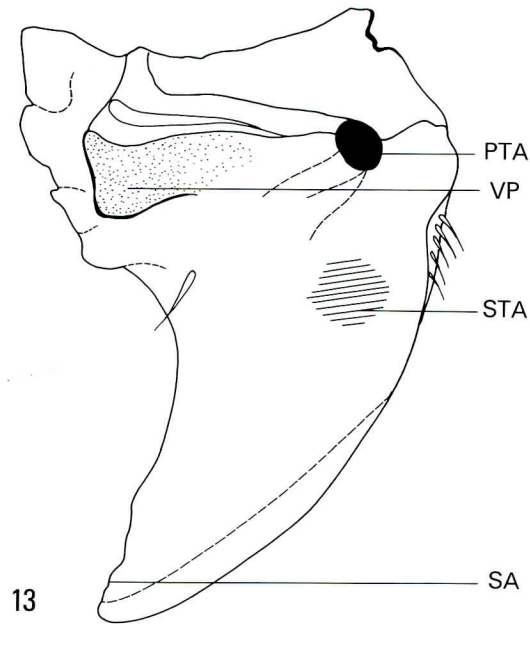


Figs 7–12. Dorsal surface of mandibles of third instar larvae. **7**, *Heteronychus arator*; **8**, *Adoretus ictericus*; **9**, *Asthenopholis subfasciata*; **10**, *Congela valida*; **11**, *Trochalus politus*; **12**, *Macrophylla ciliata*. AC = acia; B = brustia; DEMR = dorsoexterior mandibular region; DMS = dorsomolar setae; M = molar lobes; SA = scissorial area; SCR = scrobe. Scale bars = 1 mm.

3.8 mm ($n = 9$). Unguiculus present on all legs, slender, curved, dark-brown. Spiracles distinct, C-shaped, closed at the ends.

Cranium (Fig. 1). Smooth, dark-brown. Clypeo-

frontal suture distinct, with precoilae. Frontal sutures distinct, with epicranial suture clearly visible, bearing a thickened area. Frons with anterior frontal setae in a row parallel to clypeofrontal



Figs 13–15. *Heteronychus arator* third instar larvae. **13**, ventral surface of right mandible; **14**, dorsal surface of maxilla; **15**, ventral surface of maxilla. CAR = cardo; LAC = labacoria; MA = mala; MP = maxillary palp; PTA = postartis; SA = scissorial area; SD = stridulatory teeth; ST = stipes; STA = stridulatory area; U = uncus; VP = ventral process. Scale bar = 0.5 mm.

suture. Two pairs of posterior frontal setae and one pair of exterior frontal setae present. Each anterior angle with three setae. Epicranial surface with dorsoepicranial setae forming a row of three setae, with five pairs of setae on lateral edges of epicranium. Ocelli visible as darkly-pigmented spots

near base of antennae. No pores on surface of epicranium and frons.

Clypeus (Fig. 1). Trapezoidal, postclypeus and preclypeus equally sclerotized; postclypeus longer than preclypeus. Anterior clypeal setae long, paramedian and close to distal end of postclypeus. Two

pairs of long exterior clypeal setae on lateral margin of postclypeus. Postclypeal pores present; preclypeal pores absent.

Labrum (Fig. 1). Asymmetrical, with rounded lateral margins, a rough texture and no transverse ridge. Pores present. Two pairs of proximal setae and one pair of distal setae present. Apical lobe with fringe of setae; lateral lobe with four pairs of setae on border.

Antennae (Fig. 1). With four segments; antennal basal piece fused. First segment without setae on dorsal or on ventral surface. Second segment as long as first segment. No setae on ventral or dorsal surface of second or third segments. Apical joint fusiform. A single, elongated sensory spot on dorsal surface of apical segment and two sensory spots, one round, one triangular, on ventral surface.

Mandibles (Figs 7, 13). Asymmetrical. Scissorial area black, that of left mandible similar in shape to that of right mandible. Cutting edge of left mandible with single notch, right mandible without notch. No long setae below position of notches. Scrobe bound by two carinae with rows of three and five setae. Mola-bearing part of both mandibles straw-coloured. Molar part of left mandible with distal lobe large and proximal lobe bilobed with both sub-lobes small. Triangular acia with numerous coarse setae. Molar part of right mandible bearing four lobes, lobes decreasing in size towards apex. A brustia of coarse setae at base of each molar part; dorsomolar setae at base of proximal lobe; setae on dorsoexterior mandibular region.

Stridulatory area on ventral surface of each mandible clearly visible (Fig. 13). Basolateral setae absent. Ventral process on right mandible (Fig. 13) same size as on left mandible.

Maxillae (Figs 14, 15). Cardo with scattered short, sharp setae. Ventrolateral surface of maxillae with three stipes. Ventral surface of stipes with a range of short to long, scattered setae and dorsolateral edge with row of small, truncate stridulatory teeth. Galea and lacinia fused to form mala, with one large uncus and three smaller ones surrounded by thick setae. Ventral surface of lacinia and labacoria without sensilla. Maxillary palp with three segments; sensory pegs present on distal end of last segment.

Labium. Glossa covered with long, slender setae below palpi; setae become thicker and shorter towards centre. Hypopharyngeal sclerome asym-

metrical. Truncate process prominent and second process on right side present. Lateral lobe with clump of stout, blunt setae.

Epipharynx (Fig. 16). With rounded lateral margins. Apical margin protuberant in region of corypha and indented in region of epizygum. Long, thin setae present on corypha. Epizygum and zygum present. No plegmatium on each lateral margin. Acanthopariae with 12–14 flattened, curved setae. Gymnopariae broad, without setae. Chaetopariae covered with setae pointing towards centre, surrounding ovate and indented pedium. Haptomerum with three heli, arranged in a transverse row.

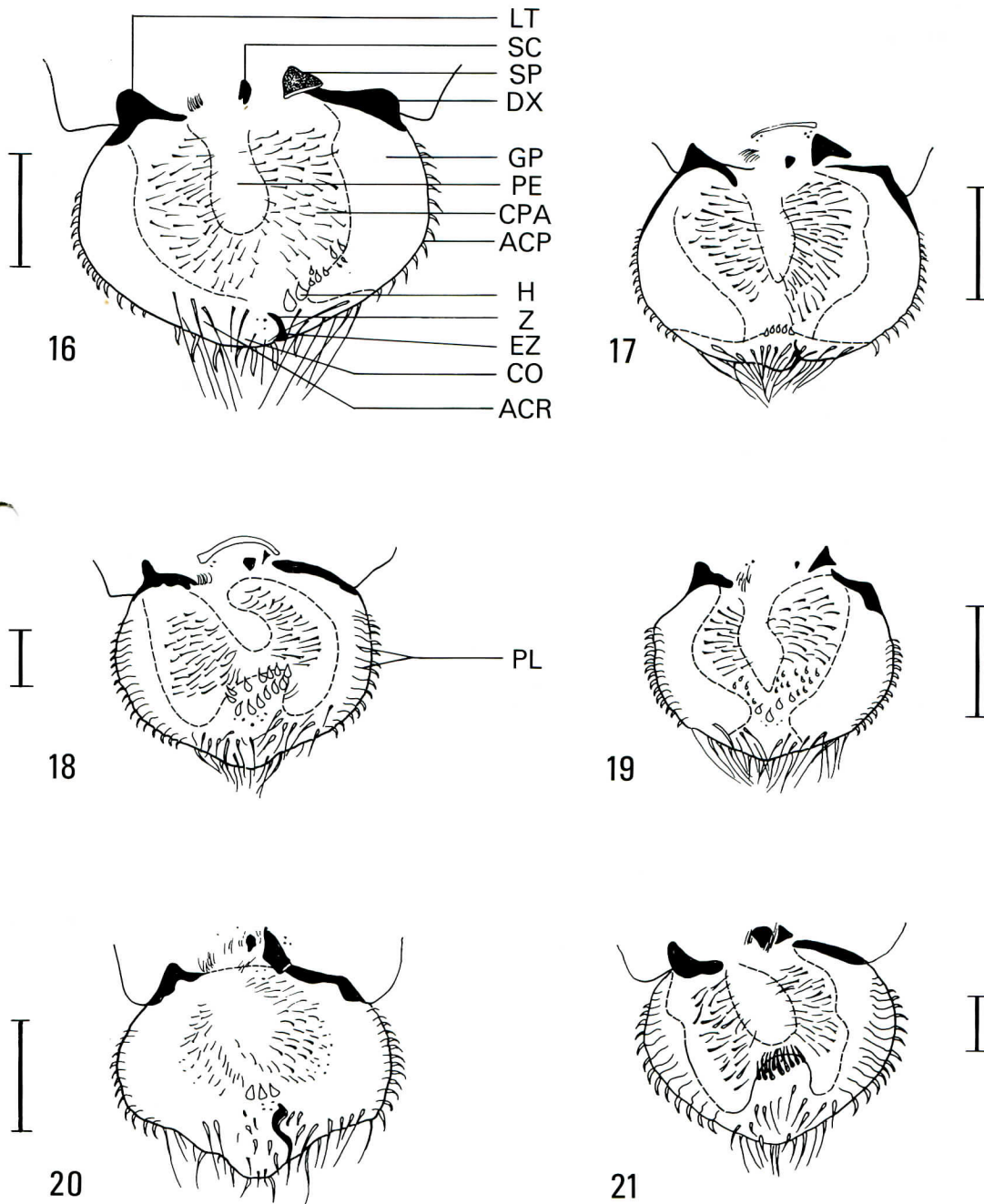
Sclerotized laeotorma on right side of epipharynx in shape of an inverted triangle and dexitorma on left side of epipharynx long. Haptolachus at base of epipharynx incomplete. Sclerotized crepis below haptolachus absent. Sclerotized nesia present with elongated thin nesium (= sense cone) and second nesium (= sclerotized plate) close to dexitorma. Dexiphorba absent but a row of slender setae, mesad of laeotorma.

Raster (Fig. 22). Lacking a septula and palidia. Tegilla with few, short, scattered, hamate setae. Presepular hamate setae present. Anal opening transverse and straight. Setae around anal opening very short and stout with a line of longer setae along lower anal lip.

Biological notes

Adult black maize beetles damage a range of crops including maize, sugarcane, pasture plants and some vegetables (Sweeney 1967). They bore into the lower portion of pineapple stems and may also eat the roots (Le Roux 1992). Adults leave characteristic entry holes where they have burrowed into the soil, and can be found in the root zone of infested plants. It is not known whether their larvae cause any damage. Larvae were found in pineapple fields from July to February; none was found in winter, perhaps because they were buried below the sampling depth (Petty 1976, 1978).

Black maize beetle infestations can be prevented by applying pesticides to the planting ridge before planting. Fields should be inspected for entry holes in the soil, particularly in spring and late summer, and sprayed when infestations are noticed (Le Roux 1992).



Figs 16–21. Epipharynx of third instar larvae. **16**, *Heteronychus arator*; **17**, *Adoretus ictericus*; **18**, *Asthenopholis subfasciata*; **19**, *Congela valida*; **20**, *Trochalus politus*; **21**, *Macrophylla ciliata*. ACP = acanthoparia; ACR = acroparia; CO = corypha; CPA = chaetoparia; DX = dextorma; EZ = epizygum; GP = gymnoparia; H = heli; LT = laetorma; PE = pedium; PL = plegmatia; SC = sense cone; SP = sclerotized plate; Z = zygum. Scale bars = 1 mm.

Subfamily Rutelinae

Adoretus ictericus Burmeister, Figs 2, 8, 17, 23*Description*

Body. Cylindrical, typically scarabaeiform, average length 31.3 mm, average head width 3.2 mm ($n = 6$). Unguiculus present on all legs, slender, curved, dark-brown. Spiracles distinct, C-shaped, open at ends.

Cranium (Fig. 2). Reticulate, blackish-brown. Clypeofrontal suture distinct, with precoilae. Frontal sutures indistinct. Frons without anterior frontal setae. One pair posterior frontal setae but no exterior frontal setae. Each anterior angle with one seta. Epicranial surface with a row of three dorsoepicranial setae and four pairs of setae on lateral edges. Ocelli visible as darkly-pigmented spots near base of antennae. No pores on surface of epicranium or frons.

Clypeus (Fig. 2). Trapezoidal; postclypeus more sclerotized than preclypeus; postclypeus longer than preclypeus. Anterior clypeal setae long, paramedian, close to distal end of postclypeus. Two pairs of long exterior clypeal setae on lateral margin of postclypeus. Postclypeal pores present, preclypeal pores absent.

Labrum (Fig. 2). Asymmetrical, with rounded lateral margins, a rough texture and no transverse ridge or pores. Labrum with two pairs of proximal setae and one pair of distal setae. Apical lobe with fringe of setae and lateral lobe with two pairs of setae on border.

Antennae (Fig. 2). With four segments. Antennal basal piece partially fused. First segment with one seta on dorsal surface, none on ventral surface. Second segment as long as first segment. Second and third segments without setae. Apical joint fusiform; a single, elongate sensory spot on dorsal surface of apical segment and two sensory spots, one round, one triangular, on ventral surface.

Mandibles (Fig. 8). Asymmetrical. Scissorial area of left mandible similar in shape to that of right mandible. Cutting edge of left mandible with double notch, right mandible with single notch. A single, long seta below position of notches. Scrobe bound by two carinae with a row of three setae. Mola-bearing part of both mandibles dark-brown. Molar part of left mandible bilobed, with distal lobe large and concave, proximal lobe small. Molar part of right mandible bearing four lobes. A brustia

of coarse setae present at base of each molar part, and dorsomolar setae present at base of proximal lobe but setae absent from dorsoexterior mandibular region.

Stridulatory area on ventral surface of each mandible clearly visible. Basolateral setae absent. Ventral process on right mandible same size as on left mandible.

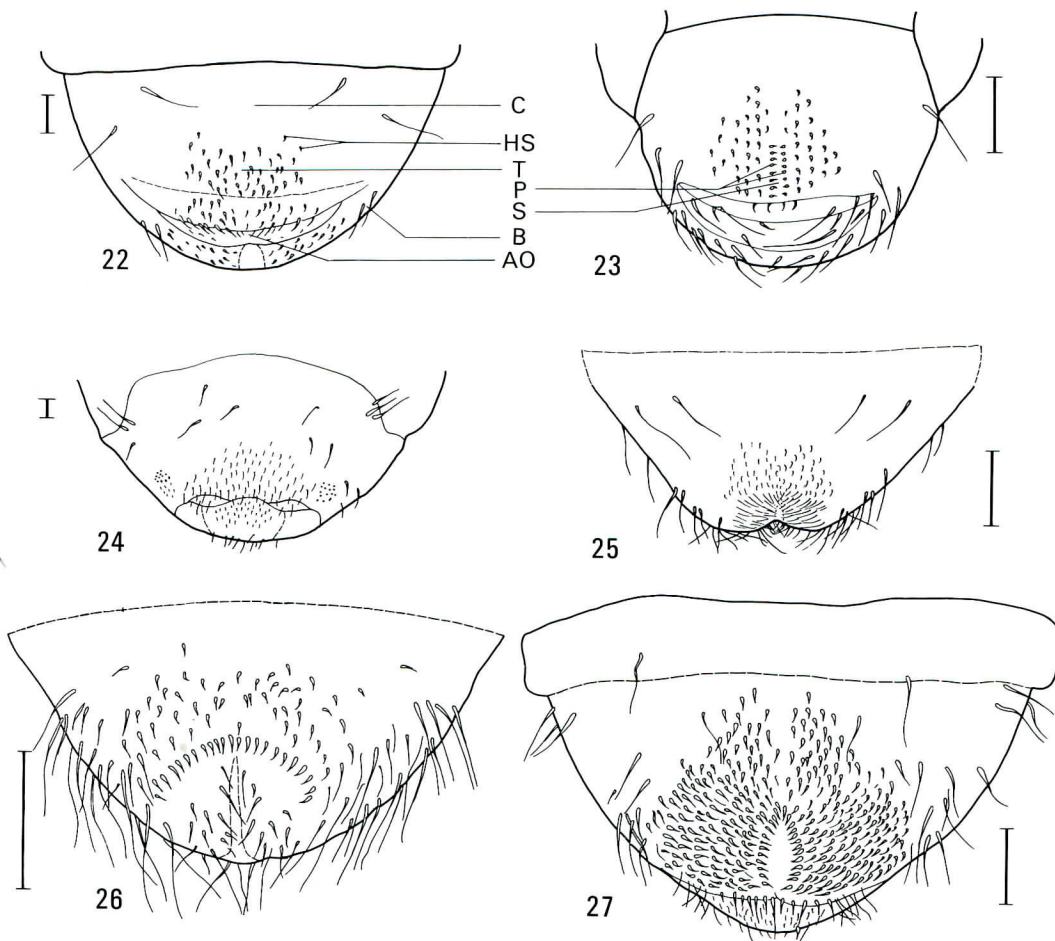
Maxillae. Cardo without setae. Ventrolateral surface of maxillae with two stipes. Ventral surface of stipes with long, scattered setae and dorsolateral edge with row of small, flattened, sickle-shaped stridulatory teeth. Galea and lacinia fused to form mala, with one large unci at tip and two smaller, blunt unci below it. Ventral surface of lacinia and labacoria without sensilla. Maxillary palp with four segments; sensory pegs present at distal end of last palp segment.

Labium. Prementum with a pair of long, slender setae; glossa covered with stout setae. Hypopharyngeal sclerome asymmetrical. Truncate process prominent but second process on right side absent. Lateral lobe with a clump of setae.

Epipharynx (Fig. 17). With rounded lateral margins. Apical margin protuberant in region of corypha, indented in region of epizygum. Epizygum and zygum present. Plegmatium absent from each lateral margin. Acanthopariae with 12–14 flattened setae. Gymnopariae broad, without setae. Chaetopariae covered with many perpendicular, hard setae that are softer and smaller towards gymnoparia and surrounding an ovate and indented pedium. Haptomerum with five heli, in a transverse row.

Sclerotized laeotorma on right side of epipharynx in shape of inverted triangle with top, left corner longer; dextorma on left side of epipharynx broad. Haptolachus at base of epipharynx incomplete. Sclerotized crepis present below haptolachus. Sclerotized nesia present with conical nesium and pointed second nesium. Dexiphorba absent but row of slender setae present mesad of laeotorma.

Raster (Fig. 23). With septula. Palidia parallel with less than 10 pali in each row. Tegilla extending from barbula to palidia, covered with short, hamate setae arranged in an ordered pattern. Presepular hamate setae present. Barbula and campus with few, long, slender setae present. Anal opening transverse and straight. Setae around anal opening both long and slender, but short, sharp on dorsal surface.



Figs 22–27. Raster patterns of third instar larvae. **22**, *Heteronychus arator*; **23**, *Adoretus ictericus*; **24**, *Macrophylla ciliata*; **25**, *Congela valida*; **26**, *Trochalus politus*; **27**, *Asthenopholis subfasciata*. AO = anal opening; B = barbula; C = campus; HS = hamate setae; P = palidia; S = septula; T = tegilla. Scale bars = 1 mm.

Biological notes

Nothing is known of the biology of this species in pineapple fields.

Subfamily Melolonthinae

Asthenopholis subfasciata Blanchard, Figs 3, 9, 18, 27

Description

Body. Cylindrical, typically scarabaeiform, average body length 43.5 mm, average head width 5.6 mm ($n = 5$). Unguiculus present on all legs, longer on first two than on hind leg. Spiracles distinct, C-shaped, closed at ends.

Cranium (Fig. 3). Reticulate, darkish-brown. Clypeofrontal suture distinct, with precoilae. Frontal sutures indistinct; epicranial suture about half the length of one frontal suture; thickened area of epicranial suture dark-brown. Frons with a row of anterior frontal setae parallel to clypeofrontal suture. No posterior frontal setae, but with four pairs of exterior frontal setae. Each anterior angle with three setae. Epicranial surface with one pair of dorsoepicranial setae and four pairs of setae on lateral edges of epicranium. Ocelli absent. No pores on surface of epicranium or frons.

Clypeus (Fig. 3). Trapezoidal; postclypeus more sclerotized, slightly longer than preclypeus. Anterior clypeal setae long, paramedian, close to

distal end of postclypeus. Three pairs of long exterior clypeal setae on lateral margin of postclypeus. Postclypeal pores present but preclypeal pores absent.

Labrum (Fig. 3). Symmetrical, divided by transverse ridge; surface with rough texture but no pores. Lateral margins rounded. Labrum with three pairs of proximal setae and two pairs of distal setae. Apical lobe with five pairs of short, sharp setae, lateral lobe with four pairs of setae at border.

Antennae (Fig. 3). With four segments. Antennal basal piece fused. First segment with two setae on dorsal surface. Second segment as long as first, with one seta on dorsal surface. Apical joint fusiform, a single, elongate sensory spot on dorsal surface of apical segment and two large, round sensory spots on ventral surface.

Mandibles (Fig. 9). Asymmetrical. Scissorial area black, with area of left mandible similar in shape to that of right mandible. Cutting edge of left mandible with a single, very prominent notch, right mandible with a single notch. A single long seta below notches. Scrobe bound by two carinae with a row of six setae. Molar part of both mandibles dark-brown. Molar part of left mandible bilobed, with distal lobe large and concave, proximal lobe small. Acia triangular, with numerous coarse setae. Molar part of right mandible bearing four lobes with distal lobe small but increasing in size towards proximal lobe. A brustia of coarse setae present at base of each molar part; dorsomolar setae at base of proximal lobe, no setae on dorsoexterior mandibular region.

No stridulatory area on ventral surface of mandibles. Basolateral setae present at basolateral angle of mandible. Ventral process on right mandible larger than that on left mandible.

Maxillae. Cardo with scattered, short, sharp setae. Ventrolateral surface of maxillae with three stipes. Ventral surface of stipes with long, scattered setae and dorsolateral edge with row of small, blunt, tooth-like structures pointing anteriorly. Galea and lacinia partially fused, separated at tip. Ventral and dorsal surface of galea with long, thin setae. Galea with single unci, surrounded by thick setae and lacinia with three unci, surrounded by many long, thick setae. Ventral surface of lacinia and labacoria lacking sensilla. Maxillary palp with three segments; sensory pegs present at distal end of last segment of palp.

Labium. Prementum with setae in a transverse row. Glossa covered with long, thin setae near

palpi, becoming thicker and shorter towards centre of glossa.

Epipharynx (Fig. 18). With rounded lateral margins. Apical margin rounded in region of corypha. Long, thin setae present on corypha, acroparia prominent. Epizygum and zygum absent. Plegmatium on each lateral margin prominent, composed of 18 plegmata. Acanthopariae with 18 flattened, sickle-shaped setae, anterior two longest and decreasing in size towards posterior. Gymnopariae narrow, without setae. Chaetopariae covered with long, sharp setae pointing towards centre, surrounding an ovate, indented pedium. Hapterum with 13–16 short, stout heli, increasing in size towards anterior end.

Sclerotized laeotorma on right side of epipharynx in shape of an inverted triangle and dextortorma on left side of epipharynx broad, straight and uniformly thick along length. Hapterum at base of epipharynx complete. Sclerotized, archeocrepis below hapterum expanded at each side, with sensilla visible on right side of crepis. Sclerotized nesium conical, with two sensory spots at apex. Dexiphorba and row of slender setae mesad to laeotorma present.

Raster (Fig. 27). With septula extending from lower anal lip to venter of abdominal segment 10 in an elongated pattern. Palidia forming an elongated oval with 10–12 paired pali. Tegilla extending from barbula to palidia, covered with many closely packed, hamate setae. Presepular hamate setae present. Barbula and campus with few long, slender setae. Anal opening transverse and curved. Setae around anal opening short and stout but longer and thinner at ends of anal opening.

Biological notes

Adoretus subfasciata was the predominant grub in samples from Manley Flats (33.22S 26.40E), near Grahamstown. Population densities of 0.5 larvae per plant significantly reduce plant growth (Petty 1989). Eggs are laid in October or November and adulthood is reached within a year. Third instar larvae are most numerous in October and November (Sweeney 1967).

Congela valida Péringuey, Figs 4, 10, 19, 25

Description

Body. Cylindrical, typically scarabaeiform, average body length 26 mm, average head width 2.6 mm ($n = 7$). Unguiculus absent on hind leg, on

other legs it is slender, curved and dark-brown. Spiracles distinct, C-shaped, open at ends.

Cranium (Fig. 4). Reticulate, uniformly pale-yellow. Clypeofrontal suture distinct with precoilae. Frontal sutures distinct; epicranial suture about one third length of frontal sutures. Thickened area of epicranial suture dark-brown just above confluence. Frons with two short, paramedian anterior frontal setae. One pair of posterior frontal setae but no exterior frontal setae. Each anterior angle with one seta. Epicranial surface with dorsoepicranial setae forming a row of three setae; four pairs of setae on lateral edges of epicranium. Ocelli absent. No pores on surface of epicranium or frons.

Clypeus (Fig. 4). Trapezoidal. Postclypeus and preclypeus equally sclerotized, postclypeus longer. Anterior clypeal setae short, paramedian and close to distal end of postclypeus. Two pairs of long exterior clypeal setae on lateral margin of postclypeus. Postclypeal pores present; preclypeal pores absent.

Labrum (Fig. 4). Symmetrical, divided by a transverse ridge, with rounded lateral margins and a rough texture. Pores present. Labrum with three pairs of proximal setae and one pair of distal setae. Apical lobe with four pairs of setae and lateral lobe with two pairs of setae at border.

Antennae (Fig. 4). With four segments. Antennal basal piece partially fused. First segment without setae on dorsal or ventral surface. Second segment twice as long as first segment with three setae on dorsal surface and no setae on ventral surface. Third segment without setae on either surface. Apical joint fusiform. A single, elongated sensory spot on dorsal surface of apical segment and a single, circular sensory spot on ventral surface.

Mandibles (Fig. 10). Asymmetrical. Scissorial area black, that of left mandible similar in shape to that of right mandible. Cutting edge of left and right mandibles without notches, and a single, long seta each. Scrobe bound by two carinae with a row of five setae. Mola-bearing part of both mandibles straw-coloured. Molar part of left mandible bilobed, with distal lobe large and concave and proximal lobe small. Acia triangular, with numerous coarse setae. Molar part of right mandible bearing four lobes with distal lobe small but increasing in size towards proximal lobe. A brustia of coarse setae at base of each molar part and dorsomolar setae at base of proximal lobe both present but setae on dorsoexterior mandibular region absent.

No stridulatory area on ventral surface of each mandible. Basolateral setae present at basolateral angle of mandible. Ventral process on right mandible same size as on left mandible.

Maxillae. Cardo with scattered, short, sharp setae. Ventrolateral surface of maxillae with three stipes. Ventral surface of stipes with short, scattered setae and dorsolateral edge with a row of small, truncate stridulatory teeth. Galea and lacinia partially fused but separated at tip. Ventral and dorsal surface of galea with long, thin setae and with a single uncus surrounded by thick setae. Ventral surface of lacinia and labacoria lacking sensilla. Maxillary palp with three segments; sensory pegs present at distal end of last palp segment.

Labium. Prementum with a pair of long, slender setae. Glossa covered with long setae around palpi and small short setae towards base, a clump of stout, blunt setae present in centre. Hypopharyngeal sclerome asymmetrical. Truncate process prominent and second process present on right side. Lateral lobe with clump of long setae.

Epipharynx (Fig. 19). With rounded lateral margins. Apical margin rounded in region of corypha. Long, thin setae present on corypha. Epizygon and zygum absent. Plegmatium on each lateral margin composed of 12–14 plegmata. Acanthopariae with 12–14 flattened, curved setae. Gymnopariae broad, without setae. Chaetopariae covered with coarse setae pointing inwards, surrounding an ovate, indented pedium. Haptomerum with three short, stout heli, arranged in a triangle.

Sclerotized laeotorma on right side of epipharynx in the shape of an inverted triangle; dextortorma on left side of epipharynx broad and straight. Haptolachus at base of epipharynx incomplete. Sclerotized crepis below haptolachus absent. Sclerotized nesium conical in shape. No dexiphorba or row of slender setae mesad of laeotorma.

Raster (Fig. 25). With a septula but no palidia. Tegilla small and covered with short, hamate setae arranged in an ordered pattern. Preseptular hamate setae present. Barbula and campus with a few long, slender setae. Anal opening Y-shaped, setae around anal opening long and slender.

Biological notes

Most larvae of *C. valida* were found in fields from March to August, with the highest numbers occurring in August (Petty 1976).

Trochalus politus Moser, Figs 5, 11, 20, 26**Description**

Body. Cylindrical, typically scarabaeiform, average body length 26.2 mm, average head width 2.9 mm ($n = 8$). Unguiculus absent from hind legs, slender on other legs, curved, dark-brown. Spiracles indistinct.

Cranium (Fig. 5). Faintly reticulate, yellowish-cream to brown. Clypeofrontal suture distinct, with precoxae. Frontal sutures distinct; epicranial suture half as long as frontal suture, thickened area of epicranial suture slightly darker. No anterior frontal setae. One pair of posterior frontal setae present. No exterior frontal setae. Each anterior angle with one seta. Epicranial surface with one pair of dorsoepicranial setae and four pairs of setae on lateral edges of epicranium. Ocelli absent. Pores present on surface of epicranium and frons.

Clypeus (Fig. 5). Trapezoidal with postclypeus longer and slightly more sclerotized than pre-clypeus. Anterior clypeal setae long and close to distal end of postclypeus. Two pairs of long exterior clypeal setae on lateral margin of postclypeus. Pores on postclypeus and preclypeus.

Labrum (Fig. 5). Symmetrical, divided by a transverse ridge, with rounded lateral margins and a rough texture. Pores present. Labrum with one pair of proximal setae and one pair of distal setae. Apical lobe with five pairs of sharp setae and lateral lobe with four pairs of setae at border.

Antennae (Fig. 5). With four segments. Antennal basal piece partially fused. First segment without setae on dorsal or ventral surface. Second segment twice as long as first, with one seta on dorsal surface and one seta on ventral surface. Third segment without setae. Apical joint fusiform; a single, elongated sensory spot on dorsal surface of apical segment and two sensory spots, one round and one triangular, on ventral surface.

Mandibles (Fig. 11). Asymmetrical. Scissorial area black; area of left mandible narrower and longer than that of right mandible. Cutting edge of left mandible with double notch and of right mandible without notch. No long setae below notches. Scrobe bound by two carinae with a row of three setae. Mola-bearing part of both mandibles straw-coloured. Molar part of left mandible bilobed, with distal lobe large and proximal lobe small. Acia square, with numerous, coarse setae. Molar part of right mandible bearing four lobes, lobes decreasing in size towards apex. A brustia of coarse setae

present at base of each molar part, and dorsomolar setae present at base of proximal lobe but setae absent from dorsoexterior mandibular region.

No stridulatory area on ventral surface of mandibles. Basolateral setae present. Ventral process on right mandible larger than on left mandible.

Maxillae. Cardo with scattered, short, sharp setae. Ventrolateral surface of maxillae with three stipes. Ventral surface of stipes with long, scattered setae and dorsolateral edge with row of small, pointed structures, not pointing anteriorly. Galea and lacinia partially fused, separate at tip. Ventral and dorsal surface of galea with long, thin setae. Galea with three unci and lacinia with one terminal uncus, surrounded by stiff setae. Ventral surface of lacinia and labacoria with a sensillum. Maxillary palp with three segments; sensory pegs at distal end of last segment of palps present.

Labium. Prementum with a pair of long, slender setae and glossa covered with long, sharp setae. Hypopharyngeal sclerome asymmetrical. Truncate process small and second process on right side absent. Lateral lobe with a clump of long setae.

Epipharynx (Fig. 20). With rounded lateral margins. Apical margin protuberant in region of corypha and rounded in region of epizygum. Long, thin setae present on corypha and prominent acroparia. Epizygum and zygum present. Plegmatium on each lateral margin composed of 16 plegmata. Acanthopariae with 16 flattened, curved setae. Gymnopariae broad, without setae. Chaetopariae covered with short, stout setae, surrounding an ovate, indented pedium. Haptomerum with three heli, arranged in a transverse row.

Sclerotized laeotorma on right side of epipharynx shaped as an inverted triangle, with top left corner extended and dexitorma on left side of epipharynx broad. Haptolachus at base of epipharynx incomplete. No sclerotized crepis below haptolachus. Sclerotized nesia present, with conical nesium and second triangular nesium. Dexiphorba and row of slender setae present mesad of laeotorma.

Raster (Fig. 26). With a septula and palidia forming an arc with 10–12 pali. Tegilla, extending from barbula to palidia, covered with very few short, sharp, hamate setae. Presepular hamate setae absent. Barbula and campus with a few long, slender setae. Anal opening Y-shaped. Setae around anal opening small and sharp closer to opening, but longer further away; short setae covering dorsal surface.

Biological notes

Larvae of *T. politus* are present in the soil throughout the year but their numbers increase from April through to December (Petty 1976, 1978). They are not specifically associated with pineapples, but adults damage pineapple stems and encourage decay.

Macrophylla ciliata* Herbst, Figs 6, 12, 21, 24*Description**

Body. Cylindrical, typically scarabaeiform, average body length 34 mm, average head width 4.8 mm ($n = 3$). Unguiculus present on all legs, but longer on first two legs than on hind leg and half as long as tibiotarsus. Spiracles distinct, C-shaped, closed, with raised centres.

Cranium (Fig. 6). Smooth, light- to dark-brown. Clypeofrontal suture distinct, with precoilae. Frontal sutures distinct; epicranial suture half the length of frontal suture; thickened area of epicranial suture present. Frons with a row of anterior frontal setae parallel to clypeofrontal suture. Three pairs of posterior frontal setae and two pairs of exterior frontal setae present. Each anterior angle with one seta. Epicranial surface with a row of three dorsoepicranial setae and more than five pairs of setae on lateral edges of epicranium. Ocelli absent. No pores on surface of epicranium or frons.

Clypeus (Fig. 6). Trapezoidal. Postclypeus more sclerotized than preclypeus, but equal in length to preclypeus. Anterior clypeal setae short, paramedian and close to the distal end of the postclypeus. Two pairs of long exterior clypeal setae on lateral margin of postclypeus. Postclypeal pores present but preclypeal pores absent.

Labrum (Fig. 6). Symmetrical, divided by two transverse ridges, with rounded lateral margins and a rough texture. Pores present. Labrum with three pairs of proximal setae and one pair of distal setae. Apical lobe with five pairs of setae and lateral lobe with three pairs of setae at border.

Antennae (Fig. 6). With four segments. Antennal basal piece partially fused. First segment with two setae on dorsal surface and one seta on ventral surface. Second segment as long as first, with one seta on dorsal surface. Apical joint fusiform, a single, elongated sensory spot on dorsal surface of apical segment and two sensory spots, one round and one triangular, on ventral surface.

Mandibles (Fig. 12). Asymmetrical. Scissorial area black; area of left mandible similar to that of right

mandible. Cutting edge of both mandibles with a single notch. Scrobe bounded by two carinae; with a row of six setae. Mola-bearing part of both mandibles straw-coloured. Molar part of left mandible bilobed, with distal lobe large, concave, proximal lobe small. Acia triangular, with numerous coarse setae. Molar part of right mandible bearing three lobes, lobes decreasing in size towards apex. Brustia of coarse setae present at base of each molar part. Dorsomolar setae at base of proximal lobe, but no setae on dorsoexterior mandibular region. Stridulatory area absent from ventral surface of each mandible. Basolateral setae present. Ventral process on right mandible smaller than that on left mandible.

Maxillae. Cardo with scattered, long setae. Ventrolateral surface of maxilla with two stipes. Ventral surface of stipes with long, scattered setae; dorsolateral edge with row of small, blunt, tooth-like structures pointing anteriorly. Galea and lacinia partially fused, separated at tip. Ventral and dorsal surface of galea with long, thin setae. Galea with single, hooked unci, surrounded by many long, thin setae. Lacinia with four unci, surrounded by setae. Ventral surface of lacinia and labacoria without sensillae. Maxillary palp with three segments; sensory pegs present at the distal end of last palp segment.

Labrum. Setae on prementum in a transverse row. Glossa covered with long thin setae, becoming shorter and thicker toward base. Hypopharyngeal sclerome asymmetrical. Truncate process prominent and second process present on right side.

Epipharynx (Fig. 21). With rounded lateral margins. Apical margin rounded in region of corypha. Long, thin setae present on corypha. Epizygum and zygum absent. Plegmatium prominent and composed of 16 plegmata. Acanthopariae with 16 flattened, sickle-shaped setae. Gymnopariae narrow, without setae. Chaetopariae covered with long, thick setae, surrounding indented pedium. Haptomerum with 10 heli surrounding a clump of 16 heli. Sclerotized laeotorma on right side of epipharynx large, shaped like an inverted triangle. Dexitorma present on left side of epipharynx. Haptolachus at base of epipharynx incomplete. Sclerotized crepis below haptolachus absent. Sclerotized nesia present. Conical nesium close to dexitorma and second nesium lying close to first. Dexiphorba present.

Raster (Fig. 24). Lacking a septula and palidia. Tegilla extending from barbulae to region of

palidia, covered with long setae close to anal opening and shorter ones further away. Presepular hamate setae absent. Barbulae with few, long, slender setae. Anal opening transverse, curved. Setae around anal opening short and stout.

Biological notes

Mating occurs in January and February. The life cycle takes two years to complete but the generations overlap, so that adult beetles are found every year (Petty 1978).

ACKNOWLEDGEMENTS

We thank H. Davies-Coleman (Institute for Water Research, Rhodes University) for her invaluable help and ideas during this study; M. Sullivan and R. Yendall (landowners) for generously allowing us to collect specimens from their farms; R. Oberprieler (SANC) and E.K. Hartwig for identifying adult specimens and S. Abraham (Cartography Unit, Rhodes University) for arranging the drawings into plates.

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Accepted 15 May 1995