

Aspects of female reproductive biology of two southwestern Australian *Temognatha* species (Coleoptera: Buprestidae)

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Abstract – Oviposition behaviour is described for the first time in a *Temognatha* species, *T. chalcodera* (Thomson, 1878). *Allocasuarina acutivalvis* (F. Muell.) L. Johnson subsp. *acutivalvis* (Casuarinaceae) is the first recorded larval hostplant for *T. chalcodera*. Pre-oviposition behaviour is described for the first time in *Temognatha bruckii* (Thomson, 1878) and *T. chalcodera*. In-situ photos of *T. chalcodera* oviposition and *T. bruckii* pre-oviposition behaviour are provided. The published literature on pre-oviposition behaviour in *Temognatha* is reviewed. The *Temognatha variabilis* species-group is defined and diagnosed. Possible reasons for evolution of the apomorphic oviposition/pre-oviposition behaviour in these species are discussed.

INTRODUCTION

Temognatha Solier, 1833 is a moderately large Australian stigmoderine genus of ca. 85 valid known taxa, the bionomics of which are poorly known. In this paper I present the first observations of *Temognatha* oviposition, in *T. chalcodera* (Thomson, 1878), and pre-oviposition behaviour in *T. chalcodera* and *T. bruckii* (Thomson, 1878). All observations are based on recent fieldwork I have undertaken at a single site 18km east of Yellowdine, Western Australia (31°17'S, 119°50'E). At this site the *Temognatha chalcodera* and *T. bruckii* observations were made 25 m apart. During the course of observations, I was able to take a number of in-situ photos of *T. chalcodera* oviposition and *T. bruckii* pre-oviposition behaviour, and the most informative photo of each is provided. I also review the little that has been published on "pre-oviposition" behaviour in the genus.

Zoological specimen measurements linear, measured to nearest 0.05 mm using Zeiss stereomicroscope ocular micrometer (0–10 mm) or calipers (1–20 cm). Botanical specimen measurements linear, measured to nearest 0.05 mm using calipers or nearest 1 mm using tape measure. Buprestid morphology measurement definitions and their text abbreviations (capitalized in brackets) as follows: total length (TL) – from front of head (between antennae) to elytral apex; head width (HW) – to outer margins of eyes in frontal view; minimum interocular distance at vertex (MIDAV).

OBSERVATIONS

Temognatha (Temognatha) bruckii (Thomson, 1878)

Figure 1

Three female adults observed on 26 January 1990, at 1410–1515 hrs. All were "charcoal-scraping" 0.5–1.7 m above ground on two dead tree stumps (plant taxon unidentifiable) that were burnt on one side.

First female (TL: 29.2 mm) observed "charcoal-scraping", at 1410–1432 hrs. It was initially located by the sound of its scraping, audible for 1.5 m. This individual was 0.9 m above ground on south face of a 2 m high tree stump, and its body was positioned with longitudinal axis parallel to the ground. It had used its legs to raise the forepart of its venter off the stump surface, while simultaneously curving sternites 5,6 and 7 ventrally so that the extruded ovipositor and sternite 7 apex made contact with the stump surface. It then walked transversely across the charcoal patch (burnt area), while in this raised posture, and scraped and picked up charcoal particles into its ovipositor by using the combined action of its ovipositor and sternite 7 apex. After completing one scrape, it faced the opposite direction (180° to the direction of the previous scrape) and repeated the process, thereafter constantly alternating the direction of scrapes. Each unidirectional scrape lasted 2–3 sec., with the ovipositor remaining in contact with the charcoal surface for 1–2 cm maximum width. This female



Figure 1 *Temognatha bruckii* female charcoal-scraping (showing combined action of ovipositor and sternite 7) at 1425hrs on fire-blackened tree stump, 18km east of Yellowdine, Western Australia. Photo: author.

continuously scraped charcoal on this stump until 1415 hrs, after which it flew to a second blackened stump (1.2 m high) 8 m south of the first. Adopting the same posture and methods it continued charcoal-scraping 0.5 m above ground for a further 15 min., on north side of second stump (Figure 1). It ceased scraping at 1432 hrs and took flight to north-west.

Two more females were observed, at 1443 hrs, flying in from south-east and landing on first stump used by previous female. One landed 0.9 m above ground, while the other landed 1.7 m above ground. Their choice to use the first scraping site of the previous female was obviously not based on making visual contact with already present individuals, since the first female had already left. They then simultaneously and continuously scraped charcoal into their ovipositors, from 1445–1515 hrs, mostly working parallel to the ground and using the same methods as the first individual. No further observations were made.

Temognatha (Temognatha) chalcodera
(Thomson, 1878)

Figure 2

Two female adults observed on 26 January 1990,

at 1525–1535 hrs. Each was ovipositing 6–7 cms above ground on living trunks of mature diminutive non-flowering *Allocasuarina acutivalvis* (F. Muell.) L. Johnson subsp. *acutivalvis* (Casuarinaceae).

First female observed, at 1525 hrs, to oviposit on trunk of an apparently healthy 1.6 m high *A. acutivalvis* plant. It laid a single subcircular egg (on south face of trunk) with maximum diameter of 4.0 mm, 6.7 cm above ground on outside of trunk surface (trunk diameter 1.8 cm at this level), and then immediately (almost simultaneously) completely coated the egg with cemented yellow sand, thereby roughly forming a hemisphere (maximum diameter 8.5 mm, maximum height 3.8 mm) glued to the trunk surface. The encased egg thus appeared as a small "cemented sand-dome" (composed of quartzitic sand grains with maximum size of 1.3 mm) attached to the bark. Oviposition lasted a total of 30 sec., whereupon this female walked down onto ground and was observed to scrape and pick up yellow sand into its extruded ovipositor using the combined action of its ovipositor and sternite 7 apex, as it slowly walked along. This female eventually disappeared into scrub.

Second female (TL: 35.8 mm) observed, at 1531



Figure 2. *Temognatha chalcodera* female ovipositing (showing sand being ejected onto egg) at 1532hrs on *Allocasuarina acutivalvis*, 18km east of Yellowdine, Western Australia. Photo: author.

hrs, flying and then landing on top of an apparently healthy 1.4 m high *A. acutivalvis* plant, 3 m south of first oviposition site. It then walked head-first to base of trunk at ground level, turned 180°, and returned up trunk for a short distance to begin ovipositing at 1532 hrs (Figure 2). It laid a single subcircular egg (on east face of trunk) with maximum diameter of 4.7 mm, 7 cm above ground on outside of trunk surface (trunk diameter 1.3 cm, at this level), and then immediately completely coated the egg with cemented yellow sand, thereby forming a roughly hemispherical cemented sand-dome (maximum diameter 7.7 mm, maximum height 3.7 mm) composed of quartzitic sand grains with a maximum size of 1.0 mm. Oviposition duration as in previous individual.

In both instances the appearance of the domes contrasted strongly with the coloration and texture of the stems to which they were attached.

A search of the surrounding area revealed numerous fresh domes, of similar size and appearance, attached to the surface of the lower branches and trunk bases of other living and apparently healthy *A. acutivalvis* plants (with and without seed cones), including mature individuals up to 3 m high. Some living plants had disintegrating domes scattered over their stems

and branches, but no emergence (exit) holes that could be attributed to adult beetles the size of *T. chalcodera*. There was no evidence that *T. chalcodera* oviposited on the few dead or dying *A. acutivalvis* plants in the area.

Sand was not present on the stem immediately under the centre (where the egg was/is located) of any old or fresh domes examined. However, a single 1.5–2 mm maximum diameter oval hole was present under the centre of some fresh domes, and was associated with a first instar buprestid larvae in one instance.

Occasional plants of *Allocasuarina corniculata* (F.Muell.) L.Johnson were also present at this site, but there was no evidence that *T. chalcodera* oviposited on this species. Interestingly, in this locality *A. acutivalvis* has smooth bark on its branches and trunk while *A. corniculata* has rough corrugated bark on same.

DISCUSSION

The presence of numerous fresh domes suggested *T. chalcodera* frequently oviposited at this locality during the 1989/1990 summer period. The occurrence of old and disintegrating domes on plants lacking adult emergence holes possibly

indicates failed larval development in previous years or prolonged development of larvae/pupae.

The presence of powdered or particulate material in the abdomen of female stigmoderine buprestids has been previously noted by three authors, although the purposes ascribed to this material and the hypotheses of its method of uptake and utilisation have differed.

Dodd (1913: 103–104; 1916: xxvi–xxvii) reported two or three little sacs containing fine sand “at the extreme tip of the abdomen” in dissected female *Temognatha regia* (Blackburn, 1892) (as *Stigmodera regia*) and observed females on the ground taking up sand into these sacs, although he was unable to determine the exact mechanism of sand uptake. As the females involved were old and contained few eggs, he suggested that the sand served as ballast to stabilize post-oviposition flight in females, in windy conditions.

Macqueen (1948: 1–2; 1964: 17) similarly reported powdered charcoal in the abdomen of *Temognatha fortnumi* (Hope, 1843) (as *Stigmodera (Thermognatha) fortnumi*), and observed females scraping their abdomens against charred timber, apparently taking in charcoal. These observations were made in “similar circumstances” to his earlier observations of presumed oviposition in the same species. In these earlier instances, females were observed probing among charred ironbark (*Eucalyptus* spp.) sapwood with their abdominal tips, although oviposition was not specifically observed. Macqueen (1948: 2) suggested that the eggs were coated with charcoal, in some manner, prior to oviposition.

Gardner (1990: 296) reported a posteriorly opening sac lying dorsal to the vagina and interposed between the dorsal valve and style-bearing valve of the stigmoderine ovipositor. She named this sac the “particle sac”, as it was often packed with charcoal, sand, or fragments of plants (Gardner, 1990:313). Gardner (1990: 313) further suggested that the short ovipositor of the Stigmoderini (with its heavily sclerotised spatulate setae) was an adaptation for excavating an oviposition depression in soil or host plants, that the particle sac filled with particles during the creation of this excavation, and that the eggs *may* be subsequently coated by material expelled from the sac. Gardner (1990: 296, 298–300) also reported the presence of a multilobed female accessory gland (in the median ventral surface of the vagina) in the genera *Temognatha*, *Calodema* and *Metaxymorpha* (one species-group). She suggested (1990:299) controlled release of the gland’s contents because of the presence of striated muscle penetrating between its lobes. Gardner (1990:319) also suggested as uses for the glandular secretion (at least partly composed of mucopolysaccharides) “an eggshell which hardens on contact with air to

protect against water loss or attack by bacteria or fungi; a toxin to discourage predators; an adhesive to make the eggs sticky so that they acquire a protective covering of particles or to cement the eggs to a substrate or to each other; a trophic substance; or a tropho-stimulant to encourage newly emerged larvae to eat their eggshells”.

The observations reported in this paper partially elucidate the function/use of the contents of the particle sac and female accessory gland in some stigmoderine buprestids.

The observations on charcoal-scraping by *Temognatha bruckii* extend those made for *T. fortnumi* by Macqueen and confirm that charcoal is taken up by the combined action of sternite 7 and ovipositor. Dodd and Macqueen had previously only established that material was taken in via the abdominal apex, although Macqueen (1948: 2; 1964: 17) had suggested that charcoal was powdered by the ventral plates of the abdomen and gathered by “short bristly hairs” around the anal opening.

The observations on *T. chalcodera* confirm the suggestions of both Macqueen and Gardner that the material in the particle sac may be used to cover the egg (*contra* Dodd), but differ in several features from their suggested mechanisms. Firstly, at least in *T. chalcodera*, the egg is covered by a protective dome of sand immediately after/during oviposition, not coated with it prior to being laid (Macqueen’s hypothesis). Secondly, in this species the material in the particle sac is clearly not collected by the female from the oviposition site, but is collected elsewhere prior to oviposition, and then transported in the particle sac to the oviposition site where it is ejected over the surface of the egg as part of the oviposition sequence. Thirdly, the eggs of *T. chalcodera* are laid on the surface of the stem/trunk, not in an excavation (either in the ground or host plant) as suggested by Gardner. While direct observations on oviposition in the charcoal-scraping species are lacking, the similarities in uptake of particles suggest a similar use for the material to that seen in *T. chalcodera*. In light of these observations, it seems likely that the spatulate setae on the style-bearing valve of the ovipositor of the Stigmoderini are involved in particle collection rather than any excavation for egg deposition (*contra* Gardner, 1990: 313). It also seems likely that the primary function of the accessory gland secretion is to “glue” the egg to the surface of the intended hostplant and to then cement particles ejected from the particle sac onto the remaining exposed surface of the egg. The accessory gland secretion may secondarily augment the role of the sand/charcoal coating on the eggs and perform some of the other functions suggested by Gardner.

The four species for which observations of oviposition and presumed pre-oviposition

behaviour are available are, co-incidentally, closely allied and members of the *Temognatha* (*Temognatha*) *variabilis* species-group, as defined herein. This species-group contains the following species: *T. variabilis* (Donovan, 1805) (type species of *Temognatha*), *T. fortnumi* (Hope, 1843), *T. mitchellii* (Hope, 1846), *T. bruckii* (Thomson, 1878), *T. chalcodera* (Thomson, 1878), *T. regia* (Blackburn, 1892). The *T. variabilis* species-group is diagnosed by the following character combination: size moderately small to large (TL 19–46 mm); eyes strongly converging dorsally (MIDAV 10–33% of HW, sexually non-dimorphic intraspecifically); pronotum with explanate lateral margins; pronotal base same width as (not wider than) elytral base; scutellum shape scutiform (subpentagonal) to subcircular; elytra punctate-striate; epipleuron entire (non-serrate), without caudally directed ventral spur at level of hind-coxae, and only weakly expanded anterior to this level; elytron apex bispinose with narrow arcuate or broad truncate excision between spines (spine length reduced in some taxa); sternite 7 sexually dimorphic: females convexly rounded/more elongate, males concavely/arcuately excised (notched); presence on female sternite 7 of an arcuate subapical carina (parallel to and near apical margin) with dense subapical setae; female proctiger comprised of completely fused epiproct and paraprocts, without discernible suture between both; male proctiger comprised of incompletely fused epiproct and paraprocts, with visible suture between both; basal hind-tarsomere length 1–1.5x that of following hind-tarsomere; tarsal claws moderately to strongly curved and with weak to strong basal lobes (intraspecifically constant); 19–56 tubules per testis (*bruckii* and *fortnumi* not examined for this character); "shape" of male genitalia; ovipositor broad (wider than long), dorsal valve longitudinally striate dorsally, ventral valve not strongly sclerotized ventrally.

On the limited data known (this paper; pers. obs.; $n = 3$ species), members of the *T. variabilis* species-group breed in *Allocasuarina* spp. (*contra* Macqueen: 1948; 1964). In the discussion following Macqueen's (1948) observations there is mention (p.3), probably attributable to A.P. Dodd, that *T. regia* "breeds near the base of Casuarinas". In the absence of observations of reproduction in other members of this species-group and other *Temognatha* taxa, the phylogenetic generality of the behavioural characteristics discussed herein is indeterminate. Variation in *Temognatha* ovipositor form/structure (see Peterson, 1991: 121,123, figs 2–4) may be indicative of alternative mechanisms of particle collection/oviposition in other *Temognatha* species. However, the slight structural modifications of female sternite 7 within the *T. variabilis* species-group are likely to relate to sand/

charcoal-scraping, and thus this latter habit (in conjunction with the unusual egg-laying behaviour) may be characteristic of this species-group. Additional observations are required to determine the extent and constancy of species-level differences in the type of particles collected.

The functional significance of covering the egg with sand (aside from the confirmed function of aiding glueing of egg to trunks of plants), and possibly charcoal, is unknown. In the interests of stimulating further research, I propose three potential functions for the sand-covering, acting singly or in combination: protection against parasitism/predation of egg; protection against desiccation of egg; thermoregulation to maximise rate of development of egg to first instar larva.

Additionally, the nature/duration of this type of oviposition behaviour is likely to place adult females at less risk from predation, which would be increased if they had to spend extra time to penetrate the tough non-fissured living bark to lay eggs. This type of oviposition also puts the onus on the larvae to penetrate into the hostplant and thus suggests it is likely to be more energy efficient because of the following factors: larval mandibles are presumably better designed to penetrate living unfissured bark/timber than the "reduced" stigmoderine ovipositor; the hole created by first instar larva is smaller (only required to be width of larval pronotum, the widest part of larval body) than that required to oviposit an egg into.

Three major types of oviposition behaviour have been previously described in the family Buprestidae: exophytic (egg layed directly into soil so larva, upon hatching, can feed externally on roots while initially protected by soil: *Julodini* (Holm, 1979: 98; Holm and Gussmann, 1992: 3), *Julodimorpha bakewelli* (White) (Hawkeswood and Peterson, 1982: 242)); simple endophytic (egg layed directly into crevices/fire-scars in timber/bark, or into leaf/stem tissue so larva, upon hatching, can feed internally on cambium, bark or leaves/stems while initially protected by timber/leaf/stem surface: majority of buprestid genera (e.g. Hadlington and Gardner, 1959: 325, 326)); complex endophytic (egg layed on surface of leaf/stem or timber/bark and covered by a presumably protective coating of material until larva hatches and bores into hostplant: *Agrilus obtusus* Horn (Manley, 1977: 80, fig.2.)).

The behaviour described in this paper generally conforms to the latter oviposition method, which I consider ecologically intermediate between the two former oviposition types. However, Manley's observations differ from mine in being apparently based on captive beetles, and *A. obtusus* adults utilize their own faeces to provide a mat to lay the egg on, and to then cover and presumably camouflage exposed parts of the egg. This suggests

that *Temognatha chalcodera* oviposition behaviour is even more derived than that previously described, since this taxon utilizes non-hostplant material to coat the egg, and the ovipositor has special receptacles to store this material. There are two independent aspects of *T. variabilis* species-group larval/oviposition behaviour which may have resulted in the evolution of their apomorphic oviposition type: the larval requirement to utilize living unfissured timber/bark; the lack of suitably sized crevices/fire scars in the larval host plants to accommodate the large eggs. The available data suggest that this novel oviposition behaviour has primarily evolved to allow *T. chalcodera*, and possibly other *T. variabilis* species-group taxa, to internally access (in an energy-efficient manner) living hostplants independent of heat/fire-created access routes, though structural/physiological and ecological studies of their larvae are required to confirm this. Finally, the precise mechanisms of site selection (presumably based on visual or olfactory cues, or both) are unknown for ovipositing *T. chalcodera* and charcoal-scraping *T. bruckii* females.

ACKNOWLEDGEMENTS

I thank Dr G.M. Shea (Sydney) for assistance with some aspects of manuscript preparation.

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Manuscript received 24 July 1994; accepted 13 November 1996.