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Notes on the ethology of *Rolandia maculata* (Hymenoptera: Vespidae: Masarinae), a pollen wasp with a psammophore

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Abstract – *Rolandia maculata* (Meade-Waldo), a pollen wasp restricted to southwestern Australia, produces a single summer generation of adults. A nesting population was observed in Kings Park, Perth, where females excavated burrows solitarily in level sandy ground from late November to January. Females carried dry soil excavated from the burrows in a psammophore (formed by the posteriorly hollowed head capsule, propleura and fore legs, all of which bear fringes of long setae) and scattered it up to 4m from the burrow entrances.

The burrows and the brood cells constructed singly at the lower ends of burrows were uncemented and unlined. Provisions were typical of Masarinae in consisting of moist masses of pollen, the pollen being derived from flowers of *Jacksonia* species (Fabaceae). Nests were visited by the wasp *Hyptiogaster arenicola* Turner (Gasteruptiidae), an apparent parasitoid or cleptoparasite of the species.

INTRODUCTION

Masarinae are unusual among the aculeate wasps in having a strictly vegetarian diet in both larval and adult stages. Females provision their brood cells with pollen and nectar just as do the bees. However, our knowledge of the biology of Australian masarine wasps is very sketchy and observations are recorded for few species. *Rolandia* Richards, as interpreted by Snelling (1986), is an endemic Australian genus with four species[1]. Hitherto, no detailed studies have been made of the habits of any *Rolandia* species and the limited published information has concerned floral preferences and nest locations (Richards 1968, Houston 1984, Snelling 1986). *Rolandia maculata* (Meade-Waldo) is endemic to southwestern Australia. Houston (1984) noted having examined a single incomplete nest burrow of this species in sandy soil but nothing else has been published regarding the ethology of the species.

The observations reported herein were made in a bushland area of Kings Park, Perth in the summers of 1992–93 and 1994–95, and at Neerabup National Park, *ca.* 34 km NNW of Perth, on 13 January 1995. In the first summer of observation, adult activity at Kings Park was noticed first on 17 November and return visits were made on 11 further occasions (24 and 27 November; 2, 3, 9, 10, 15 and 16 December; 6 January; and 12 and 22 February). Visits were made between the hours of 9 am – 5 pm (but chiefly between 10 am – 3 pm) and totalled in excess of 20 hours. All visits were made during warm to hot, sunny weather when adult activity could be expected.

[1]van der Vecht and Carpenter (1990) noted that *Rolandia* Richards, 1962, is a junior subjective synonym of *Metaparagia* Meade-Waldo, 1911, and referred to J.M. Carpenter in an unpublished work as the authority of the synonymy. As Carpenter's work is still unpublished, I have preferred to retain use of the name *Rolandia*.

OBSERVATIONS

Distribution and habitat

Perusal of literature records and specimen data labels in the insect collections of the Western Australian Museum (WAM) and the W.A. Department of Agriculture (WADA) reveals that *Rolandia maculata* has been collected only from coastal plain localities ranging from Moore River (110 km N of Perth) to Yallingup (ca. 200 km SSW of Perth). Its habitat consists of mixed woodland/heath communities, the upper storey of which is dominated by *Eucalyptus*, *Casuarina* and *Banksia*. The soils are predominantly sand derived from old coastal dune systems.

Nesting area

Nest burrows and females initiating burrows were distributed sparsely and apparently randomly along a 70 metre long section of a little used fire access trail in a bushland area of Kings Park (Figure 1). The surface of the trail was flat with white sand, bare for the most part but with a sparse cover of stunted grass and herbs (mostly dried off) and, in places, a sparse to dense covering

Figure 1 Trail in Kings Park used by nesting females of *Rolandia maculata*.

Figure 2 Female of *R. maculata* departing from her nest burrow, carrying a load of sand between her head and fore legs.

of fallen *Casuarina* 'needle' leaves. Despite searching, I could find no nest burrows nor nesting activity to the sides of the trail among the heath understorey nor along other trails in the general vicinity. Excavation revealed that only the top few millimetres of the soil profile consisted of white sand. Beneath that, to a depth of about 18–20 cm, the soil was brown loamy sand laced with grass

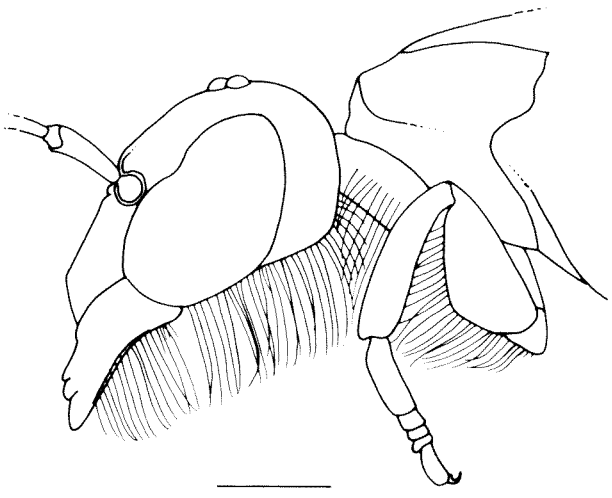

Figure 3 Profile of head and forebody of *Rolandia maculata* female showing long setae comprising the psammophore (shorter, generally distributed setae omitted for simplicity). Scale line 1 mm.

and herb roots and deeper still was uniform yellow sand. The soil was damp throughout as a result of heavy rains preceding excavation.

Phenology

Comparatively few WAM and WADA specimens (other than those originating from this study) are labelled with their collection dates. Those with dates (both sexes) were collected in the months of December and January in various years.

On the first occasion I observed adults in Kings Park (17 November), both sexes were numerous at flowers of *Jacksonia* species and over the section of fire access trail described above. Many females were searching over the surface of the trail, some alighting intermittently to make exploratory excavations, while two other females were well advanced in excavating burrows. All specimens collected in November 1992 had entire wing margins indicating recent emergence (most specimens collected in December and January show slight to marked fraying of wing margins). Clearly, it was then early in the nesting season but probably activity had begun at least several days prior. A week of electrical storms with strong wind and heavy rain followed the first visit and must have caused a heavy mortality for, on my subsequent visit (24 November), only one male and one female were observed over the nesting site and only a few individuals were encountered each visit thereafter in December and January. No adults at all were observed during the February visits when the forage plants had few flowers remaining and it was evident that the nesting season had finished. In summary, the available evidence suggests that the flight season of *R. maculata* extends from mid November to mid January.

Nest architecture

Burrow entrances were simple holes in the sand, without any form of turret, reinforcement or closure. Several burrow entrances observed were partly concealed beneath some small object on the ground such as a sheoak fruit, a twig or fallen grass stalks, while two were quite exposed in bare sand. All burrows entered obliquely at about 30° below horizontal. Five nests were excavated. In each case, the burrows had been marked after *R. maculata* females were observed entering or leaving them. The oblique entrance galleries curved downwards sharply into vertical shafts which were horizontally displaced from the entrances by 2–3 cm (Figure 4). Entrance galleries and the shafts below them were 4–5 mm in diameter, round in section, unlined and uncemented. Freshly constructed brood cells were found in association with two shafts at depths of 28–32 cm, well into the yellow sand zone. No brood cells were found near the first shaft excavated which extended to a depth of only 10 cm and was plugged with white surface sand in its upper half. It appeared to have been abandoned while incomplete.

The second nest had one open cell at the lower end of the shaft. The cell was a 2 cm long lateral extension of the shaft and was not formed or lined in any detectable way. Resting on the floor of the cell at its inner end was a partially completed provision mass bearing a first instar larva and a flaccid egg chorion.

Three cells were located near the lower end of the third shaft (Figure 4). One, which was open and contiguous with the shaft, contained an elongate egg lying transversely across the inner end and a newly initiated provision mass. The other two cells were slightly deeper, closed and contained completed provision masses with feeding larvae. The cells radiated out in different directions and up to 3 cm from the shaft. Long axes of two cells were horizontal while that of the third was oriented 45° below horizontal.

The fourth and fifth nests excavated were marked while still open and occupied in early December and early January, respectively, but had been completed and deserted by their makers at excavation in February. Only the upper sections of the shafts which were filled with white surface sand could be traced but several cocoons were sieved from blocks of sand cut from 20–40 cm below the entrance of each nest. Two distinct kinds of cocoons were recovered. Three cocoons of one kind (presumed to be those of *R. maculata*) contained mature defaecated larvae while five others were old, vacated and sand-filled. Three of these vacated cocoons are believed to have been made by *Hyptiogaster* larvae (see Associated Organisms).

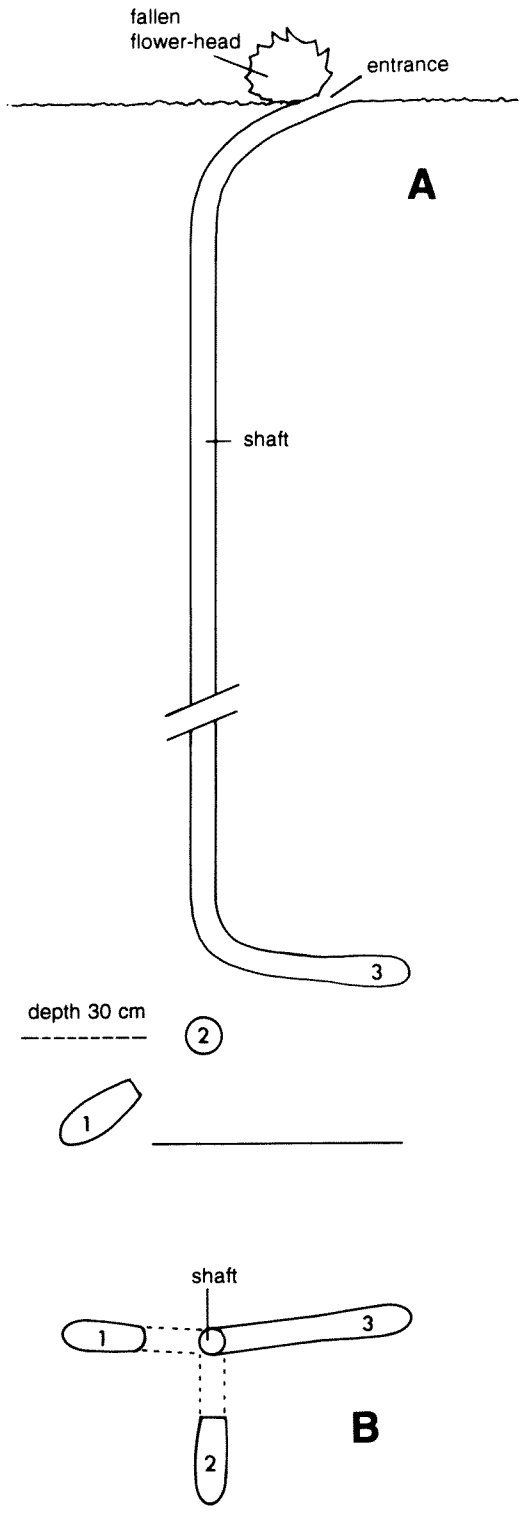

Figure 4 Details of a nest of *Rolandia maculata*: A, profile of partially completed nest; B, plan view of cells (1–3) showing relationship to shaft. Scale line 5 cm.

Cocoons

The occupied cocoons (Figure 5A) were spindle-shaped, light brown, 17–19 mm long, 5.5–6.0 mm in diameter and had sand grains adhering to their coarsely fibrous outer surfaces. Internally, they were lined by a sparsely woven and very delicate layer of fine silk and between the outer and inner layers was a densely woven, felty layer of silk. Both outer and inner surfaces were quite dull. The cell mouth end of each cocoon had a vestibule separated from the main lumen by a partition, flat on the outer surface and concave on the inner. Faecal material formed a thin meconium covering the inner end of each cocoon.

Two larvae in cocoons were kept in an airconditioned laboratory and there was no indication of development when the larvae were inspected 12–14 months later. That the larvae were still alive was evident from writhing movements in response to touching.

Provisions

The provisions consisted of firm masses of moist orange pollen. Pollen samples taken from three provisions proved under microscopic examination to be homogeneous and consistent with being derived from *Jacksonia* species (Fabaceae), the observed forage plants. Completed provisions were rather "larviform" in appearance, being elongate, segmented and having 5–7 pairs of protuberances somewhat like caterpillar pseudopods on the underside. Masses were thickest towards the cell mouth and tapered towards the cell base. Evidently, the provision masses are formed of successive deposits of pollen, commencing in the inner ends of cells and progressing towards the cell mouth.

Female behaviour

Nest burrow construction

Females in the process of excavating burrows made frequent short flights from the entrance. For example, one female made nine flights during eight minutes of observation. Females always reversed out of their burrow entrances and hesitated for several seconds prior to taking flight. Typically, the flights were 3–5 seconds in duration, directly away from the burrow in a fixed direction to a set point 10–50 cm from the entrance and straight back again. However, one female repeatedly flew 4 m from her burrow. Females slowed as they approached their entrances but scuttled straight in after alighting. The purpose of these flights was not immediately apparent but proved to be for the purpose of disposing of excavated sand: a piece of blank card placed on the ground beneath the turnabout point of two females' flight paths revealed that the wasps dropped loose grains of sand there with every flight. Because the sand grains were scattered loosely, they spread imperceptibly over the surface and no tumulus was formed. Females carry the sand in a psammophore formed between the head,

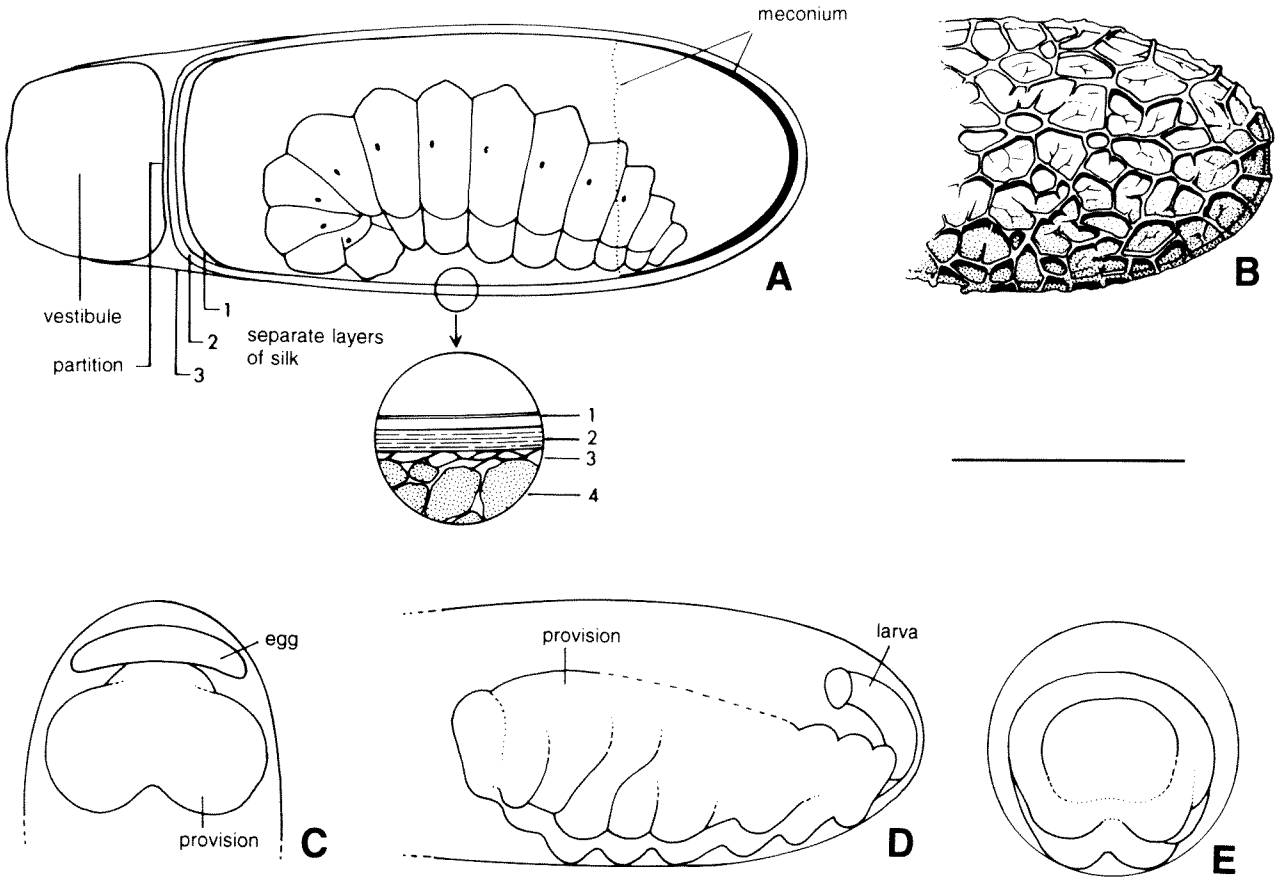

Figure 5 A, Cocoon of *Rolandia maculata* in longitudinal section showing dormant, post-defaecating larva, meconium (coating inner end of cocoon to dotted line) and (in circle) detail of cocoon wall (1, delicate inner layer of silk; 2, thick middle layer of silk; 3, network of coarse silk fibres attached to sand grains (4)); B, rear end of cocoon of ?*Hyptiogaster arenicola* showing outer surface pattern; C, newly initiated provision mass of *R. maculata* with egg in inner end of cell (plan view); D, sketch of completed provision mass in brood cell (viewed from side and slightly from below) with newly hatched larva (some detail of upper surface of provision lost as a result of damage during excavation); E, same provision mass viewed from outer end. Scale line 5 mm.

propleura and fore legs (Figures 2, 3). The head capsule and the large mandibles are excavated posteriorly, forming a shallow basin with a distinct rim. A fringe of long, erect setae occurs along the rim. The propleuron is comparatively large and flat and also has lateral fringes of long, erect setae which mesh with those of the head forming a 'cage' which serves to contain sand grains at the sides. The fore legs have expanded fore femora, somewhat flattened on their anterior surfaces with a ventral fringe of long, erect setae, and support the loads of sand from below.

Foraging

Females were observed to forage only on yellow and red flowers of *Jacksonia* species. In Kings Park, the species visited were *J. sericea* Bentham and *J. sternbergiana* Huegel. Both are leafless shrubs, the former having a dense spreading habit and not exceeding 60 cm in height, the latter having a spindly erect form and growing to 4 m. Most foraging adults were observed on *J. sericea*, females taking both nectar and pollen. Other *Jacksonia* species at which *R. maculata* has been recorded include *J. stricta* Meissn. (Neerabup National Park) and *J. spinosa* (Labill.) (Moore River National Park).

Females spent 1–3 seconds on each flower and held their wings erect while alighted. When collecting both pollen and nectar, a female first probes deep into the nectary, then backs up slightly to hunch over the anthers (released from the flower's 'keel' by downward pressure from the wasps' mid and hind legs) and the anthers contact the underside of her thorax. The propleura, fore coxae, fore trochanters and mesepisternum are clothed with stiff erect setae, many of which are bent at the tips, and several pinned females in the WAM collection carry considerable amounts of pollen among these setae. Evidently, this vestiture serves as a pollen collector and the pollen is most likely groomed off to the mouth with the brush-like fore tarsi (although no direct observations were made to confirm this).

Male behaviour

Numerous males were observed flying

persistently within 30 cm of the ground over the nesting area at Kings Park in November and December. Occasionally, a male would alight on a plant stem and rest for a few seconds to a minute before moving on. Males were also observed patrolling flowers of *Jacksonia sericea*. However, no male/female encounters were observed at the nesting area or the forage plants.

Associated organisms

A gasteruptiid wasp, *Hyptiogaster arenicola* Turner, was the only organism found living in association with *R. maculata*. One to a few adults of *H. arenicola* were encountered at the nesting area on most visits from 27 November to 6 January. Females of this wasp were most often observed flying slowly over the nesting area just above the ground surface. They followed meandering paths and their manner suggested they were searching. When an *H. arenicola* female came close to an open burrow entrance of *R. maculata* it usually circled the entrance, all the while continuing to face it with antennae directed forward and downward. In most cases, after a brief inspection, the wasp would alight on a grass stem or some ground litter about 8–10 cm from the entrance, still facing it, and remain motionless. Occasionally, females shifted position but remained close to the burrows. On one occasion, a female *H. arenicola* was observed to enter a burrow. She had been perching close to the burrow entrance for four minutes when a *R. maculata* female arrived and entered the burrow. Eight minutes later (perhaps following the departure of the burrow occupant, although I did not observe this), the *H. arenicola* female began hovering again, moved to the burrow entrance, circled it once, alighted, turned 180° and reversed down the shaft. In less than 60 seconds, she reappeared, moved to a nearby stem where she groomed herself and then moved on.

One female of *H. arenicola* maintained a vigil near a burrow for many minutes but eventually moved on without entering it. The occupant of the burrow was not sighted during the wasp's vigil and I suspect that it is the departure of the host wasp from a burrow that stimulates the cleptoparasite to enter.

Further evidence that *H. arenicola* is cleptoparasitic in brood cells of *R. maculata* came in the form of three vacated cocoons found among occupied and vacated cocoons of the host. The cocoons were easily distinguishable from those of the host by being less fibrous and were partly composed of a hard blackish material (more so at the rear end) that had penetrated between grains of sand, forming a coarsely reticulate pattern on the outer surfaces of the cocoons (Figure 5B). Internally, the cocoons had a smooth, slightly shiny, translucent brown layer formed by a hard amorphous material laid on a network of coarse brown silk fibres.

DISCUSSION

Gess and Gess (1992) provided a discussion of nesting in the subfamily Masarinae (*sensu* Carpenter 1982) and recognised seven basic nest types. Many masarine wasps construct cemented earth turrets and/or brood cells using either water or nectar as the bonding agent (nest types 1–6). One species, *Quartinia vagepunctata* Schulthess, nests in friable soil and constructs entrance turrets and brood cells of sand and silk (nest type 7). Nests of *Rolandia maculata*, being made in friable soil and having no cemented or bonded earth structures of any kind, fit none of the seven nest types and require an eighth category. In erecting the genus *Rolandia* (with *R. maculata* as the type and only known species), Richards (1962) remarked that "The very marked fringe of bristles on the periphery of the lower side of the head, around the oral fossa, is perhaps connected with the method of gathering food which would be well worth studying in life." However, Snelling (1986) noted the presence of such bristles in a few genera of Masarinae, including *Rolandia*, and termed them 'ammochaetae'. He speculated that they may form a psammophore, a "basket" for transporting sand particles excavated from nests. My observations have confirmed (at least for *R. maculata*) that Snelling's view is the correct one.

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