Aspects of reproductive biology and behaviour of scoliid wasps

DOC SCIENCE INTERNAL SERIES 147

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Published by
Department of Conservation
PO Box 10-420
Wellington, New Zealand

DOC Science Internal Series is a published record of scientific research carried out, or advice given, by Department of Conservation staff or external contractors funded by DOC. It comprises reports and short communications that are peer-reviewed.

Individual contributions to the series are first released on the departmental website in pdf form. Hardcopy is printed, bound, and distributed at regular intervals. Titles are also listed in the DOC Science Publishing catalogue on the website, refer http://www.doc.govt.nz under Publications, then Science and Research.

ISSN 1175-6519

ISBN 0-478-22513-X

In the interest of forest conservation, DOC Science Publishing supports paperless electronic publishing. When printing, recycled paper is used wherever possible.

This is a client report commissioned by Northland Conservancy and funded from the Science Advice Fund. It was prepared for publication by DOC Science Publishing, Science & Research Unit; editing and layout by Lynette Clelland. Publication was approved by the Manager, Science & Research Unit, Science Technology and Information Services, Department of Conservation, Wellington.

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ABSTRACT

The yellow flower wasp, *Radumeris tasmaniensis* Saussure (Scoliidae), has recently established in northern Northland, New Zealand. To assist in determining the potential for eradication, a literature review of some aspects of scoliid reproductive biology and behaviour was carried out. No evidence was found to suggest that any species of Scoliidae can oviposit without feeding, and feeding appears to be necessary before eggs can be matured. Some scoliid species are parthenogenetic and have been reported to produce offspring of both genders. No direct evidence was found in the literature to indicate that fecundity is increased by feeding, but given the longevity of females this was considered most likely. Adult wasps feed on nectar and honeydew, and a range of flower colours and forms appear to be attractive to them. Males emerge before females and mating occurs immediately females emerge to the soil surface after hatching from the pupal cocoon. Mating duration has been recorded for only one species, where it was short (1–4 s). Mating occurs mainly in the morning, since females of most species appear to cease activity on the soil surface by midday. Activity of both genders ceases if air temperatures are below about 20°C.

Keywords: Scoliidae, reproductive biology, mating, feeding, behaviour

Barratt, B.I.P. 2003: Aspects of reproductive biology and behaviour of scoliid wasps. *DOC Science Internal Series 147*. Department of Conservation, Wellington. 11 p.

1. Introduction and background

Radumeris tasmaniensis Saussure, the yellow flower wasp (Scoliidae) (Fig. 1), was first discovered by staff of the Department of Conservation (DOC) in northern Northland in February 2000. Specimens were observed and / or collected by DOC field staff from three sites: Whareana, Cape Maria van Diemen and Herekino. Subsequent surveys have shown that the yellow flower wasp (YFW) is now present in some additional localities in coastal Northland, and the

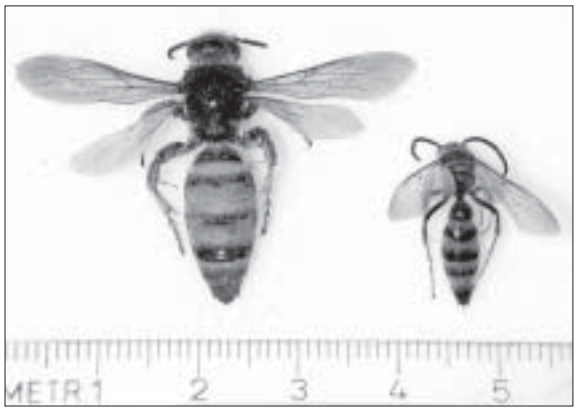

Figure 1. *Radumeris tasmaniensis* Saussure adult wasps, female (left) and male (right). Numbers on scale indicate centimetres.
Photo: B.I.P. Barratt.

possibility of eradication is unclear. Consequently, it was decided by the Yellow Flower Wasp Technical Advisory Group that both further survey work and a literature review of some aspects of scoliid reproductive biology and behaviour would assist in determining the potential for eradication. Essentially, the technical advisory group needed to clarify whether adult wasp control methods, or removal of nectar sources for feeding would significantly reduce female reproductive output, or whether the potential for eradication could be compromised by proovigenesis (where female insects emerge as adults with all eggs already fully developed) and / or parthenogenesis (where reproduction occurs without fertilisation by a male).

A literature search of Scoliidae was carried out, and experts were consulted to ascertain any information on the following aspects of wasp biology:

- Can female wasps lay eggs without feeding or mating (post cocoon emergence)?
- Does feeding increase fecundity?
- What is the mating time and frequency of mating?
- What are the above-ground temporal behaviour patterns of female scoliid wasps?

2. Results

Information gathered from literature and internet web searches and consultation with experts is summarised below.

2.1 CAN FEMALE WASPS LAY EGGS WITHOUT FEEDING OR MATING (POST COCOON EMERGENCE)?

Normally, scoliid females mate immediately they emerge from their cocoon and reach the soil surface. Males are able to detect them before they reach the surface (Till Osten, Staatliches Museum für Naturkunde, Stuttgart, pers. comm.), possibly by means of a pheromone (Lopez Pacheco 1984). After mating, the female rests for a while and then starts to feed on the nectar of flowers (Till Osten, pers. comm.). The female needs to feed before her eggs can mature (Till Osten; pers. comm.; Tony Harris, Otago Museum, Dunedin, pers. comm).

The evidence for parthenogenesis in this group is inconclusive. Lynn Kimsey (University of California, Riverside) knew of no evidence of parthenogenesis in this group, but Till Osten referred to a publication (Jarvis 1921) which reported *Radumeris radula* (F) producing male and female offspring, presumably by parthenogenesis. Jarvis (1921), however, does not mention parthenogenesis as such, but does describe female wasps (*R. tasmaniensis* and *R. radula*) confined in cages for up to two months with cane grub larvae and a daily supply of sugar and water. During this period they continued to parasitise the cane grub larvae. Whether they were mated at the beginning of the caged period was not specified. Similarly, parthenogenesis in *Scolia oryctophaga* is mentioned in another report, but no specific evidence is presented (D'Emmerez de Charmoy 1923). However, Nowell (1915) reported that virgin females of *Typhia parallela* were able to lay fertile eggs, and in the limited experiment carried out (only 3 parasitoids completed and hatched as adults), the progeny were all males.

2.2 DOES FEEDING INCREASE FECUNDITY?

No reference has been found which specifically demonstrates that feeding increases fecundity in females, but given their longevity (4–5 months in some species) this is likely to be the case. Most adult wasps feed exclusively on carbohydrates derived from nectaries of flowers (Spradbery 1973). *Campsomeria limosa* (Burmeister) (Mexico) feeds mainly on Composite, especially *Taraxacum officinale* (Lopez Pacheco 1984). *Radumeris tasmaniensis* (Saussure) can be an important pollinator of macadamia (Vithanage & Ironside 1986), and is known to feed on nectar and honeydew (Illingworth 1921). In New Zealand, this species has been observed visiting

flowers of Canadian fleabane *Conzya bilbaona* Remy (Barratt et al. 2002). Some female Australian flower wasps (including Scoliidae, Tiphiidae and Multillidae) are wingless and the male wasp picks up the female, mates on the wing and carries the female to food plants (Anon 2001). This strongly suggests that feeding is required before eggs can be matured in these groups.

2.3 WHAT IS THE MATING TIME AND FREQUENCY OF MATING?

Generally, the males of solitary wasps emerge before females (Spradbery 1973). In a study of five species of Scoliidae in Turkey, males were found to be active before females in spring, and they were observed to be more numerous than females in mid summer, but less so in late summer (Tuzun 2001). In *Campsomeria limosa* (Burmeister) (Mexico), the male wasps become active when air temperature reaches 24°C (Lopez Pacheco 1984). In New Zealand, a threshold for activity of about 20°C has been observed for *Radumeris tasmaniensis* (Barratt et al. 2002) and males have been seen burrowing into sand in cool conditions.

In *Scolia affinis* Guerin (India), the female alights when ready to mate and the males follow closely until the female becomes motionless, and then mating occurs. Following mating, the male ceases activity and the female enters the soil in search of hosts for oviposition (Misra 1996). When female *C. limosa* emerge they are immediately mated, with attempts often made by several males (Lopez Pacheco 1984). Female *C. limosa* wasps raise their 2nd pair of legs to prevent other males from approaching. When several males are present, mating lasts only about 1 s, but when only one male is present, mating lasts about 4 s (Lopez Pacheco 1984). Two daily peaks of reproductive activity by *C. limosa* are reported, one between 10.15 and 10.45 am, and the other between 11.30 am and 12.00 noon (Lopez Pacheco 1984). The sex ratio in the study area was observed to be 4 males to 1 female (Lopez Pacheco 1984). No data on frequency of mating was recorded in this study. However, Jarvis (1921) kept females confined in cages for up to two months, during which time they continued to parasitise cane grub larvae, indicating that egg laying can continue for at least 2 months.

2.4 WHAT ARE THE ABOVE-GROUND TEMPORAL BEHAVIOUR PATTERNS OF FEMALE SCOLIID WASPS AFTER MATING?

Very little information is available on behaviour and activity patterns of Scoliidae (Kurczewski & Spofford 1986; Lynn Kimsey pers. comm.). *Campsomeris limosa* females start to feed immediately after mating while the males increase their activity in search of other females (Lopez Pacheco 1984). Males of *Campsomeris plumipes fossulana* (F.) (Florida) have been observed burrowing, using their mandibles and forelegs, to avoid unfavourable weather conditions and to rest at night (Kurczewski & Spofford 1986). The males of

some *Campsomeris* species (Europe) fly in swarms and collect together to rest on leaves at night (Anon 2002). Also, male and female *Scolia affinis* wasps have been observed resting at night on vegetation, but after mating, females 'rest on debris' (Misra 1996).

Diurnal activity patterns have been observed in *Campsomeris limosa* wasps. Female activity peaks at about 10.00–10.30 am and ceases by midday, whereas males are active between 9.30 am and 1.30 pm, but their activity reaches a peak at midday (Lopez Pacheco 1984). This corresponds quite well with observations of *Radumeris tasmaniensis* in Australia which indicate that females emerge from the soil and fly during the morning before returning to the soil by midday, while males fly throughout the day (David Logan, HortResearch, New Zealand pers. comm.).

Foraging adults of the Campsomerinae fly close to the soil surface in distinctive loop patterns (Anon 2002). *Scolia hirta* Schrank (Central Europe) was thought to prefer flowers which appear blue to the human eye, but further study has indicated no obvious preference for any particular colour (Landeck 2002). Nectar foraging occurred mainly on flowers which appeared white, purple, pink or crimson to the human eye, which would appear 'bee-cyan' and 'bee-blue' to the wasps (Landeck 2002). Goldenrod (*Solidago canadensis*), which appears yellow to humans and green to bees, was used where it was the predominant flower, or when other preferred flowers were absent (Landeck 2002). Plants with composite flowers, umbels, panicles or other aggregated flower heads were preferred by *S. hirta* (Landeck 2002).

Scolia flavifrons (F.) (Romania) females searching for host larvae (in this case, rhinocerus beetle) prefered to fly in calm conditions, moving in meandering patterns approximately 15 cm above the ground (Nachtigall 1992). They flew in straight lines with periodic rapid turns. Flight speed changed from slow when near the ground to at least 3 m/s or greater during longer periods of straight flight (Nachtigall 1992). From a distance of 1 m the noise of the wasps' flight was almost inaudible (Nachtigall 1992). Some scoliids (USA) have been described as flying just a few inches above the ground in loose figure-of-eight patterns (Brandenburg & Baker 2000).

Female *Radumeris tasmaniensis* wasps in Australia appear to be able to detect scarab larvae in the soil during search flights (Peter Allsop, Department of Primary Industries, Australia, pers. comm.).

3. Recommendations

The findings of this report would suggest that if an attempt to eradicate or locally control yellow flower wasps (*Rudumeris tasmaniensis*) is considered, then it would be useful to determine the potential for parthenogenesis in this particular species, as this is likely to assist in developing suitable control methods. The strong likelihood that nectar feeding by females is required before ovary maturation can occur supports the possibility that removal of

nectar-bearing vegetation could be a potential tool in management of this species. Further work on the seasonal activity and behaviour of yellow flower wasps in relation to reproduction and feeding would be very beneficial in designing effective control strategies.

4. Acknowledgements

This report addressed a request for scientific advice from Northland Conservancy and was funded by the Science Advice Fund of DOC.

I would like to thank the following people for their assistance:

Dr Till Osten, Staatliches Museum für Naturkunde, Rosenstein 1, D-70191 Stuttgart, Germany. (osten.smns@naturkundemuseum-bw.de)

Dr Lynn Kimsey , University of California (Riverside), CA, USA. (lskimsey@ucdavis.edu)

Dr John Early, Auckland Museum, Auckland.

Mr Tony Harris, c/o Otago Museum, Dunedin.

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