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Phryssonotus novaehollandiae Silvestri, 1923: the sole Australian representative of the millipede Family Synxenidae

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Abstract

Examination of synxenid millipedes from a number of collections confirms that *Phryssonotus novaehollandiae* is the sole representative of the genus and family in Australia. *P. novaehollandiae* was found to have the most widespread distribution of any native Australian millipede species. It occurs in a range of well-drained habitats including heathlands, woodlands and coastal scrub. Several thelytokous (female only) populations were found in coastal areas of south eastern Australia.

Keywords: Diplopoda, Penicillata, Polyxenida, thelytoky

1. Introduction

Phryssonotus novaehollandiae Silvestri, 1923 (Fig. 1) is one of six extant species of penicillate millipedes in the genus *Phryssonotus* Scudder, 1885 in the family Synxenidae Silvestri, 1923. The genus has a global distribution with *P. platycephalus* Lucas, 1846 identified from Northern Africa, Spain and Sicily (Silvestri 1948), *P. capensis* Silvestri, 1923 from southern Africa, Mozambique and Madagascar (Silvestri 1948, Marquet & Condé 1950), *P. chilensis* Silvestri, 1948 and *P. orientalis* Silvestri, 1948 from South America (Silvestri 1948), and *P. cubanus* Silvestri, 1948 from Cuba (Silvestri 1948). All six species have very similar morphology with the number of ocelli and short frontal trichomes being the only distinguishing characters identified to date. As these two characters vary in immature stadia, it can be hard to identify immature stadia to species with certainty.

Previous studies have identified two species of *Phryssonotus* in Australia. Silvestri (1923) described *P. novaehollandiae* from one juvenile specimen with eight pairs of legs (stadium V) in South Australia, while Short & Huynh (2006) showed the species to be widespread in both South Australia and Victoria. Condé & Nguyen Duy-Jacquemin (1984) identified a specimen collected from Mountain Creek near Buderim, Queensland with 16 pairs of legs (stadium IX) as being *P. capensis*. In the same paper, a millipede collected at Port Moresby, Papua New Guinea was also identified as *P. capensis.*

In this study synxenid specimens were examined from all states of Australia except for the Northern Territory to determine the number of species present and their distribution.

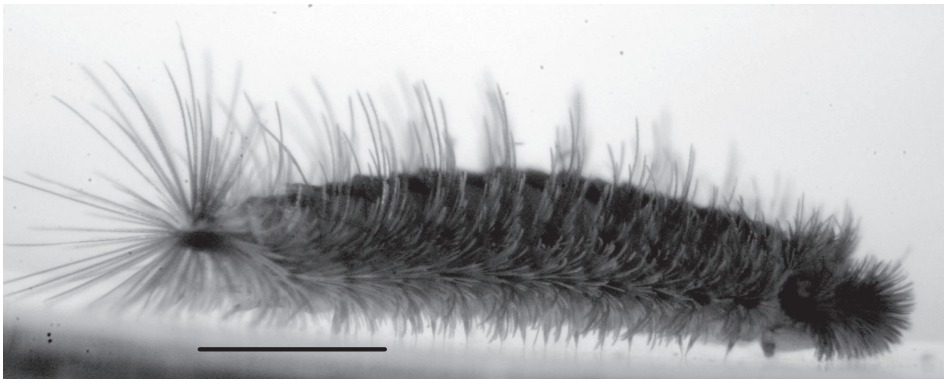

Fig. 1 Lateral view of a live *P. novaehollandiae.* Scale bar = 1 mm.

2. Materials and methods

Specimens of *Phryssonotus* were sorted from collections held in the South Australian Museum, Adelaide, Western Australian Museum, Perth, Queensland Museum, Brisbane and Museum Victoria, Melbourne, as well as from a large berlesate collection held at the Australian National Insect Collection (ANIC), Canberra. Additional specimens of *Phryssonotus* were collected from a number of localities in Victoria and South Australia and from a single location in Tasmania by sieving samples of decomposing leaf litter into a white tray and hand-picking into 70 % ethanol.

The table of characteristics of post-embryonic stadia in Short & Huynh (2006) was used to identify immature specimens in stadium VI and later.

Specimens were measured from vertex of the head to tip of the telson and sexed where possible. As the short frontal trichomes and ocelli are difficult to see clearly in untreated animals, specimens were cleared in 15 % potassium hydroxide, heated in a water bath for 2 minutes at 80 °C, then neutralised in 20 % acetic acid for 2 minutes, rinsed in distilled water and dehydrated in a series of ethanol baths prior to staining with 1 % Fast Green solution to increase contrast. The head and body were separated, the body cut open with a single latero-longitudinal incision and contents removed. After rinsing in 100 % ethanol, stained specimens were transferred to 100 % isopropanol, then xylene and mounted on slides with DPX.

3. Results

The most effective method of collecting *Phryssonotus* is to sieve decomposing leaf litter into a tray, collecting any millipedes disturbed. *Phryssonotus* can also be extracted from leaf litter using Tullgren funnels. For this study, sieving was used to determine the presence of *Phryssonotus,* followed by collection of suitable leaf litter for extraction of specimens using Tullgren funnels.

The museum collections examined for this study were either obtained as part of general invertebrate surveys using a range of collecting techniques, or they were targeted collections using the most appropriate collection method for the target taxon. None of the museum

collections were specifically targeting penicillate millipedes. Those collections obtained using an extraction method from leaf litter were more likely to contain *Phryssonotus* than those collections obtained from pitfall trapping. The majority of Queensland museum samples were obtained when bark was sprayed with pyrethrum to dislodge Coleoptera. The pyrethrum was sprayed over an area of a tree trunk with invertebrates then becoming agitated, dislodging from the bark and falling onto a square of cloth placed on the ground beneath where they are transferred to ethanol (G. Monteith, pers. comm.).

All adult and sub-adult synxenid millipedes examined were found to be *P. novaehollandiae* (Fig. 2). Size and morphology of adults (stadium X) did not vary across Australia, with the exception that *P. novaehollandiae* from Barrow Island, Western Australia, were smaller than mainland specimens. Mean length from head to telson of the adult mainland specimens was females 3.5–3.9 mm (mean = 3.8 mm, n = 10) and males 3.0–3.8 mm (mean = 3.6 mm, n = 10), while Barrow Island adults were females 2.1–2.4 mm (mean = 2.3 mm, n = 5) and males 2.1–2.3 mm (mean = 2.2, n = 5).

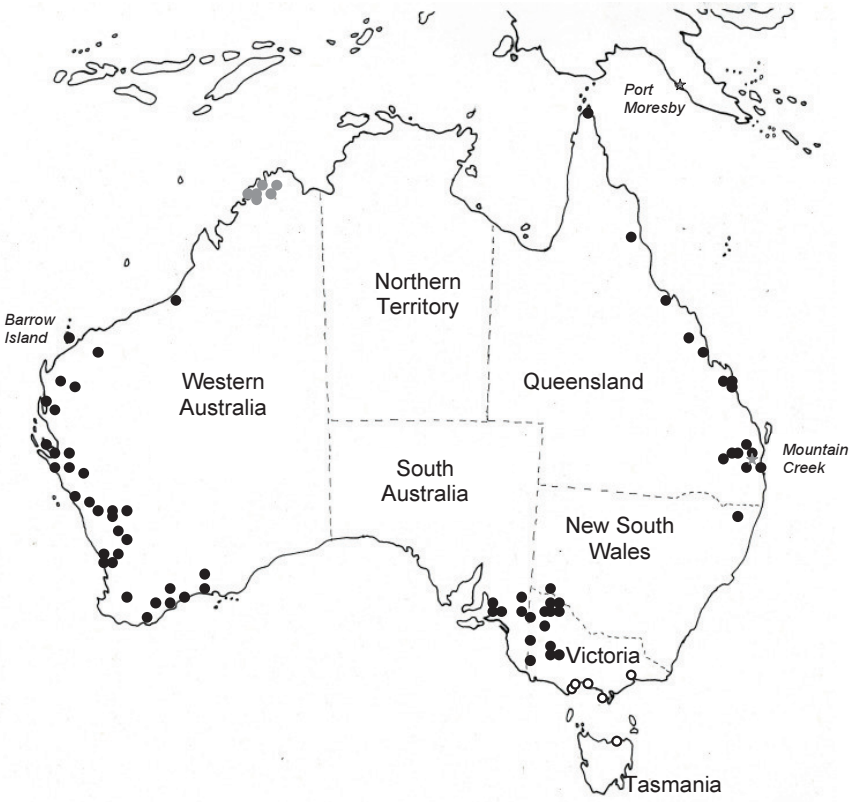

Fig. 2 Australian localities for *P. novaehollandiae*. ● males and females collected, ○ females collected, ● immature specimens- sex and species indeterminate. The positions of Port Moresby on the coast of Papua New Guinea and Mountain Creek in Queensland are indicated with stars. The relevance of these two locations is discussed in the text.

Males were found in all populations except for those along the coast of southern Victoria and the one site in northern Tasmania indicating that *P. novaehollandiae* reproduces sexually across most of Australia. *Phryssonotus* specimens from the Mitchell Plateau in north Western Australia were too immature (stadia IV–V) to show the distinguishing features necessary to confirm species and sex.

Further work is needed to clarify the sex ratio but indications are that there may be an equal or slightly higher proportion of males to females in populations containing males. For example 23 males and 20 females were collected using sieves at Deep Lead, Victoria (February–June 2006). Previously 5 males and 3 females were collected in pitfall traps by Museum Victoria at the same location (Nov.–Dec. 1995). It is not known if collecting method or time of year may affect the sex ratio.

Little can be concluded about habitat requirements from the limited information associated with the collections examined. *P. novaehollandiae* was most commonly found in collections from leaf litter, especially litter at the base of *Eucalyptus* trees. Habitats where *P. novaehollandiae* was found included rain forest (rarely), closed and open eucalypt forests, eucalypt woodlands, woody heathlands and vegetated (but treeless) coastal dunes. In fieldwork for this study we collected *Phryssonotus* from leaf litter and bark in well drained eucalypt woodlands, with occasional specimens from pockets of accumulated litter under shrubs on sand dunes.

4. Discussion

The presence of *P. novaehollandiae* throughout Australia is not unexpected as at least one other species in the genus has a wide distribution: *P. capensis* occurs in South Africa, Mozambique and Madagascar (Silvestri 1923, Marquet & Condé 1950, Hamer 1998). The records of *P. capensis* from Queensland and New Guinea (Condé & Nguyen Duy-Jacquemin 1984) however are questionable. Identification of these specimens was based on the limited species description by Silvestri (1923), and a re-analysis of the characteristics of the stadium IX specimen described in Condé & Nguyen Duy-Jacquemin (1984) indicates that they are identical to those for stadium IX *P. novaehollandiae* (Short & Huynh 2006). Given that we identified a number of specimens in the Australian National Insect Collection from the same Queensland locality (Mountain Creek) as *P. novaehollandiae* (refer Fig. 2), it appears unlikely that *P. capensis* occurs in Australia.

The Port Moresby specimen is an immature stadium VII male and the description in Condé & Nguyen Duy-Jacquemin (1984) is limited to the number of short frontal trichomes observed. This character alone is insufficient to separate *P. novaehollandiae* from *P. capensis* as the number of short frontal trichomes for stadium VII is the same in both species (Short & Huynh 2006). It should be noted that neither of the specimens described in Condé & Nguyen Duy-Jacquemin (1984) were re-examined for this study.

Dispersal of penicillates and the family Synxenidae in particular needs to be further investigated, as despite a global distribution, there are just seven extant species in two genera (Nguyen Duy-Jacquemin 2006). Is it possible that wind or birds disperse these tiny organisms? Birds' nests would be an obvious point of contact and penicillates from the family Polyxenidae have been found in birds' nests (Nguyen Duy & Condé 1966, Tajovsky et al. 2001). However to date there are no records of the occurrence of *Phryssonotus* species in nests.

Thelytokous parthenogenesis does not appear to be widespread in *Phryssonotus*, being limited to populations along the southern coast of Victoria and the one coastal site in northern Tasmania. One population at Point Addis, Victoria has been regularly sampled over five years and no males have been collected. Several millipede species are known to have both sexual and thelytokous populations, including another penicillate species *Polyxenus lagurus* Linnaeus, 1758 (Schömann 1956, Meidell 1970, Enghoff 1976a). *Phryssonotus* may be an example of geographic parthenogenesis as the thelytokous populations are the most southerly. The term geographic parthenogenesis is used to describe examples of thelytokous populations with a distribution that is geographically distinct to that of sexually reproducing populations of the same species (Haag & Ebert 2004). Thelytokous populations are found at higher latitudes (Haag & Ebert 2004), in marginal, xeric, stressful or disturbed environments (Haag & Ebert 2004), or in areas of more abiotic seasonality and lower biotic diversity (Hoy Jensen et al. 2002). Hoy Jensen et al. (2002) describe geographic parthenogenesis in the millipede *Nemasoma varicorne*, C. L. Koch, 1847, in which thelytokous populations are found on the fringe of the range of sexually reproducing populations. The authors suggest that this pattern may be due to the greater short term potential for thelytokes to disperse and rapidly build up in numbers. An alternative explanation is that of Enghoff (1976b) who found *N. varicorne* males less tolerant of desiccation that was more likely in marginal habitats for this species. However this does not appear to be a factor in *P. novaehollandiae* populations in Victoria as males are present in semi-arid inland habitats while absent in populations in wetter and cooler coastal habitats.

There are limitations to the data obtained and mapped for this study. No collections were available from central Australia and with the exception of some of the samples from Victoria, South Australia and Tasmania, collectors did not specifically target penicillate millipedes. It seems likely that *P. novaehollandiae* will be found in coastal habitats throughout Australia in future studies wherever there is well drained soil with leaf litter from native vegetation. Even now, however, *P. novaehollandiae* appears to be the most widespread native millipede species in Australia (Mesibov 2007–2009).

5. Acknowledgements

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