KEELED MILLIPEDES (DIPLOPODA: POLYDESMIDA: PARADOXOSOMATIDAE) IN NEW SOUTH WALES

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Summary

Of the keeled millipede families that comprise the order Polydesmida, Paradoxosomatidae is the most widespread and abundant in Australia, yet it is poorly known in New South Wales. This study has added 152 new and undescribed species to the existing 50. Most specimens in established collections were found in the coastal areas where paradoxosomatids are active for most of the year, but indications are that there are many species in the drier areas of the State that would be found only with targeted collecting efforts.

Keywords: Australian polydesmidan millipedes, diversity, distribution

INTRODUCTION

Keeled millipedes belong to the order Polydesmida (Diplopoda). Within the order, the Paradoxosomatidae is the most widespread and abundant of all native millipede families in Australia (Mesibov 2008a, Black 1997). Despite the work of early taxonomists (e.g. Verhoeff 1928), the on-going research of C.A.W. Jeekel and a recent study by Rowe and Sierwald (2006), relatively little is known about the diversity and distribution of paradoxosomatids in New South Wales (NSW).

Few field expeditions have been dedicated to the collection of paradoxosomatid and associated millipedes. Until recently, only Jeekel and his wife (Jeekel 1981), Melissa Rowe (Rowe and Sierwald 2006) and Peter Johns have deliberately searched for paradoxosomatids in NSW. Hundreds of specimens have, however, been collected as part of general terrestrial invertebrate surveys carried out mainly by staff of the Australian National Insect Collection (ANIC) and the Australian Museum. Specimens in the ANIC were collected mostly as berlesates from litter samples, while the Australian Museum specimens were collected largely from pitfall traps. Until recently, few of these specimens had been sorted and identified.

In 2006/07, the Department of the Environment and Heritage (DEH), Canberra (now Department of the Environment, Water, Heritage and the Arts) funded a project to sort all collected Australian paradoxosomatid material to species level. The author was responsible for the sorting of existing NSW and Australian Capital Territory specimens and collected more specimens in NSW in 2006-2008.

The sorting and identification of paradoxosomatid specimens for the DEH project added new locality data for those species already described for NSW and revealed many new species.

MATERIALS AND METHODS

All paradoxosomatid specimens from NSW in Australian museums were examined. Some specimens were loaned by the Queensland Museum, Brisbane, but most were borrowed from the Australian Museum, Sydney and the ANIC, Canberra. Additional opportunistic collecting was undertaken from 110 sites around NSW. Lastly, a transect was laid out in SE NSW. This transect ran in a south easterly direction from Tumut (35º18´S; 148º13´E) approximately 100km west of Canberra, crossed the Great Dividing Range and ended in Tathra (36º43´S; 149º59´E) on the NSW coast, 100km north of the Victorian border. The transect was chosen because it traversed a number of different vegetation types and altitudes over a distance of 225km, in a relatively accessible area where little sampling had been carried out in the past. It was sampled at approximately 10km intervals by hand searching and by setting pitfall traps. Half of the sample sites were located along the Snowy Mountains Highway, between Tumut and Cooma (36º13'S; 149º07'E): the remaining 15 were located in accessible forest areas close to Tathra, ranging from Quaama (36º27'S; 149º07'E) in the north to Tantawangalo (36º48'S; 149º33'E) in the south. Sorting and identification of specimens followed the method used by Mesibov (2008a). Specimens were assigned to species using published descriptions or were given sorting codes. New species were placed in existing genera where possible, or assigned to new genera with sorting codes. Species were separated using mature males only, as it is the male gonopods (modifed legs used for mating) that are used to distinguish between species. Females clearly associated with males were sorted with those males. All sorted specimens were documented using locality data, photographs and drawings.

All specimens that were not already registered by museums and other organizations have been deposited in the Australian Museum.

RESULTS

Rowe and Sierwald (2006) found that millipedes in the Sydney basin had peaks of activity between 06:00 and 12:00 hours and were more active on overcast or rainy days. In this study, paradoxosomatids were rarely observed actively moving about, and then only just after rain, both in the morning and the afternoon. Most specimens were found curled up in leaf litter and in or under logs.

In concordance with the results of other researchers (Mesibov *et al.* 1995, Snyder *et al*. 2006), it was found that hand searching was the most effective method of collecting millipedes, including paradoxosomatids. Nearly all specimens collected by the author were found by this method, while fewer than a dozen specimens were collected in two sets of 150 pitfall traps, set out for one month each in the transect. In direct contrast, most of the specimens in the Australian Museum and ANIC collections were collected in pitfall traps and as berlesates. A possible reason for the success of these methods is given in the Discussion.

Specimens were collected from a total of 440 localities (Figure 1) which included both the author's locality records and those of borrowed specimens.

Described Species

Of the 50 species that have been described from NSW (Table 1) representatives of 39 were examined in this study. The species *Akamptogonus caragoon* Rowe and Sierwald, *Cladethosoma calcaratum* Jeekel, *C. tortuosum* Jeekel, *Isocladosoma (Centrocladosoma) dissimile* Jeekel and *Perittogonopus perplexus* Jeekel were not seen. At present, specimens cannot be matched to species descriptions of *Polydesmus (Strongylosoma) sagittarius* Karsch nor those assigned to the genus *Strongylosoma* Brandt, particularly as three of the *Strongylosoma* species were described on examination of female specimens only.

Mesibov (2008a) has listed *Akamptogonus novarae* (Humbert and de Saussure) as a 'native exotic' as it has a very broad distribution. This study adds records of its occurrence along the NSW coast from Sydney to Forster. It seems likely that *Notodesmus scotius* Chamberlin may be another in this group of species that has been introduced into areas of Australia outside their original home ranges: it has been found in large numbers in Tasmania and Victoria (Robert Mesibov, personal communication, 2006) and has now been discovered from inland to coastal SE NSW, on both sides of the Great Dividing Range, by the author. More investigation is needed to determine the likely original ranges of these two species.

Figure 1. Paradoxosomatidae localities in NSW.

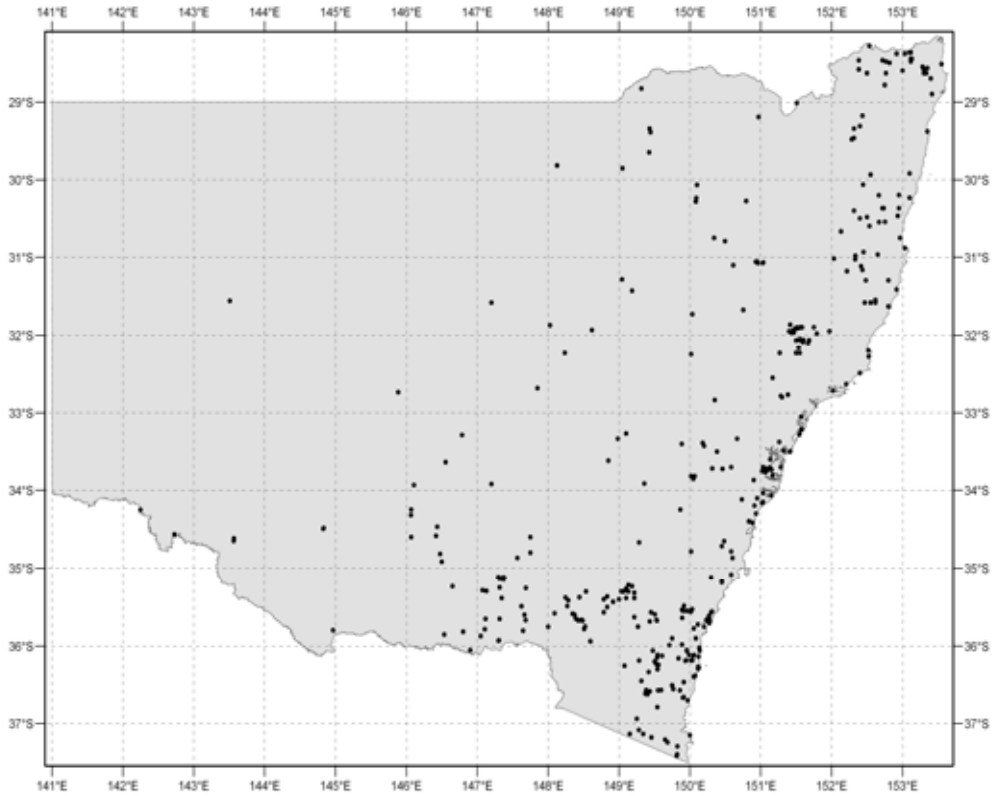


Table 1. Described species of Paradoxosomatidae in NSW.

Species name
Akamptogonus caragoon Rowe & Sierwald, 2006
Akamptogonus novarae (Humbert and de Saussure, 1869)
Australiosoma clavigerum (Verhoeff, 1928)
Australiosoma combei Rowe and Sierwald, 2006
Australiosoma fulbrighti Rowe and Sierwald, 2006
Australiosoma inusitatum Jeekel, 2003
Australiosoma michaelseni (Attems, 1931)
Australiosoma nodulosum Jeekel, 2003
Australiosoma rainbowi Brölemann, 1913
Cladethosoma calcaratum Jeekel, 2006
Cladethosoma cruciatum (Verhoeff, 1937)
Cladethosoma gladiator Jeekel, 1982
Cladethosoma inflatum Jeekel, 1982
Cladethosoma lucidum (Verhoeff 1928)
Cladethosoma tortuosum Jeekel, 2006
Cladethosoma trilineatum (Newport, 1844)
Dicladosoma etheridgei (Brölemann, 1913)
Dicladosomella modesta Jeekel, 2007
Dicladosomella segmentata Jeekel, 1982
Gigantowales chisholmi Verhoeff, 1937
Gigantowales latescens Jeekel, 2000
Hoplatessara anulata (Attems, 1931)
Hoplatessara clavigera Verhoeff, 1928
Hoplatessara froggatti (Brölemann, 1913)
Hoplatessara luxuriosa Silvestri, 1985
Hoplatessara musgravei Verhoeff, 1928
Hoplatessara prativaga Jeekel, 2003
Hoplatesssara pugiona Verhoeff, 1941
Isocladosoma(Centrocladosoma) dissimile Jeekel, 2006
Myallosoma auritum Jeekel 2006
Myallosoma hamuligerum Verhoeff, 1928
Notodesmus scotius Chamberlin, 1920
Orocladosoma kosciuskovagum Brölemann, 1913)
Parwalesoma rubriventris (Verhoeff, 1928)

Table 1 continued. Described species of Paradoxosomatidae in NSW.

Parwalesoma walesium(Verhoeff 1928)
Perittogonopus perplexus Jeekel 2003
Phyllocladosma andersoni (Verhoeff, 1928)
Phyllocladosoma annulatipes (Verhoeff, 1924)
Phyllocladosma dorrigense Verhoeff 1928)
Polydesmus (Strongylosoma) sagittarius Karsch, 1881
Solaenodolichopus pruvoti (Brölemann, 1931)
Solaenodolichopus sulcatus (Verhoeff, 1928)
Somethus biramus Jeekel, 1984
Somethus flavipes Jeekel, 2007
Strongylosoma nigrum Chamberlin, 1920
Strongylosoma petersii L.Koch, 1965
Strongylosoma quaesitum Chamberlin, 1920
Strongylosoma robustior Chamberlin, 1920
Strongylosoma rubrimarginatum Chamberlin, 1920
Walesoma helmsii Verhoeff, 1928

Figure 2. *Cladethosoma trilineatum*.
Scale bar = 1cm

Figure 3. *Cladethosoma lucidum*.
Scale bar = 1cm

Figure 4. *Hoplatessara froggatti*.
Scale bar = 1cm

Figure 5. *Dicladosomella* n. sp. Tinderry Range.
Scale bar = 1cm

Figure 6. *Solaenodolichopus* n. sp. Nelson Bay.
Scale bar = 1cm

Figure 7. *Heterocladosoma* n. sp. Balranald.
Scale bar = 1cm

Cladethosoma trilineatum (Newport) and its synonyms have a complicated taxonomic history (Mesibov 2006 - 2008): the species appears as *Cladethosoma clarum* (Chamberlin) in Rowe and Sierwald (2006) but Jeekel (2007) synonymised it with *Strongylosoma trilineatum* Newport. It is a large and showy species (Figure 2) and appears to be common along the coast of NSW as it has been found in large numbers in pitfall traps from Macksville (30º45´S; 152º55´E) to Sydney. Another spectacular species of *Cladethosoma, C. lucidum,* was described 80 years ago by Verhoeff (1928) and had not been seen since. In October 2008, while on a visit to Barrington Tops National Park, the author found several specimens of this attractive species (Figure 3), close to the original type locality.

The genus *Somethus* Chamberlin is known to be diverse and widespread in Victoria and South Australia (Mesibov 2008b). This study has extended the range of the genus. *S. biramus* Jeekel has been collected in the far south east of NSW and a new species has been recorded from the Bateman's Bay area.

Similarly, this study has provided new locality data for

Hoplatessara prativaga Jeekel and *H. froggatti* (Brölemann) (Figure 4) and has confirmed the presence of both *H. clavigera* Verhoeff and *H. luxuriosa* (Silvestri) in NSW. The former is a large species which occurs in the far south of NSW and northern Victoria. The latter was reportedly first collected in New Guinea in the 1870s, but Jeekel (1956, 1967) suspected the type may instead have come from Queensland. All other known *Hoplatessara* have been collected in NSW and Victoria and the author has identified specimens of *H. luxuriosa* from near Bathurst in NSW.

New species

Seventy five new species have been assigned to existing genera, the most notable increases in species numbers occurring in the genera *Dicladosomella* Jeekel with 15, and *Solaenodolichopus* Verhoeff with 17 new species. *Dicladosomella* (Figure 5) appears to be confined mainly to an area of SE NSW, extending from altitudes of 1400m in the Snowy Mountains to the coast. *Solaenodolichopus* is a very widespread genus and is well represented in Queensland: some of the new species in NSW have been collected from semi-arid areas, west of the Great Dividing Range, such as Hay (34º29'S; 144º50'E) and Wilcannia (31º33´S; 143º30´E) and tend to be large specimens (3cm or more in length)(Figure 6).

Another genus that appears to have species adapted to living in dry conditions is *Heterocladosoma* Jeekel (Figure 7). This genus has been recorded from Queensland and Western Australia, and species such as *H. zebratum* Jeekel are found on the Eyre Peninsula in South Australia. Four new species of *Heterocladosom*a have now been collected in NSW, in the drier regions west of the Great Dividing Range. In the same way as their Queensland counterparts, these species show mosaic parapatry (Mesibov 2008a) in their distribution patterns (Figure 8).

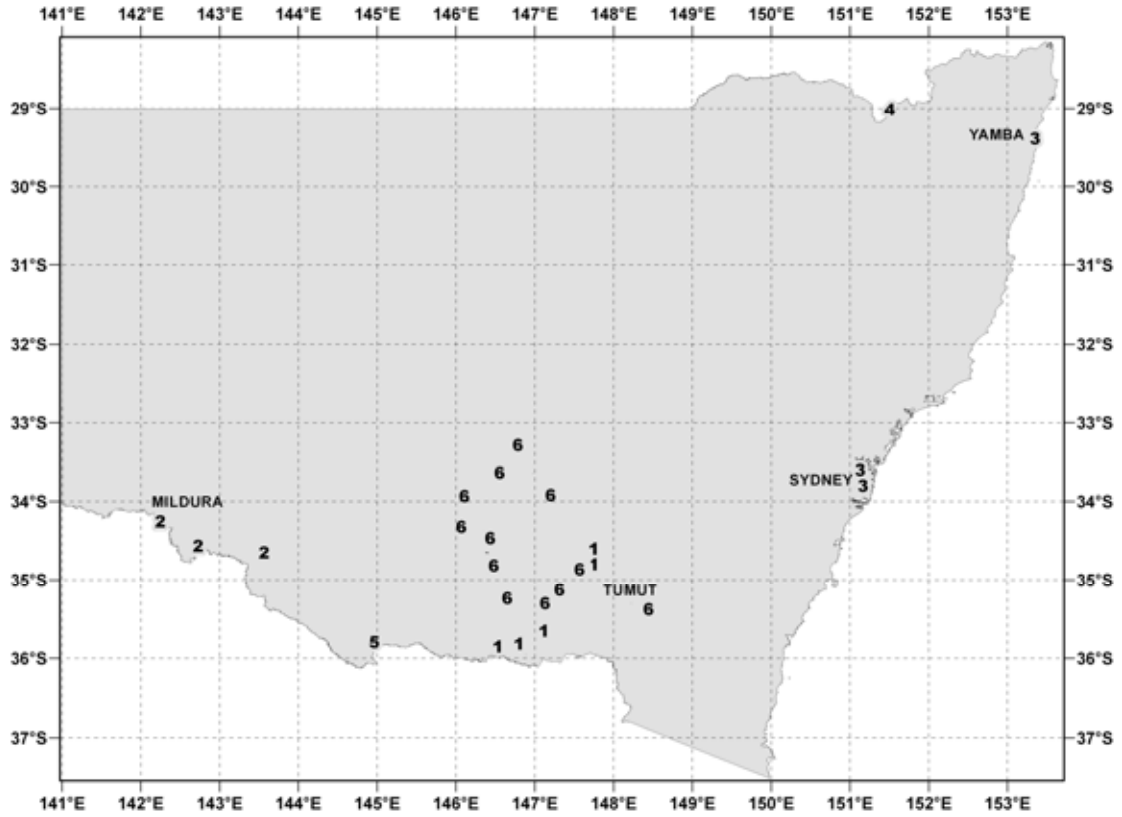
Seventy seven more new species have not been assigned to described genera but have been allocated codes.

DISCUSSION

It seems likely that the gaps that appear on Figure 1 are not due to lack of specimens, but rather lack of collecting opportunity.

Paradoxosomatids are mainly active in damp or humid conditions, perhaps because, as in most other millipede species, their cuticles are permeable to water (Hopkin and Read 1992). In wetter areas, such as those along the NSW coast, records show that paradoxosomatids can be collected at most times of

Figure 8. Distribution of paradoxosomatid millipede species of the genus *Heterocladosoma* in New South Wales. Each number represents a species. Species 3 = *Heterocladosoma bifalcatum.* Species 1, 2, 4, 5 and 6 = new species.



the year. In these areas, it is generally wet enough for paradoxosomatids to remain active on the surface for extended periods of time. It is probably for this reason too, that specimens were easily collected by pitfall trapping and in litter samples.

Collection of specimens in drier areas, however, is much more difficult. It depends on entomologists being in the right place at the right time, as rainfall is infrequent. It seems that paradoxosomatids must remain buried in the soil for unknown periods of time and have only a small window of opportunity when conditions are suitable in which to emerge, feed and mate on the surface in these dry areas. The author's observations indicate that there has to be sufficient rain to reach their hiding places before paradoxosomatids emerge. Consequently, hand searching of targeted areas in suitable conditions is more likely to yield specimens. As soon as surface conditions start to dry out, paradoxosomatids are no longer to be found (personal observations). There has also been a report of paradoxosomatids emerging from the cracks in dried out pan beds (Mark Wilson, Charles Sturt University, personal communication, 2006) near Hay. Presumably the cracks themselves retain enough moisture for the millipedes to remain active.

The paradoxosomatid fauna in NSW west of the Great Dividing Range remains largely unknown and may be more diverse than expected for a dry area.

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