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OPHYIULUS IN VICTORIA: RESULTS OF MILLIPEDE SURVEYS FROM SOUTH-EASTERN AUSTRALIA

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ABSTRACT: The composition and ecology of the millipede fauna of Victoria remain poorly understood. We collected millipedes as part of a series of ecological arthropod surveys across south-eastern Australia, focusing mainly on Victoria. These samples almost exclusively contained millipedes from the introduced order Julida. We pursued species identification of the julids when it became apparent there were species other than the well-recorded *Ommatoiulus moreleti* (Lucas, 1860) (Portuguese millipede) in the samples. The majority of specimens were *O. moreleti*, but we also detected at least one species of *Cylindroiulus* Verhoeff, 1894, as well as an *Ophyiulus* Berlese, 1884, species, specimens of which have been identified as *Ophyiulus* cf. *targionii*. These are the first *Ophyiulus* records for Victoria to our knowledge. We present preliminary data on the abundance through the year of *Ophyiulus*. This is the first study to examine this species in Victoria and little is currently known about its likely impact on agriculture or on native species. Monitoring and research of the species in the future is therefore warranted.

Keywords: Diplopoda, Julida, Portuguese millipede, invasive species, pest management

INTRODUCTION

In Australia, exotic millipedes are known to flourish in many habitats, especially anthropogenic habitats (Paoletti et al. 2007). There are eleven exotic species recorded on mainland Australia from four orders and ten genera (Mesibov 2015). Many of these exotic millipedes are from the order Julida (Black 1997), which is native to the northern hemisphere (Enghoff 1993).

Both native and exotic millipedes have not been researched extensively in Australia and, with one exception, there is limited information available about the distribution of exotic species (Black 1997; Judd & Horwitz 2001; Mesibov 2015). The exception to this is the julid millipede *Ommatoiulus moreleti* (Lucas, 1860), commonly known as the Portuguese millipede. This has been a problem species for many years (Baker 1985), reaching plague proportions in some cases (Bailey 1997; Baker 1979b). Because it is a nuisance to humans, *O. moreleti* has received considerable research attention from professional researchers (Bailey 1997; Bailey & Kovaliski 1993; Bailey & Mendonça 1990; Baker 1979b, 1984; Baker 1985; Griffin & Bull 1995; McKillup 1988) and the general public (Baker et al. 2013; Levy 2010).

Little is currently known about the contribution of exotic millipedes to plant litter breakdown in native or agricultural landscapes in Australia (Paoletti et al. 2007), about their interactions with native species (Griffin & Bull 1995), or to what extent they are pests in agricultural landscapes (McColl & Umina 2012; Nash et al. 2014). As a first step to understanding how exotic millipedes are contributing to ecological processes in the Australian environment, it is important to understand their distribution.

Millipedes were examined during a series of ecological and agricultural surveys of arthropod assemblages across south-eastern Australia. The majority of the specimens collected were from the exotic order Julida. All the sampling areas were within the known distribution of the Portuguese millipede (Baker 1985; Baker et al. 2013). At the time of sampling, the Portuguese millipede was the only known julid in Victoria, where the majority of sampling was undertaken (Mesibov 2015). The discovery that not all julids collected were *O. moreleti* prompted us to investigate further to determine what other species were present. We report here on the composition and patterns of abundance through the year of the sampled millipede communities across south-eastern Australia.

METHOD

All samples were collected as part of diverse projects across south-eastern Australia looking at the full terrestrial arthropod or invertebrate assemblage (Nash, unpublished data; Chong et al. 2011; Norton 2012; Norton et al. 2014). Collections were from Victoria, South Australia and New South Wales, but excluded Tasmania, which has a relatively well-documented millipede fauna. Millipedes were identified to order and later identified to genus or species.

Collection methods

Collections of millipedes were made using pitfall trapping and extraction from leaf litter using Tullgren funnels. Two pitfall trap types were used: 20 mm diameter (narrow-necked) and 100 mm diameter (large). Specimens from Mortlake (see below) were collected in 500 mL containers with 100 mm diameter openings. All other pitfall-trapped specimens were collected in glass test tubes (diameter 20 mm, length 145 mm) placed in a polyvinyl chloride (PVC) pipe (internal diameter 22 mm, length 170 mm) with a bevelled edge, so the opening of the test tube was flush with the soil surface. Traps were filled to 5 cm with a 1:1 mixture of absolute ethanol and ethylene glycol. The narrow-necked trap type used in the majority of sampling in this study was originally designed for ants (Majer 1978) but has since been used for a wide range of invertebrate groups (Thomson & Hoffmann 2007; Thomson et al. 2004). It is inconspicuous in public places and has a low probability of vertebrate bycatch (Pearce et al. 2005). Traps were left open for seven days and were replaced during or soon after rain events if they filled with water.

Leaf litter samples were collected in a 0.1 m^2 collecting ring and were kept cool and moist until placed in funnels. Tullgren funnels were modified plastic tubs (approx. 40 cm diameter, 10 cm depth), with a cross-hatched grill (6 mm x 6 mm) and one larger hole, placed in sealed wooden chambers and suspended over trays of water and ethylene glycol (1:1). Heat- and light-producing 120 W bulbs were suspended above the samples and an air-conditioner was used to maintain a temperature gradient between the room and the funnels. Samples were processed over four days, which has been shown to be sufficient time for all the invertebrates to emerge (York 2000). The collections were sieved through plankton mesh and stored in 70% ethanol. A small number of specimens were hand-sorted from leaf litter samples.

Victorian samples

In Victoria, samples were collected from public parks, remnant woodlands and experimental sites in Melbourne and from agricultural areas in south-western Victoria (Figure 1). The majority of the eleven woodland remnant sites and ten public park sites are in the Victorian Volcanic Plains bioregion of Greater Melbourne and have remnant *Eucalyptus camaldulensis* (River Red Gum) overstoreys. The woodland remnants represent the Plains Grassy Woodland plant communities and the public parks have mown amenity grass in the understorey. Almost all sites are regularly used and have a history of disturbance (Hahs & McDonnell 2007; Norton 2012). At each site there were ten pitfall traps across two 400 m^2 sampling areas, opened in October 2008 and October 2009 (Norton 2012). Litter samples for Tullgren extraction were collected in November 2009. Further samples were collected from Royal Park, Parkville, Victoria (37°47’18.96”S, 144°56’43.08”E) in October 2010, where leaf litter and mulch were hand-sorted and a subset examined for millipedes.

The experimental site in Melbourne was in the grounds of the University of Melbourne’s Burnley campus (37°49’49.44”S, 145°1’30”E). One hundred and forty-four pitfall traps were placed in an area 38 m x 8 m and were opened six times over one year (December 2008, February 2009, April 2009, August 2009, October 2009 and December 2009) (Norton et al. 2014). Leaf litter and woodchips were collected for Tullgren extraction in January 2010.

Pitfall trap collections were made from two locations in agricultural regions of south-western Victoria – Merindie West, near Mortlake (38°0’48”S, 142°5”E), and Wickliffe (37°47’53”S, 142°40’51”E), approximately 40 km north of Mortlake. At Merindie West, 240 large pitfall traps were placed in a 40 ha area (M. Nash, unpublished data) and collections made in April 2004, March 2006, July 2006, September 2006 and March 2007. At Wickliffe, 81 narrow-necked pitfall traps were set in a 1 ha area of failed canola in July 2011. In early summer (25 November – 2 December 2011), 180 traps were set in a 40 ha field of a barley crop.

South Australian samples

Sixty-one commercial vineyard blocks were sampled in the 2006–2007 growing season from the viticultural regions of South Australia, extending from Padthaway (36°36’S, 140°29’E) to the Barossa Valley (34°28’S, 138°59’E) (Chong et al. 2011). Millipedes had previously been stored in separate vials from the main samples and a random selection of 57 millipede samples was re-examined.

NSW observations

Millipedes were observed in 2012 and again in 2014 in canola fields in the eastern Riverina district (e.g. at sites 35°22’16”S, 147°14’36”E; 35°43’2”S, 147°2’16”E), where slugs had been causing damage. Any specimens not positively identified in the field using a 10 x magnification hand lens were collected and returned to the laboratory.

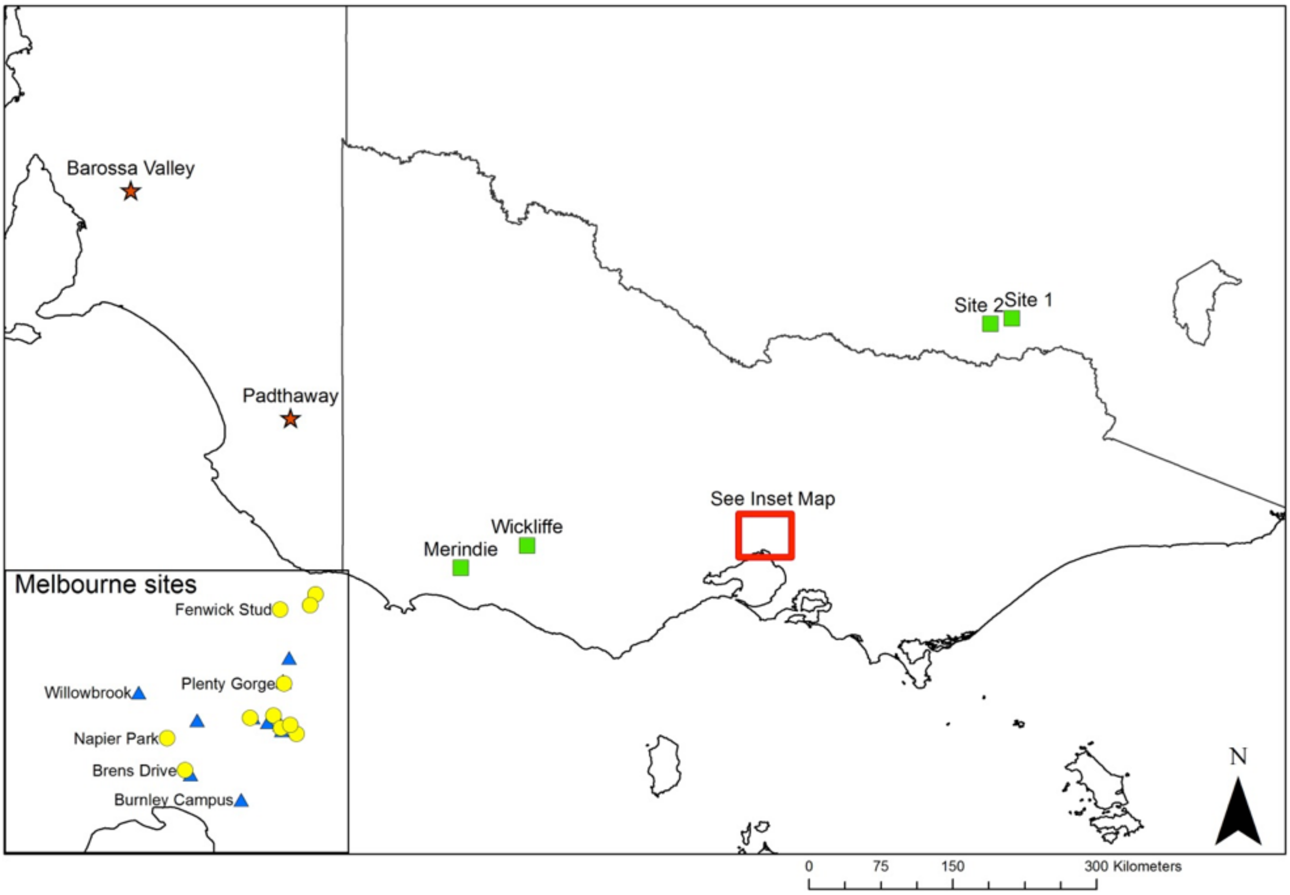

Figure 1: Map of south-eastern Australia with location of all sites surveyed for millipedes marked. Agricultural sites are denoted by green squares, vineyards by red stars, and urban sites (inset) – which all fall within Greater Melbourne – are divided into urban parks (blue triangles) and remnant vegetation (yellow circles). The two vineyard points denote the extreme points of the sampling area. A selection of Greater Melbourne sites are named for context. Site location details are in Appendix 1.

Millipede identification

From all samples, millipedes were extracted and all individuals were identified to order (Sierwald et al. 2007). Adult millipedes from the order Julida, which formed the majority of the collections, were then identified to genus and species (Mesibov 2012b). Juveniles were not identified below order as millipede species identification can only be confirmed by examining the gonopods of mature males. A reference collection of mature male julids was checked by Dr Robert Mesibov, at the Queen Victoria Museum and Art Gallery, Tasmania. All Victorian specimens collected from the order Polydesmida were also examined by Dr Mesibov and mature males identified. A number of julids were identified as being from the genus *Ophyiulus* Berlese, 1884, while a selection of mature male *Ophyiulus* was examined by European experts for species-level identification. The checked polydesmidans and *Ophyiulus* specimens have been lodged with Museum Victoria.

Seasonal occurrence patterns

The *Ophyiulus* specimens collected in this study are the first in Victoria (see 'Results'). To get a preliminary sense of the patterns of abundance through the year of this exotic genus, we selected sites where collections had been made from multiple seasons (Burnley, Mortlake, Wickliffe) (Appendix 1). *Ommatoiulus moreleti* was the most abundant species in our collections and its seasonal abundance patterns are well known (Baker 1979a; Baker 1979b). We used data for this species from the same samples to explore whether *Ophyiulus* is abundant at similar times.

RESULTS

In total, approximately 3500 millipedes were examined, of which only 21 were from the order Polydesmida, the remainder from the exotic Julida. The polydesmidans were collected from a vineyard in South Australia (one individual); Burnley experimental plots, Victoria (one); and remnant *Eucalyptus camaldulensis* woodland patches across northern Melbourne (nineteen) (Norton 2012). Over half of the polydesmidan specimens could not be identified as they were either too young or were female (Mesibov pers. comm. 2011). The four identifiable species that were found, all native species from the family Paradoxosomatidae, are *Akamptogonus novarae* (Humbert & de Saussure, 1869), *Taxidiotisoma portabile* Mesibov and Car, 2015,

Table 1: Records of *Ophyiulus* Berlese, 1884 collected during ecological surveys in Victoria, Australia, from 2004 to 2012.

Land use and site name	Latitude	Longitude	Sampling period	Collection method	*Ophyiulus* (N)
Agricultural field					
Merindie, Mortlake	-38.0	142.7	April 2004; March, July, Sept 2006; March 2007	Wet pitfall trap	183
Wickliffe	-37.8	142.68	July and December 2011	Wet pitfall trap	268
Horticultural teaching field site					
Burnley University Campus, Richmond	-37.8304	145.0250	Dec. 2008; Feb., April, Aug., Oct., Dec. 2009	Wet pitfall trap	174
Burnley University Campus, Richmond	-37.8304	145.0250	January 2010	Tullgren extraction	80
Public parkland					
Delacombe Drive greenspace, Mill Park	-37.6585	145.0850	November 2009	Tullgren extraction	1
Royal Park, Parkville	-37.7886	144.9453	October 2010	Hand collection	3
Simpson Barracks Park	-37.7217	145.0814	November 2009	Tullgren extraction	2
Tennyson Circuit greenspace, Mill Park	-37.6600	145.0871	October 2009	Wet pitfall trap	1
Remnant vegetation – Red Gum woodland					
Brens Drive, Royal Park, Parkville	-37.7869	144.9434	October 2008	Wet pitfall trap	2
Bundoora Park	-37.7122	145.0411	October 2008	Wet pitfall trap	1
Bundoora Park Remnant	-37.7120	145.0382	October 2009	Wet pitfall trap	1
Bundoora Park Remnant	-37.7120	145.0382	November 2009	Tullgren extraction	2
Gresswell Forest, Mont Park	-37.7089	145.0720	November 2009	Tullgren extraction	1
Martins Lane, Parks Victoria, Viewbank	-37.7351	145.1057	November 2009	Tullgren extraction	18
Napier Park, Essendon	-37.7420	144.9188	October 2008, October 2009	Wet pitfall trap	7
Simpson Barracks (BCEA)	-37.7268	145.0810	October 2008, October 2009	Wet pitfall trap	2
Simpson Barracks (BCEA)	-37.7268	145.0810	November 2009	Tullgren extraction	6
Simpson Barracks (RR)	-37.7218	145.0950	October 2009	Wet pitfall trap	1
Yan Yean, South	-37.5479	145.1260	November 2009	Tullgren extraction	1

Notodesmus scotius Chamberlin, 1920 and a species very close to *Somethus* sp. 'Blakeville'. Two of these species, *A. novarae* and *Taxidiotisoma portabile*, were found in Simpson Barracks (RR). *Notodesmus scotius* was found at Martins Lane and Yan Yean North, and *Somethus* sp. was found at Bundoora Park Remnant (Appendix 1).

There were three genera of julid collected: *Ommatoiulus* Latzel, 1884 – all *Ommatoiulus moreleti* (Lucas, 1860) – *Ophyiulus* Berlese, 1884 and *Cylindroiulus* Verhoeff, 1894. By far the most abundant was *O. moreleti*, which was collected at all locations.

There were 754 *Ophyiulus* specimens detected across all the collections, including in the earliest sample from April 2004. The majority of the specimens were collected at Mortlake (183) and Wickliffe (268) (Table 1). The remaining specimens (303) were collected from the Greater Melbourne sites (Table 1). There were no *Ophyiulus* specimens in the samples examined from either South Australian vineyards or southern New South Wales.

The specimens of *Ophyiulus* were most likely *O. targionii* Silvestri 1898, in the 'verruculiger' group. Both the species and genus are due for revision, as the last major revision was in 1927 (Mesibov pers. comm. 2014; Jeekel 2000). *Ophyiulus* is a largely Italian genus (Kime 1990) and *Ophyiulus targionii* is primarily found on the Italian peninsula and in Sicily, although it has also been introduced to Menorca and New Zealand (Jeekel 2000). These are the first records of *Ophyiulus* from Victoria to our knowledge (ABRS 2009; Mesibov 2015). *Ophyiulus targionii* Silvestri 1898 has been known from South Australia since 1983 (Jeekel 2000; McKillup 1988), yet was not recorded from the Adelaide region during extensive 1996–1997 surveys (Hensel 1999).

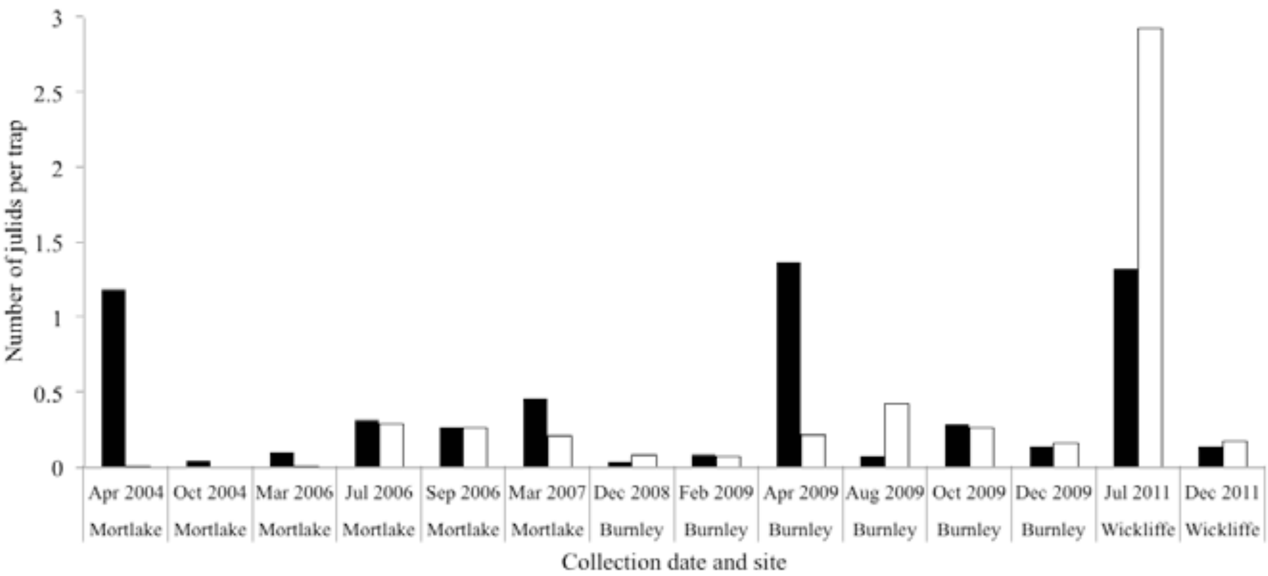

Figure 2: Relative abundance of *Ophyiulus* Berlese, 1884, and *Ommatoiulus moreleti* (Lucas, 1860) in Victoria from April 2004 to December 2011. Data are all from pitfall traps only, at sites where sampling occurred at multiple times per year: Burnley Campus, Greater Melbourne; Merindie, Mortlake, western Victoria; and Wickliffe, western Victoria. The bars represent the number of millipedes per trap of *O. moreleti* (black bars) and *Ophyiulus* sp. (white bars). Refer to main text and Appendix 1 for details of trapping effort at each site.

Only sixteen millipedes from the genus *Cylindroiulus* were identified in these collections, and could not be identified to species due to poor taxonomic resolution of the genus (Mesibov pers. comm. 2014). All specimens came from *Eucalyptus camaldulensis* sites in Melbourne and most (15) were from parks with mown amenity grass (Norton 2012). *Cylindroiulus* sp. has also been observed in leaf litter and mulch from Royal Park (B. Norton pers. obs. 2010 & 2011).

Julid millipede community dynamics

Ommatoiulus moreleti comprised more than half of the julid community at most times of the year (Figure 2). *Ophyiulus* made up more than 50% of the sample only at Burnley and Wickliffe, in summer samples (Burnley: December 2008 and 2009; Wickliffe: December 2011) and winter samples (Burnley: August 2009; Wickliffe: July 2011). The data from Burnley show a trend suggesting an increase in *Ophyiulus* activity during winter (Figure 2).

DISCUSSION

All the sites examined for millipedes in south-eastern Australia — including urban, agricultural and remnant vegetation areas — were dominated by introduced species from the order Julida. Primarily these are *Ommatoiulus moreleti* (Lucas, 1860), but also include *Cylindroiulus* Verhoeff, 1894 and *Ophyiulus* Berlese, 1884. These are the first records of *Ophyiulus* from Victoria, and the specimens with a confirmed identification are *Ophyiulus* cf. *targionii*.

Ophyiulus was detected across many sites in Greater Melbourne as well as the survey areas in western Victoria, but was absent from collections examined from New South Wales and South Australia. The oldest sampling period in this study was April 2004, and *Ophyiulus* was detected in those. Given that *Ophyiulus targionii* has been in South Australia since at least 1983 (Jeekel 2000; McKillup 1988), it is perhaps unlikely that these data reflect a recent invasion in Victoria, but rather an undocumented one.

The preliminary temporal data suggest that *Ophyiulus* is active in Victoria throughout the year, with a trend towards greater catch numbers in winter. Greater pitfall catch can reflect increases in activity and/or abundance. There were no obvious peaks in abundance and activity as there appeared to be in the *Ommatoiulus moreleti* samples, which have been documented elsewhere for that species (Baker 1979a; Baker 1979b). These temporal data are preliminary results from studies designed for different purposes and the data provide a step in understanding the dynamics of this species in Victoria. Standardised systematic sampling in areas of interest would be required to explore these dynamics, both within and between years.

The likelihood of *Ophyiulus* cf. *targionii* becoming a pest in agricultural or urban areas is not clear due to poor taxonomic resolution and insufficient information about its activity in Australia. Crop damage but not losses are currently attributed to Portuguese millipedes (McColl & Umina 2012; Nash et al. 2014) in areas where we determined *O.* cf. *targionii* was also present (cesar pty ltd 2014). Further investigation of diet and interactions is needed if crop damage is to be attributed correctly. In contrast to *O. moreleti*, information to date would suggest that *O.* cf. *targionii* is likely to cause minimal annoyance in urban Australia (Johns 1966; McKillup 1988), and we do not consider *O.* cf. *targionii* to be a pest that warrants control.

Few native polydesmidans were collected in this study. The diversity and species' distributions of native millipedes in Victoria are still poorly known, although the fauna appears to be diverse (e.g. Jeekel 1982, 1983, 1984; Mesibov 2004, 2008). Some native species are sensitive to disturbance and may recover slowly from historical disturbance, especially in fragmented landscapes (Mesibov 2008), which may explain some of the low numbers in our samples. All sites sampled here are either regularly disturbed (agriculture, urban parklands) or have a history of disturbance (urban remnant bush) (Hahs & McDonnell 2007), which is not uncommon for bushland patches in south-eastern Australia (Jurskis 2011; Kirkpatrick 2004; Lunt & Spooner 2005). The julids are able to cope with much drier conditions than Australian native millipedes (Baker 1979b; Kime & Golovatch 2000; Paoletti et al. 2007), which may contribute to explaining their success in fragmented bushland and modified landscapes, where the understorey is often cleared and there is less leaf litter. There has been little research into the interaction between julid and native millipedes, making it difficult to ascertain to what, if any, extent native species have been affected by the introduction of julids, although research suggests that the Portuguese millipede does not directly interfere with normal activity of tested native species (Griffin & Bull 1995).

Although published papers have detailed more effective methods than pitfall trapping for establishing the millipede fauna of an area (e.g. Mesibov et al. 1995; Snyder et al. 2006), narrow-necked pitfall traps have been successfully used to collect large millipedes (M. Nash and B. Norton pers. obs.) as well as other large invertebrates (Nash et al. 2010) across a range of studies, indicating they do provide useful comparative information. In this study we supplemented narrow-necked pitfall trapping with larger-diameter pitfalls as well as extraction from leaf litter at certain sites. Although a far greater abundance of julids was extracted from litter, the community composition detected by the two methods was very similar (Norton 2012; Norton et al. 2014).

An issue for future survey work, particularly by non-specialists, is that accurate identification of the range of julid millipedes in Victoria is not currently straightforward. Furthermore, the full range of species has not been recorded and there is not currently a key available for the state. This is particularly an issue for the farming community, who can be interested in millipedes in their fields but, using the available evidence, may erroneously assume they are all Portuguese millipedes. We were able to identify genus-level differences in the community using Mesibov's online key to Tasmanian juliform millipedes (Mesibov 2012c). This covers the species *Ophyiulus pilosus* (Newport, 1843) rather than *O.* cf. *targionii*, but there are sufficient characters in the key to identify that a millipede is not *Ommatoiulus moreleti*, even using just a hand lens. Mesibov (2012a, c; 2015) provides a range of other resources to assist with survey efforts and in appreciating the current state of knowledge of millipedes.

In this examination of millipedes collected from agricultural and urban areas we found very few native polydesmidans, but large numbers of exotic julids from three genera, including, for the first time in Victoria, *Ophyiulus*, with a selection of specimens confirmed as *Ophyiulus* cf. *targionii*. *Ophyiulus* is already widespread in the state, and may be more widespread than reported here, and it is likely to have been here for some time. Little is currently known about this millipede's habits in Australia and therefore what its impact on agriculture and on native species has been or could be. This is the first study to examine this genus in Victoria and monitoring and research in the future is warranted.

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Appendix 1: Location of all sites in south-eastern Australia surveyed for millipedes. For each site a description of the land use and vegetation type is given as well as the dates and methods of invertebrate collections. All plots numbered 1 and 2 in Greater Melbourne are 20 m x 20 m. Other details of sampling methods are in the main text.

Site name	Plot	Latitude	Longitude	Land use	Vegetation type	Date	Trapping type	Number of pitfall traps	Collector
Greater Melbourne, Victoria									
Brens Drive, Royal Park, Parkville	1	-37.7878	144.9440	Public park – remnant vegetation	Plains Grassy Woodland (*Eucalyptus camaldulensis* Dehnh. dominant)	Wet pitfall trap (20 mm dia.) 21 to 28 Oct 2008 and 13 to 20 Oct 2009. Litter collection for Tullgren extraction 18 Nov 2009.		5	B.A.N.
	2	-37.7869	144.9434					5	
Bundoora Park, Bundoora	1	-37.7118	145.0421	Public park – amenity grass	Mown grass and trees (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 20 to 27 Oct 2008 and 12 to 19 Oct 2009. Litter collection for Tullgren extraction 1 Dec 2009		5	B.A.N.
	2	-37.7122	145.0411					5	
Bundoora Park Remnant, Bundoora	1	-37.7120	145.0382	Public park – remnant vegetation	Plains Grassy Woodland (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 20 to 27 Oct 2008 and 12 to 19 Oct 2009. Litter collection for Tullgren extraction 1 Dec 2009		5	B.A.N.
	2	-37.7107	145.0385					5	
Burnley University Campus, Richmond	experimental plots	-37.8304	145.0250	Horticultural teaching	Twelve replicates of four experimental treatments: Bare ground, native leaf litter, Red Gum woodchips, amenity grass	28 Dec to 4 Jan 2009 26 Feb to 5 Mar 2009 27 Apr to 4 May 2009 2 to 9 Aug 2009 24 to 31 Oct 2009 29 Dec 2009 to 5 Jan 2010	Wet pitfall trap (20 mm dia.)	3 per plot; 48 plots; N = 144	B.A.N.
Burnley University Campus, Richmond		-37.8304	145.0250	Horticultural teaching	Twelve replicates of two experimental treatments: Native leaf litter, Red Gum woodchips	6 Jan 2010	Collections from Tullgren extraction	NA	B.A.N.
Cascades Park (Linaker Drive), Macleod	1	-37.7181	145.0631	Public park – amenity grass	Mown grass and trees (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 24 to 31 Oct 2008 and 14 to 21 Oct 2009. Litter collection for Tullgren extraction 2 Dec 2009		5	B.A.N.
	2	-37.7174	145.0625					5	
Delacombe Drive greenspace, Mill Park	1	-37.6585	145.0850	Public park – amenity grass	Mown grass and trees (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 20 to 27 Oct 2008 and 12 to 19 Oct 2009. Litter collection for Tullgren extraction 25 Nov 2009		5	B.A.N.
	2	-37.6587	145.0856					5	
Fahey Crescent greenspace, Watsonia	1	-37.7300	145.0837	Public park – amenity grass	Mown grass and trees (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 24 to 31 Oct 2008 and 14 to 21 Oct 2009. Litter collection for Tullgren extraction 2 Dec 2009		5	B.A.N.
	2	-37.7299	145.0842					5	

Site name	Plot	Latitude	Longitude	Land use	Vegetation type	Date	Trapping type	Number of pitfall traps	Collector
Fawkner Crematorium Horse Paddock, Fawkner	1	-37.7156	144.9616	Public park	Mown grass and trees (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 21 to 28 Oct 2008 and 13 to 20 Oct 2009. Litter collection for Tullgren extraction 18 Nov 2009		5	B.A.N.
	2	-37.7161	144.9616					5	
Fenwick Stud, Whittlesea	1	-37.5558	145.0814	Horse and cattle grazing	Plains Grassy Woodland (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 22 to 29 Oct 2008 and 15 to 22 Oct 2009. Litter collection for Tullgren extraction 24 Nov 2009		5	B.A.N.
	2	-37.5556	145.0800					5	
Foxtail Park, South Morang	1	-37.6256	145.0944	Public park – amenity grass	Mown grass and trees (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 22 to 29 Oct 2008 and 15 to 22 Oct 2009. Litter collection for Tullgren extraction 25 Nov 2009.		5	B.A.N.
	2	-37.6257	145.0936					5	
Greenwood Drive greenspace, Mont Park	1	-37.7085	145.0744	Public park – amenity grass	Mown grass and trees (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 25 Oct to 1 Nov 2008 and 11 to 18 Oct 2009. Litter collection for Tullgren extraction 1 Dec 2009		5	B.A.N.
	2	-37.7082	145.0718					5	
Gresswell Forest, Mont Park	1	-37.7089	145.0720	Public park – remnant vegetation	Plains Grassy Woodland (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 25 Oct to 1 Nov 2008 and 11 to 18 Oct 2009. Litter collection for Tullgren extraction 1 Dec 2009		5	B.A.N.
	2	-37.7096	145.0679					5	
Martins Lane, Parks Victoria, Viewbank	1	-37.735	145.1049	Public park - remnant vegetation	Plains Grassy Woodland (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 25 Oct to 1 Nov 2008 and 11 to 18 Oct 2009. Litter collection for Tullgren extraction 2 Dec 2009		5	B.A.N.
	2	-37.7351	145.1057					5	
Napier Park, Essendon	1	-37.7417	144.9181	Public park - remnant vegetation	Plains Grassy Woodland (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 21 to 28 Oct 2008 and 13 to 20 Oct 2009. Litter collection for Tullgren extraction 18 Nov 2009.		5	B.A.N.
	2	-37.7420	144.9188					5	
Plenty Gorge, near Vanbrook Drive, Parks Victoria, Mill Park	1	-37.6625	145.0867	Remnant vegetation	Plains Grassy Woodland (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 20 to 27 Oct 2008 and 2009. Litter collection for Tullgren extraction 25 Nov 2009		5	B.A.N.
	2	-37.6617	145.0861					5	
Royal Park, Parkville	NA	-37.7940	144.9520	Public park	Leaf litter under trees, surrounded by amenity lawn	20 to 22 Oct 2010	Hand collection	NA	B.A.N.
Simpson Barracks, BCEA, Yallambie	1	-37.7268	145.0827	Army Barracks - remnant vegetation	Plains Grassy Woodland (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 24 to 31 Oct 2008 and 14 to 21 Oct 2009. Litter collection for Tullgren extraction 17 Nov 2009		5	B.A.N.
	2	-37.7268	145.0810					5	

Site name	**Plot**	**Latitude**	**Longitude**	**Land use**	**Vegetation type**	**Date**	**Trapping type**	**Number of pitfall traps**	**Collector**
Simpson Barracks, Park, Yallambie	1	-37.7217	145.0814	Army Barracks – amenity grass	Mown grass and trees (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 24 to 31 Oct 2008 and 14 to 21 Oct 2009. Litter collection for Tullgren extraction 17 Nov 2009		5	B.A.N.
	2	-37.7219	145.0823					5	
Simpson Barracks, RR Yallambie	1	-37.7223	145.0959	Army Barracks - remnant vegetation	Plains Grassy Woodland (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 24 to 31 Oct 2008 and 14 to 21 Oct 2009. Litter collection for Tullgren extraction 17 Nov 2009		5	B.A.N.
	2	-37.7218	145.0950					5	
Tennyson Circuit greenspace, Mill Park	1	-37.6606	145.0872	Public park – amenity grass	Mown grass and trees (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 20 to 27 Oct 2008 and 12 to 19 Oct 2009. Litter collection for Tullgren extraction 25 Nov 2009		5	B.A.N.
	2	-37.6600	145.0871					5	
Willowbrook Reserve, Westmeadows	1	-37.6756	144.8770	Public park – amenity grass	Mown grass and trees (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 21 to 28 Oct 2008 and 13 to 20 Oct 2009. Litter collection for Tullgren extraction 18 Nov 2009.		5	B.A.N.
	2	-37.6761	144.8800					5	
Yan Yean Reservoir, North, Yan Yean	1	-37.5336	145.1323	Remnant vegetation	Plains Grassy Woodland (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 22 to 29 Oct 2008 and 15 to 22 Oct 2009. Litter collection for Tullgren extraction 24 Nov 2009.		5	B.A.N.
	2	-37.5330	145.1315					5	
Yan Yean Reservoir, South, Yan Yean	1	-37.5497	145.1245	Remnant vegetation	Plains Grassy Woodland (*Eucalyptus camaldulensis* dominant)	Wet pitfall trap (20 mm dia.) 22 to 29 Oct 2008 and 15 to 22 Oct 2009. Litter collection for Tullgren extraction 24 Nov 2009.		5	B.A.N.
	2	-37.5479	145.1260					5	
Western Victoria agricultural areas, Victoria									
Merindie, Mortlake	NA	-38.01	142.08	Agricultural field	Barley stubble Wheat Canola stubble Wheat Wheat Wheat stubble	26 Mar to 4 Apr 2004 Oct 2004 17 to 24 Mar 2006 1 to 8 July 2006 3 to 30 Sept 2006 Mar 2007	Wet pitfall trap (100 mm dia.)	4 per plot; 5 plots per site; 12 sites; N = 240	M.A.N.
Wickliffe	NA	-37.80	142.70	Agricultural field	Failed canola crop Barley	21 to 28 and 7 to 14 July 2011 25 Nov to 2 Dec 2011	Wet pitfall trap (20 mm dia.)	3 per plot; 27 sites N = 81 3 per plot; 60 sites N = 180	M.A.N.

Site name	Plot	Latitude	Longitude	Land use	Vegetation type	Date	Trapping type	Number of pitfall traps	Collector
Agricultural area, New South Wales									
New South Wales	NA	-35.67; -35.72	147.25; 147° 03’	Agricultural field	Canola field	2012 2014	Hand collection		M.A.N.
Viticultural regions, South Australia									
From Padthaway (36°36’S, 140°29’E) to the Barossa Valley (34°28’S, 138°59’E), South Australia	NA			Vineyard	see Chong et al. (2011) for details	range of seasons and months, from 2005 to 2008	Wet pitfall trap (20 mm dia.)	5 per plot; N = 285; 57 samples randomly selected to check	see Chong et al. (2011) for details