Distribution and host range of the recently introduced willow sawfly, *Nematus oligospilus* Förster, on willows (*Salix* spp.) in southeast Australia.

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Summary A survey of pathogens and invertebrate fauna of willows (*Salix* L. spp., Salicaceae) was undertaken in southeast Australia. Rapid sampling techniques were employed to gather presence /absence data on the organisms inhabiting willows.

The willow sawfly, *Nematus oligospilus* Förster, is far more widespread than was previously thought and new occurrences were recorded for the Australian Capital Territory, New South Wales, Victoria and South Australia, as well as being detected in Tasmania for the first time. Willow species predominantly affected by sawfly included *S. fragilis* L. (crack willow), *S. babylonica* L., *S.* x *sepucralis* Simonk. var. *sepucralis* Simonk. and *S.* x *sepucralis* Simonk, (Dode) Meikle var. *chrysocoma* (Dode) Meikle (weeping willows) and *S. alba* L. var. *vitellina* (L.) Stokes (golden willow). It was also been found on (*S. matsudana* Koidz. 'Tortuosa' (tortured willow), *S. humboldtiana* Willd. 'Pyramidalis' (pencil willow) and *S. cinerea* L. (pussy willow). Occurrences on the *S. cinerea*, are the first records of sawfly on these species in the Southern Hemisphere.

Keywords. willows, *Salix*, sawfly, *Nematus oligospilus.*

INTRODUCTION

Willows occupy large areas of temperate Australia with extensive invasions in the southeast. They have deleterious impacts on water, agriculture, recreational, amenity and biodiversity values, but are considered by some to positively influence landscape values. Of the 32 willow taxa naturalised in Australia all, with the exception of *S. babylonica, S.* x *reichardtii* A. Kern and *S.* x *calodendron* Wimm., are designated Weeds of National Significance (ARMCANZ 2001). Despite this, there is no detailed knowledge of the indigenous and introduced organisms utilising willow taxa in Australia, or the effect that these organisms are having on willow growth and reproduction.

The willow sawfly, first detected in Canberra in 2004, was possibly introduced from New Zealand where it has been established since 1997 (Bruzzese and McFadyen 2006). The current distribution of the sawfly encompasses disparate locations in Canberra, southern New South Wales (NSW), the Adelaide Hills and suburban Melbourne (Anon. 2005a, Bruzzese and McFadyen 2006). A major objective of this survey was to determine the current geographical and willow host range of *N. oligospilus* in Australia as it is reported to have a destructive effect on willows elsewhere in the southern hemisphere (Koch and Smith 2000)

MATERIALS AND METHODS

Following a survey of willow pathogens and invertebrate fauna undertaken in the summer of 2005-2006 in southeast Australia, the presence and absence of willow sawfly was recorded. The survey focussed on Victoria due to its extensive willow invasions (ARMCANZ 2001), but also included NSW, the Australian Capital Territory (ACT), South Australia and Tasmania. Tree willows (*Salix* subgenus *Salix*) and shrubs willows (*Salix* subgenus *Vetrix*) were included in the survey as encountered.

Site selection. A site consisted of one or more trees and was selected to cover as much as possible of the current distribution of willows in southeast Australia. Time constraints dictated that sites had to be spaced widely so there was little deviation from major road routes. At each site a detailed description was recorded along with GPS and altitude readings taken.

Tree sampling. Trees at each site were chosen randomly for sampling according to the following criteria: a basal diameter of at least 10 cm, the lowest branches were within reach of the long-handled tree loppers (about 5m) and within a cluster of willows; no two trees with overlapping canopies were sampled. Early in the survey two trees of each taxon were sampled per site, but this proved excessively time-consuming and later only one tree per taxon was sampled. Any obviously unhealthy or herbivore-damaged tree at a site was also sampled.

Rapid standardized sampling techniques were employed to collect presence/absence data only. Quantitative sampling to determine abundance was

beyond the scope of this project. A branch sample of each tree was taken and pressed for identification. Each tree was tagged with an identification number, and details such as tree height, distance from and type of watercourse, tree habit, bark colour, fragility, leaf glaucousness and apparent herbivory were recorded.

Sampling involved three methods: visual inspection of whole trees, beating branches using a beating tray and laboratory examination of cut branches. Each tree was visually inspected from the ground for a total of ten minutes, with the entire circumference of the tree inspected if possible. Invertebrates found during this search were collected with a pooter and foliage with sessile insects and / or diseased leaves or twigs was stored in plastic bags for later identification. Two randomly selected branches, on opposite sides of the tree, were beaten with a rod for 30 seconds each and a beating tray (84cm square) was used to collect fallen invertebrates. A further two branches were cut down, again on opposite sides of the tree, using long handled tree loppers to cut about 5m above the ground. Branches between 0.5m and 1m were immediately placed in plastic bags for subsequent microscope examination in the laboratory.

All invertebrate material collected was preserved in 70% ethanol except any material likely to be damaged by this method of preservation such as moths, which were placed in a jar containing ethyl acetate. Plant material was kept refrigerated at between 10-15ºC until examined. All samples were inspected for the presence of willow sawfly.

RESULTS

A total of 214 sites were visited and a total of 336 trees sampled (see Fig. 1). Willow taxa sampled included the tree willows (*Salix* subgenus *Salix*) such as *S. alba* L. var. *caerulea* (Sm.) Sm. (cricket bat willow), *S. alba* var. *vitellina, S. alba* x *matsudana*, *S. babylonica, S x pendulina, S.* x *sepulcralis* var. *sepucralis, S.* x *sepulcralis* var. *chrysocoma, S. fragilis*, *S. matsudana* 'Tortuosa', *S. humboldtiana*, *S. x rubens* Schrank (basket willow), *S. nigra* Marshall (black willow) and a number of unusual hybrid species such as *S. alba* var. *vitellina* x *S. matsudana* 'Tortuosa'. (golden tortured willow). Also sampled were the shrub willows (*Salix* subgenus *Vetrix*) including *S. cinerea* L. and *S.* x *reichardtii* (pussy willows), *S. viminalis* L. (osier) and *S. purpurea* L. (purple osier). Nomenclature follows Cremer (1995) with updates from G. Carr (pers. comm.).

The predominant tree species affected by *N. oligospilus* was identified as *S. fragilis*. However, willows readily hybridize causing some difficulty in identification. In the field, *S. fragilis* and *S.* x *rubens* (hybrid between *S. alba* and *S. fragilis*) can be easily confused (Kennedy *et al.* 2003). Closer examination of specimens may reveal that trees referred to as *S. fragilis* may have been *S.* x *rubens.*

Other prominent taxa of willows affected were the *S. alba* var. *vitellina, S. babylonica, S. sepulcralis* var. *sepulcralis, S. sepulcralis* var. *chrysocoma.* There were also some occurrences of *N. oligospilus* on *S. alba* x *matusdana, S. humboldtiana* and *S. cinerea.* There were no occurrences on *S. viminalis, S. nigra* or *S. purpurea.*

In the ACT, *N. oligospilus* occurred predominantly on *S. fragilis*, but also on *S. babylonica, S. sepucralis* var. *sepucralis, S.* x *sepucralis* var. *chrysocoma, S. alba* var. *vitellina, S. matsudana* 'Tortuosa' and *S.* x *rubens.* The sawfly was not found on any shrub willows sampled. Most of the sampling sites were in Canberra, where the insect was first recorded in Australia (Bruzzese and McFadyen 2006), although new occurrences were found in the Brindabella.

In NSW occurrences mirrored that of the ACT *N. oligospilus.* Existing distribution records of *N. oligospilus* in NSW were not specific and referred only to surrounding areas of Canberra such as Queanbeyan, Braidwood and Cooma, southeast and southwest NSW (Anon 2005a,b), although the latter is probably a typographical error. New distribution records found in this study include Gundagai, Tumut, Mullengandra, Deniliquin and the Snowy Mountains region (Adaminaby, Jindabyne, and Tumbarumba).

In South Australia, *N. oligospilus* was found primarily on the weepers; *S. babylonica, S.* x *sepucralis* var. *sepucralis* and *S.* x *sepucralis* var. *chrysocoma*) and to a lesser extent on *S. fragilis* and *S. alba* var. *vitellina*. The Adelaide Hills were the only previously reported location for *N. oligospilus* (Anon 2005b), but this study has found populations from Victor Harbour, sites east to Murray Bridge and north to Tanunda in the Barossa Valley.

In Tasmania willow species attacked included S. fragilis, *S. fragilis* crosses with *S. babylonica* or *S.* x *sepucralis* var. *sepucralis* and a golden New Zealand hybrid species *(S. alba* x *matsudana* x. *alba* var. *vitellina).* All occurrences constitute new distribution records.

In Victoria there were relatively few occurrences for the number of sites sampled.

However, *N. oligospilus* was found on *S. fragilis*, *S. babylonica, S. sepucralis* var. *sepucralis, S.* x *sepucralis* var. *chrysocoma, S. alba.* var. *vitellina* and an usual cross between *S.* x *rubens* and *S. matsudana* 'Tortuosa'. There was also one occurrence each *S. humboldtiana* and *S. cinerea*. The only previously reported occurrence of *N. oligospilus* in Victoria was in suburban Melbourne (Bruzzese and McFayden 2006).

Table 1 shows the number of sites per state and the areas in each state/territory where sawfly were found. Figure 1 represents survey samples sites with occurrences of sawfly marked.

Of the other tenthredinid species associated with willows in Australia the gall-inducing *Pontania proxima* (Lepeletier) was found predominantly on *S. fragilis* in Tasmania, where it is currently endemic (Naumann et al 2002). *Amauronematus viduatus* (Zetterstedt), currently known only from southeast NSW (Naumann *et al.* 2002), was found on weeping willows and *S. fragilis* in this area and scattered locations throughout Victoria.

DISCUSSION

The host preference of sawfly for tree willow species in Australia concurs with New Zealand research that showed it has a marked oviposition preference for tree over shrub willows (Charles *et al.* 1998).

The low incidence on *S. humboldtiana* in this survey is not representative of the South American situation where it has been reported numerous times (Koch and Smith 2000).

There are records of *S. nigra* as hosts for *N. oligospilus* in New Zealand (Charles *et al.* 1998) and South America (Koch and Smith 2000) and only very recently (April 2006) there have been reports of extensive infestations of sawfly on *S. nigra* from the Ovens River near Wangaratta, Vic (A. Briggs pers. *comm.*). The apparent absence of sawfly on *S. nigra* in this survey is probably a result of the relatively few trees of this species sampled. Our study has recorded for the first time sawfly feeding on pussy willow in Australia, although there is anecdotal evidence of feeding on this species in New Zealand (Harman 2004). It must be borne in mind, however, that host range may differ from country to country given that sawfly may be considered a complex of closely related species (Koch and Smith 2000).

The level of defoliation from sawfly was particularly high on *S. fragilis* and its hybrids. Occurrences on shrub willows usually constituted only a few individuals and were in places where *S. fragilis* was not present; perhaps indicating that feeding on these species occurred not by choice but necessity.

The distribution of sawfly in southeast Australia is more widespread than previously thought. The current disparate occurrences, many kilometres apart, probably indicate recent spread. In the Kiewa Valley (Victoria) the unsightly appearance of defoliated trees caused residents to contact the Catchment Management Authority (Bugelly 2006). It is possible that sawfly had been present in low densities around Kiewa for some time but the public response in early 2006 strongly suggests it had not previously achieved a significant population there.

In most instances, new detections of sawfly have consisted of only a few individuals indicating it may have recently spread to new areas but not yet built up in numbers. Given that the

Table 1: Occurrence of the willow sawfly, *N. oligospilus,* in southeast Australia

State	No. sites present / No. sites sampled	Trees with sawfly present/trees sampled	New distribution records for *N. oligospilus*
ACT	9/12	21/25	Brindabella
NSW	15/37	22/56	Adaminaby, Deniliquin, Jindabyne, Mullengandra, Tumbarumba,
SA	10/24	14/29	Mount Compass, Murray Bridge, Strathalbyn, Tanunda, Victor Harbour, Williamstown,
TAS	4/40	5/56	Deloraine, Devonport, Longford, Trevallyn (Launceston).
VIC	8/101	14/170	Beechworth, Bendoc, Geelong, Kergunyah, Kiewa, Melton, Rosedale, Tambo Crossing, Wodonga, Yea.

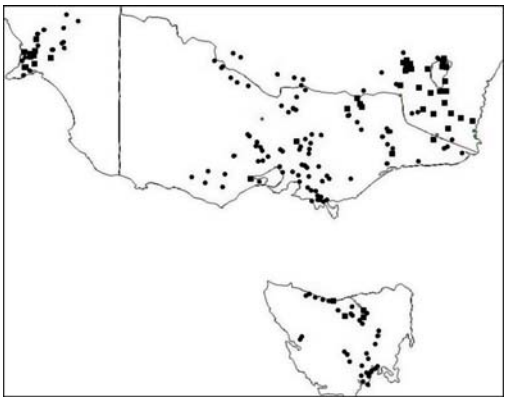

Figure 1 Survey sample sites (●) showing distribution of the willow sawfly *N. oligospilus* (■).

distribution has been extensively revised from only one season's survey, the rate of spread seems to be following the New Zealand example of up to 300km a year (Charles and Allen 2000). At the time of writing, there have been further unconfirmed reports of sawfly present in Armidale, Orange and Woomargama in NSW, and the King River Valley in Victoria (P. Ash, A. Briggs, S. Holland-Clift, *pers. comm.*).

Although we cannot yet report data on the incidence of other organisms associated with willows in Australia, the overwhelming impression is that the general level of herbivory is extremely low which is in direct contrast with *Salix* spp. from their country of origin (Sagliocco and Bruzzese 2001). The arrival of sawfly, therefore, constitutes a considerable change for willows in Australia as it may be the first time they are subjected to substantial herbivore injury. Given the very large sums expended in willow removal the likely impact of the sawfly requires further investigation.

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