

Which species of the thistle biocontrol agent *Trichosirocalus* are present in New Zealand?

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Summary

Trichosirocalus horridus (Panzer) (Coleoptera: Curculionidae), nodding thistle crown weevil, was introduced to New Zealand in 1989 for classical biological control of *Carduus nutans* L. (nodding thistle). Later, it was introduced from New Zealand to Australia. In 2002, a revision of the species concluded that *T. horridus* was in fact a complex of three species, with distinct host plant genus preferences: *T. horridus*, *Trichosirocalus mortadelo* Alonso-Zarazaga and Sánchez-Ruiz, and *Trichosirocalus briesei* Alonso-Zarazaga and Sánchez-Ruiz with preferences for *Cirsium*, *Carduus* and *Onopordum* thistles, respectively. In the revision, crown weevils on *Carduus* thistles in Australia were identified as all *T. mortadelo*, sourced from New Zealand. This suggests that the original introductions into New Zealand were wholly or partly *T. mortadelo*. A survey conducted to confirm which species of *Trichosirocalus* are present in New Zealand shows that all adults collected here are *T. horridus* regardless of whether the source host was *Cirsium vulgare* (Savi) Tenore or *C. nutans*. This presents two paradoxes: firstly, that *T. mortadelo* was collected from New Zealand and shipped to Australia but has not been found in our surveys, and secondly, that *T. horridus* does not show distinct preference for *Cirsium* thistles in New Zealand as reported elsewhere.

Keywords: *Trichosirocalus horridus*, *T. mortadelo*, *Carduus nutans*, *Cirsium vulgare*, *Onopordum acanthium*.

Introduction

The thistle biological control agent *Trichosirocalus horridus* (Panzer) was first introduced to New Zealand in 1984 and was released in the Canterbury plains of the South Island (Jessep, 1989b). By 1989, established populations were available for distribution to further sites in both the North and South Islands, and the weevil has been considered established in New Zealand ever since. The weevils introduced to New Zealand are originally from *Carduus nutans* L. from Neuenburg, Germany, and were established on *C. nutans* in Canada

(Agriculture Canada, Regina Station, SK) prior to their introduction (Jessep, 1989a, 1989b; Julien and Griffiths, 1998; P. Harris, personal communication).

Preliminary trials in New Zealand soon after the weevil's establishment suggested it readily attacked the three *Carduus* spp. present in the South Island, *C. nutans*, *Carduus pycnocephalus* L. and *Carduus tenuiflorus* Curtis (the fourth *Carduus* sp., present only in New Zealand's North Island, *Carduus acanthoides* L., was not tested), and two *Cirsium* spp., *Cirsium vulgare* (Savi) Tenore and *Cirsium palustre* (L.) Scopoli. It did not attack *Cirsium arvense* (L.) Scopoli, *Silybum marianum* (L.) Gaertner and *Onopordum acanthium* L. (Jessep, 1989b). The damage caused by weevil attack to both *Carduus* and *Cirsium* spp. in these trials was substantial.

In 1992, *T. horridus* from New Zealand was introduced to Australia for *C. nutans* control, and releases were initiated in 1993 (Woodburn, 1997). At the same time, scientists from Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australia

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were engaged in research in Europe towards a biocontrol programme for *Onopordum* spp. thistles (Briese *et al.*, 1994). One of the highly prioritized biocontrol agents was identified as *T. horridus*, partly because it had already been used successfully in Virginia for controlling the related *C. nutans* thistle (Kok, 1986, cited by Briese *et al.*, 1994). The weevils were introduced from Europe into quarantine in Australia, where it was noticed that they exhibited some consistent non-similarities to the *T. horridus* introduced from New Zealand for *C. nutans* control (T. Woodburn, personal communication). Specimens were sent to a taxonomist (M. Alonso-Zarazaga), who re-described the species and revealed that, what was until then regarded as one species, *T. horridus*, was in fact a complex of three species (Alonso-Zarazaga and Sánchez-Ruiz, 2002). The samples sent from Australia included specimens of the *Onopordum* specialist from quarantine and specimens from the population established on *C. nutans* near Canberra. The latter are considered progeny of the weevils introduced from New Zealand (Alonso-Zarazaga and Sánchez-Ruiz, 2002). The European samples from *Onopordum* in quarantine in Australia were identified as a new species, *Trichosirocalus briesei* Alonso-Zarazaga and Sánchez-Ruiz, with trophic linkage to the thistle genus *Onopordum* (larvae and adults did not survive on *Carduus* spp. and *Cirsium* spp.). Specimens from *C. nutans* from the Canberra region were, too, identified as a new species, *Trichosirocalus mortadelo* Alonso-Zarazaga and Sánchez-Ruiz, associated with thistles of the genus *Carduus*, mainly *C. nutans* (Alonso-Zarazaga and Sánchez-Ruiz, 2002). It was assumed that the weevils introduced from New Zealand to Australia were either *T. mortadelo* or a mixture of *T. mortadelo* and *T. horridus*. The species *T. horridus* was now associated with thistles of the genus *Cirsium* (Alonso-Zarazaga and Sánchez-Ruiz, 2002).

In Australia, efforts to establish weevils originating from New Zealand on *Cirsium* spp. were unsuccessful (A. Swirepick, personal communication), which settles with their identification as *T. mortadelo*, the *Carduus* specialist. In New Zealand, however, the weevils occur on both *Carduus* spp. and *C. vulgare*, although their effect on *C. vulgare* populations is, for the most part, somewhat poor. *Trichosirocalus* spp. are extremely attractive biocontrol agents for weeds that exhibit a long-lived seed bank, such as *C. nutans* and *Onopordum* spp., as they reduce the plants' vigour such that they either produce less seeds or even die prior to any seed production; and they also reduce plant biomass at the time that lapses until seed reserves in the soil are depleted (Briese, 2006). It was therefore desirable to find out whether the non-satisfactory control of *C. vulgare* in New Zealand was attributed to *T. horridus*, the *Cirsium* specialist, not being present here. In 2006, a survey was conducted in New Zealand to record which thistle species are attacked by which *Trichosirocalus* spp.

Methods and materials

A field survey was initiated in autumn 2006 and lasted to the end of summer 2007. Regional Councils staff visited release sites in different parts of the country, collected weevil specimens and, where possible, estimated whether thistle populations decreased since the weevil's introduction into their region. All thistle species present at each site were noted, as well as the relative abundance of damaged rosettes (which can be readily distinguished by the black frass secreted by the feeding larvae). Where weevils were found on more than one thistle species at one site, they were collected separately for each thistle species. Sample size varied between sites, depending on the difficulty to obtain specimens. All weevils were preserved in 70% ethanol prior to identification.

For identification, all weevils were dissected under a stereo microscope. Their gender was recorded, and male's aedeagi were examined against the key provided in Alonso-Zarazaga and Sánchez-Ruiz (2002). All specimens were then mounted and deposited at the University of Canterbury arthropod collection for future referencing.

Results and discussion

Different responses from Regional Councils in different parts of the country resulted in large variation in the number of samples collected per region. Eight regions (three in the North Island and five in the South Island, Figure 1) and 51 sites were sampled, and 744 adults were dissected, 337 of which were males. In one region (Auckland), no weevils could be collected. All males in all samples were identified as true *T. horridus* (Table 1). Where estimated, *C. nutans* populations in New Zealand's South Island appear to have decreased since *T. horridus* introduction (Table 2).

Three main points can be highlighted: (1) there is no evidence for any species other than *T. horridus* being present in New Zealand (Table 1); (2) *T. horridus* readily attacks *Carduus*, *Cirsium* and *Onopordum* thistles (Tables 1 and 3); and (3) *C. vulgare* appears to be, for the most part, affected not as strongly as *C. nutans* and *O. acanthium* by the weevil (Tables 2 and 3). The latter two points are inconsistent with the recent re-description of the species (Alonso-Zarazaga and Sánchez-Ruiz, 2002). According to this description, *T. horridus* should be able to feed on *Carduus* spp. but should show preference for *Cirsium* spp., in particular to *C. vulgare*. In addition, it has been indicated that *T. horridus* might be seen on *Onopordum* spp. in mixed thistle stands but that it would not feed on it (M. Alonso-Zarazaga, personal communication).

The presence and feeding of *T. horridus* on *O. acanthium* in New Zealand is of special interest: in the early 1990s, not long after the weevil had been introduced to

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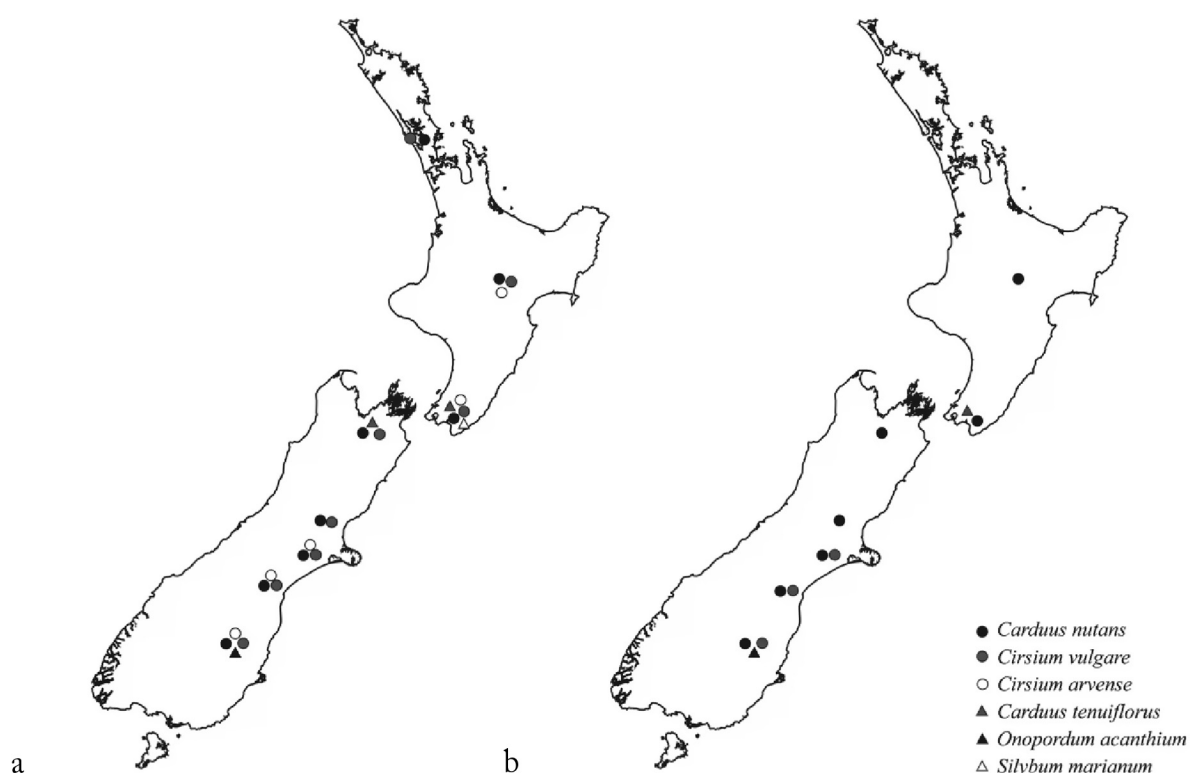


Figure 1. Regions of New Zealand visited in the survey with points marking: (a) thistle species present in each region and, (b) species from which weevils were collected.

Table 1. Geographic origin of *Trichosiocalus* spp. samples and species ID.

Region	Number of sites sampled	Host thistle species	Number of males examined	Species ID ^a
North Island				
Central NI	3	<i>Carduus nutans</i>	20	<i>Trichosiocalus horridus</i>
Greater Wellington	1	<i>Carduus nutans</i>	8	<i>Trichosiocalus horridus</i>
	1	<i>Carduus tenuiflorus</i>	6	<i>Trichosiocalus horridus</i>
South Island				
Tasman	1	<i>Carduus nutans</i>	20	<i>Trichosiocalus horridus</i>
North Canterbury	3	<i>Carduus nutans</i>	39	<i>Trichosiocalus horridus</i>
Mid Canterbury	2	<i>Carduus nutans</i>	19	
	2	<i>Cirsium vulgare</i>	13	
South Canterbury	29	<i>Carduus nutans</i>	158	
	5	<i>Cirsium vulgare</i>	12	<i>Trichosiocalus horridus</i>
Central Otago	1	<i>Carduus nutans</i>	15	<i>Trichosiocalus horridus</i>
	1	<i>Cirsium vulgare</i>	5	<i>Trichosiocalus horridus</i>
	2	<i>Onopordum acanthium</i>	22	<i>Trichosiocalus horridus</i>
Total	44 ^b		337	<i>Trichosiocalus horridus</i>

^a Based on male aedeagus; identified using the key provided in Alonso-Zarazaga and Sánchez-Ruiz (2002).

^b In some sites, weevils were collected from more than one thistle species.

Table 2. Estimates of changes to *Carduus nutans* and *Cirsium vulgare* populations since the introduction of *T. horridus*.

	Number of sites where populations were		
	Estimated to have declined	Estimated to have not declined	Not estimated (unknown site history)
<i>Carduus nutans</i>			
North Island	3	3	0
South Island	16	6	17
<i>Cirsium vulgare</i>			
North Island	1	1	3
South Island	2	2	18

New Zealand and had established, T. Jessep (who was responsible for its introduction and distribution), realizing the weedy status of *Onopordum* spp. in Australia, decided to establish the weevil on *O. acanthium* in New Zealand as a measure to prevent this thistle from becoming weedy here (M. Turner, personal communication). *O. acanthium* (the only *Onopordum* spp. present in New Zealand) is not common and can mainly be found in Central Otago. A site was located in Central Otago, hosting an isolated dense *O. acanthium* stand, with no *C. nutans* to be found at a radius of 10 km. In 1993, 1300 weevils, collected from *C. nutans*, were released at the site (M. Turner, personal communication). The weevils have established and have dramatically reduced *O. acanthium* density at the site over several years. Today, only few thistles are germinating, fewer reach the flowering stage, and ones that do flower show

reduced height and vigour (R. Groenteman, personal observation). Moreover, with the loss of prickliness attributed to the weevil's larval feeding, the capitula appear palatable to the deer grazing on the farm, which further helps depleting the soil seed bank. The landowner assured us that he does not manage thistles on the farm by any other control means or land management practices. The weevils were never redistributed from that original site; yet we were able to collect them from another *O. acanthium* stand, about 50 km (aerial distance) away from the original site. At this distant site, part of the plants were high and vigorous and exhibited no weevil feeding signs, whereas others appeared much less vigorous, exhibited feeding signs, and hosted the weevil (R. Groenteman, personal observation). It seems that the weevils dispersed by themselves to the site, and their impact is beginning to be noticeable. Adults that

Table 3. Relative abundance of different thistle species in different regions of New Zealand and fraction of sites in which *Trichosirocalus horridus* adults and/or damaged rosettes were abundant.

Region	Host species	Presence ^a	Relative abundance of thistle rosettes	Frequency of sites in which adult <i>T. horridus</i> and/or damaged rosettes were abundant
North Island				
Auckland	<i>Carduus nutans</i>	1/1	moderately common	0/1
	<i>Cirsium vulgare</i>	1/1	moderately common	0/1
Central NI	<i>Carduus nutans</i>	3/3	very common	1/3
	<i>Cirsium vulgare</i>	2/3	moderately to very common	0/2
Greater Wellington	<i>Carduus nutans</i>	2/2	rare	1/2
	<i>Cirsium vulgare</i>	2/2	rare	1/2
South Island				
Tasman	<i>Carduus nutans</i>	1/1	moderately common	0/1
	<i>Cirsium vulgare</i>	1/1	rare	0/1
North Canterbury	<i>Carduus nutans</i>	3/3	moderately to very common	3/3
	<i>Cirsium vulgare</i>	2/3	rare	0/2
Mid Canterbury	<i>Carduus nutans</i>	3/3	varies	1/3
	<i>Cirsium vulgare</i>	3/3	moderately common	0/3
South Canterbury	<i>Carduus nutans</i>	30/30	moderately common mostly	21/30
	<i>Cirsium vulgare</i>	14/30	rare to moderately common	5/14
Central Otago	<i>Carduus nutans</i>	2/3	moderately common	2/2
	<i>Cirsium vulgare</i>	2/3	rare to moderately common	1/2
	<i>Onopordum acanthium</i>	2/3	moderately to very common	2/2
NZ total	<i>Cirsium nutans</i>	45/46		29/45
	<i>Carduus vulgare</i>	27/46		7/27

^a Presence is expressed as the fraction of sites in which the thistle species was recorded, out of the total number of sites visited in each region.

were collected from *O. acanthium* at both sites were identified, again, as *T. horridus*. At the self-introduced site, adult weevils were also collected from *C. vulgare*, and these, too, were identified as *T. horridus* (Table 1).

The results from the survey thus far present two paradoxes: firstly, that *T. mortadelo* was collected from New Zealand and shipped to Australia but has not been found in our survey, and secondly, that *T. horridus* does not show a distinct preference for *Cirsium* thistles in New Zealand as reported elsewhere.

What, then, might the origin of *T. mortadelo* in Australia be? It appears that although CSIRO scientists have been engaged in searches for biocontrol agents in several European countries in the mid 1990s, the only *Trichosirocalus* sp. introduced into Australia as a result of this were the *Onopordum* specialist from Spain, later named *T. briesei*; and the only weevils released on *Carduus* thistles a few years earlier were of New Zealand origin (A. Sheppard, D. Briese, T. Woodburn, A. Swirepick, personal communication). If any *Trichosirocalus* spp. had been collected from *Carduus* thistles in Europe as part of these surveys, they would have been examined in quarantine only and not released (A. Sheppard, personal communication), whereas the *Carduus* weevils used in the revision were collected from established populations in Australia (D. Briese, personal communication).

It has been suggested that *T. mortadelo* may have disappeared from New Zealand or was out-competed by *T. horridus*. An examination of 30 specimens that were collected in South Canterbury in 1990, as part of a Lincoln University Master thesis, does not support this possibility. These specimens were collected at the original release site in New Zealand, where the weevils have been established the longest. This, most probably, was the site that sourced the weevils for the introduction to Australia. Sixteen of these specimens were males, and they were identified as *T. horridus*. Thus, it is hard to believe *T. mortadelo* was there at the time but was not represented in the sample.

A third paradox arises from the revision itself (Alonso-Zarazaga and Sánchez-Ruiz, 2002) and is supported by the personal communications surrounding this survey: that there is no evidence for *T. horridus* presence in Australia.

Conclusions and outlook

To conclude, it appears that the *Trichosirocalus* spp. fauna in New Zealand consists of only one species, *T. horridus*, feeding on thistle hosts belonging to the genera *Carduus*, *Cirsium* and *Onopordum*. It is unclear why the weevils in New Zealand exhibit host utilization that is inconsistent with the recent revision. It also remains unclear where *T. mortadelo* in Australia originates from and why *T. horridus* is absent there. A similar survey in Australia would shed some light on these matters.

It is probably not desirable to re-introduce *T. horridus* from *C. vulgare* to achieve better control of this thistle, since the specialized populations may blend with the existing populations already well established on *Carduus*. However, it might be useful to harvest weevils from the few sites in New Zealand where they do well on *C. vulgare* and redistribute those. It is certainly unjustified to introduce the *Carduus* specialist, *T. mortadelo*, since *T. horridus* is well established on *C. nutans* and appears to have a significant negative effect on this weed.

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