National Asparagus Weeds Management Workshop

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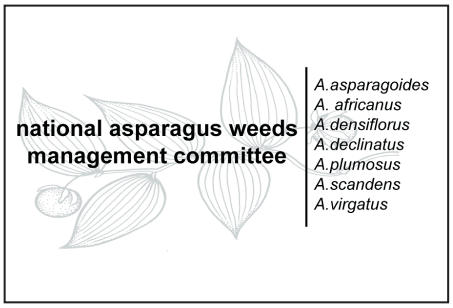

Introduction

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Welcome to this special issue of Plant Protection Quarterly, which details the current state of Asparagus weeds management in Australia. Bridal creeper, *Asparagus asparagoides* (L.) Druce, is the best known Asparagus weed and certainly deserves its Weed of National Significance (WoNS) status in Australia. However, there are other *Asparagus* species in Australia that have the potential to reach similar levels of impact as bridal creeper on biodiversity (and hence their inclusion in the national bridal creeper strategic plan [ARMCANZ *et al.* 2001]). There is much to be gained from sharing information and experiences about the biology, ecology, impacts and control of all Asparagus weeds to advance their overall strategic management.

The National Asparagus Weeds Management Committee (NAWMC) convened the National Asparagus Weeds Management Workshop in Adelaide, 10–11 November 2005. The workshop was attended by 60 people including representation extending from South Africa, through most regions of continental Australia, to Lord Howe Island in the Pacific. The workshop was made possible with funding assistance through the Australian Government's Natural Heritage Trust. This special issue of Plant Protection Quarterly contains the proceedings of the workshop, as well as additional research and management papers on Asparagus weeds including the review of bridal creeper for the Biology of Australian Weeds series. We thank all authors for the effort they have put into their papers and all the workshop participants for their contribution. A special thanks for workshop organization also goes to Dennis Gannaway and Susan Lawrie.

Reference

Agriculture & Resource Management Council of Australia & New Zealand, Australia & New Zealand Environment & Conservation Council and Forestry Ministers (2001). 'Weeds of national significance: Bridal creeper (*Asparagus asparagoides*) strategic plan'. (National Weeds Strategy Executive Committee, Launceston).

Asparagus weeds in Australia – a South African perspective with emphasis on biological control prospects

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Summary

The results of an extensive South African survey to identify potential biological control agents for *Asparagus asparagoides* are discussed. Two forms of *A. asparagoides* were found that are distinguished by characteristics of the tuber system. Not all the natural enemies found in association with *A. asparagoides* attacked both forms. Three biocontrol agents (*Zygina* sp., *Crioceris* sp. and *Puccinia myrsiphylli*) from South Africa, have been released in Australia against the first form which has a wide distribution in South Africa. No candidate was found that damages the tuber system of this form of *A. asparagoides*, but foliage damage reduced tuber mass and fruit production under experimental conditions. The seed wasp *Eurytoma* sp. occurs throughout the distributional range of this form of *A. asparagoides*. Damage levels vary but can be 90% or more. The second form of *A. asparagoides* has only recently been found in Australia. In South Africa it is restricted to the winter rainfall region of the Western Cape. This form of the plant is a host for *Zygina* sp. and *Eurytoma* sp. and the tubers are damaged by weevil larvae, but *Crioceris* sp. and *P. myrsiphylli* were not recorded.

Potential taxonomic difficulties of some of the other *Asparagus* spp. that occur in Australia are discussed, and preliminary observations are provided on their associated natural enemies in South Africa.

Keywords: *Asparagus*, *Asparagus asparagoides*, Australia, biological control, *Crioceris*, environmental weed, *Eurytoma*, natural enemies, *Puccinia*, South Africa, *Zygina*.

Introduction

South Africa supports a wealth of *Asparagus* species with several endemic to the region. The most recent taxonomic revision of South African plants recognized 81 species, of which only 15 are recorded as occurring naturally beyond the borders of southern Africa (Obermeyer *et al.* 1992). The higher taxonomy of *Asparagus* spp. has tended to oscillate between the recognition of one and

three genera. Obermeyer recognized three genera: *Myrsiphyllum* (with 12 species in South Africa), *Protasparagus* (with 69 species in South Africa) and *Asparagus* (with no South African species). However, all species are currently considered members of a single genus, *Asparagus* (Malcomber and Sebsebe 1993, Fellingham and Meyer 1995).

The *Asparagus* species considered a threat in Australia (*Asparagus asparagoides* (L.) Druce, *Asparagus scandens* Thunb., *Asparagus declinatus* L., *Asparagus plumosus* Baker, *Asparagus densiflorus* (Kunth) Jessop and *Asparagus africanus* Lam.) occur naturally in South Africa, but only *A. asparagoides* has been surveyed comprehensively for natural enemies for use in a biological control program.

This paper reports on the surveys conducted on *A. asparagoides* in South Africa and provides incidental observations of the natural enemies associated with the other species of concern in Australia, with the exception of *A. africanus* for which no information is available.

Asparagus asparagoides

Taxonomy and distribution of A. asparagoides

Soon after surveys for natural enemies of *A. asparagoides* were initiated in South Africa during 1988, problems were encountered with the distribution records for this species. Published distribution records for *A. asparagoides* proved to be misleading and required reassessment. Our surveys showed that *A. asparagoides* does not occur in subtropical coastal regions and the arid interior and west coast regions of South Africa (Kleinjan and Edwards 1999), areas which Obermeyer (1984) had included in the distribution.

In revising the taxonomy of the 12 southern African *Asparagus* species placed previously in *Myrsiphyllum*, Obermeyer (1984) relied on characteristics of the tuber system for identification of several species, including *A. asparagoides*. However, the majority of *A. asparagoides* specimens (86%) in the Pretoria National Herbarium lack tuber material, but had nonetheless been identified as *A. asparagoides*. In the absence of tuber material, these specimens cannot be classified with confidence (Kleinjan and Edwards 1999), which undoubtedly led to errors in the published distribution for *A. asparagoides* in the revision by Obermeyer (1984).

Furthermore, two distinct forms of *A. asparagoides* that can be readily separated by characteristics of the tuber system were found during the search for biological control agents in South Africa (Kleinjan and Edwards 1999). For those familiar with both forms of the plant, subtle differences in leaf texture and colour are discernible on living plants. However these characters are not preserved in herbarium specimens. Based on the observed distributions of the two forms of the plant, Kleinjan and Edwards (1999) refer to one form of the plant as the 'widespread form' of *A. asparagoides*, which has a wide distributional range in South Africa. The second form is restricted to the western Cape and is referred to as the 'Western Cape form' of *A. asparagoides*. These same terms are used throughout this text.

Asparagus asparagoides specimens from Australia were compared against both forms of this species from South Africa and were found to be consistent with the 'widespread form' (Kleinjan and Edwards 1999). In 2004 it was discovered that the 'western Cape form' of *A. asparagoides* is also present in Australia.

The widespread form of *Asparagus asparagoides* in South Africa

Distribution and habitat associations

The widespread form of *A. asparagoides* occurs in the winter, summer and aseasonal (i.e. the rainfall is not restricted to any particular season) rainfall regions of South Africa (Kleinjan and Edwards 1999). In the winter rainfall region, ripe fruits develop in November and the plants subsequently senesce completely. Production of new shoots starts well ahead of the next rainy season. In the aseasonal rainfall region ripe fruits also develop in November, but vegetative parts of the plants are present throughout the year, with an approximately annual turnover of stems. The situation in the summer rainfall region is unclear due to infrequent surveys in the area. However, it appears that most plants senesce during the dry season (winter), but that some plants in mesic microhabitats persist. Fruit was recorded in October (the start of summer) and also in March (at the end of summer).

Throughout its distributional range in South Africa, the widespread form of *A. asparagoides* occurs primarily in dappled shade or at the edge of dense shade and is usually found scrambling within shrubs or the lower branches of trees.

Natural enemies

Surveys of natural enemies of the widespread form of *A. asparagoides* revealed several candidates suitable for use in a biological control program against this plant in Australia. Those considered to have the greatest potential were: an undescribed leafhopper, *Zygina* sp. (Cicadellidae) (see Witt and Edwards 2000), an undescribed leaf beetle, *Crioceris* sp. (Chrysomelidae) (see Witt and Edwards 2002), and the rust fungus *Puccinia myrsiphylli* (Thuem.) Wint. (see Kleinjan *et al.* 2004). These species have been released in Australia. They are discussed below and observations on other species identified during our surveys are included.

Impact of foliage feeding on fruit production and tuber mass

The agents released to date all target the foliage of the widespread form of *A. asparagoides.* It was hoped that a potential agent would be identified that directly damages the tuber system of the plants, but despite intensive searching no such candidate was found. However, substantial outbreaks of *Zygina* sp. had been noted in the aseasonal rainfall region and consequently an experiment (Kleinjan *et al.* 2004) was conducted with *Zygina* sp. to explore the impact of foliage damage on tuber growth. As reduced fruit loads were recorded subsequent to the *Zygina* sp. outbreak, the experiment also investigated the impact of foliage damage on fruit production. The results showed that extensive foliage damage substantially reduced both fruiting and final tuber mass. The experimental design made it impossible to determine whether the impact of *Zygina* sp. caused a reduction in the rate of tuber mass accumulation or whether it caused a reduction in existing tuber reserves. Morin *et al.* (2002) demonstrated experimentally that infection of the widespread form of *A. asparagoides* with *P. myrsiphylli* similarly resulted in a reduction in tuber number, rhizome length and shoot mass.

Natural enemies that attack seed or fruit

As *Asparagus* species are bird dispersed, a reduction in seed output could be predicted to decrease the rate of colonization of new sites and may reduce the rate at which infestations develop. Two natural enemies (*Zalaca snelleni* (Wallengren) (Noctuidae) and *Eurytoma* sp. (Eurytomidae)) were recorded in South Africa that attack the fruit or seeds of several *Asparagus* species including the widespread form of *A. asparagoides*. Both these species have been recorded from commercial asparagus in South Africa.

Larvae of the moth, *Zalaca snelleni*, consume the fruits of *Asparagus* species throughout South Africa. They can cause considerable damage since each larva consumes several fruits during its development. They are subject to parasitism by an unidentified braconid wasp. It is not known whether this species targets plant species other than *Asparagus*, but due to its destructive capabilities it warrants further investigation if conflicts with commercial asparagus growers can be resolved.

An undescribed wasp, *Eurytoma* sp. targets the seeds of the widespread form of *A. asparagoides* and other *Asparagus* spp. Damage levels to the widespread form of *A. asparagoides* in the Knysna area were assessed over four successive seasons (Table 1). Sample size varied slightly due to variation in the availability of fruits between years and the partial destruction of samples by *Z. snelleni*. In 1991, damage attributable to *Eurytoma* sp. was

substantially less than in 1990, at all sites except Phantom Pass. However, fruit availability was low in 1991, possibly as a result of the *Zygina* sp. outbreak noted that year which could have reduced fruiting by the plants (Kleinjan *et al.* 2004). In 1992 and 1993 *Eurytoma* sp. damage levels increased, and in 1993 damage ranged between 94% and 97.7% at four sites. Damage at another site (Kaaimans River Mouth), where *Z. snelleni* was abundant, was only 29.2%. When *A. asparagoides* fruit availability is low, *Eurytoma* sp. probably utilizes fruit from other *Asparagus* spp. growing in the vicinity.

Fruit samples were not readily available in the winter and summer rainfall regions, but damage levels for the samples obtained are listed in Table 2. In the winter rainfall region, 92% damage was recorded at Swellendam in 1993. The highest damage level recorded in the summer rainfall region was 95.9% at Giant's Castle in October 1992. *Eurytoma* sp. was not reared from fruit collected at the end of summer from other sites in this region, but these fruit samples were probably too young.

Various factors, including fruit availability, environmental conditions and levels of parasitism, may impact on *Eurytoma* sp. abundance, but unravelling these was beyond the scope of the surveys. However, the preliminary results indicate that parasitism is not a significant factor. The number of parasitoid versus *Eurytoma* sp. adults that emerged was assessed for 67 samples of the widespread form of *A. asparagoides* collected from localities throughout the distribution of the plant in South Africa. Parasitoids were only encountered in six samples from three sites (Table 3). Overall, only 22 parasitoids versus 3290 *Eurytoma* sp. emerged (<1% parasitism). Four parasitoid species were involved, but the only site where substantial parasitism was recorded was Giant's Castle in the summer rainfall region. In this case the species responsible is most probably a multiple parasitoid (i.e. several parasitoid individuals developing within a single *Eurytoma* sp. host) thereby inflating apparent parasitism levels.

Eurytoma sp. occurs on *Asparagus* species throughout South Africa and has the capacity to substantially reduce seed availability. It has considerable potential as a biocontrol agent in Australia. Assessment of host specificity is however difficult because the adults have a short life span and fruit for testing is often unavailable at a time that coincides with natural emergence. *Eurytoma* sp. was not recorded from fruits of four plant species closely related to Asparagaceae (*Agave* sp., *Agapanthus praecox* Willd., *Behnia reticulata* (Thunb.) Didr. and *Sanseveria* sp.) nor from eight plant species that produce berries, growing in association with the widespread form of *A. asparagoides* in the

Table 1. Mean percentage (± S.D.) damage attributable to *Eurytoma* sp. on widespread *A. asparagoides* in the aseasonal rainfall region of the western Cape over four successive fruiting seasons.

Date and localities	Mean percentage damage	Standard deviation	No. of samples (No. of fruits per sample)
1990			
Brenton Lake	70.4	11.0	5(20)
Lake Pleasant	80.5	29.9	5(20)
Sedgefield	55.8	12.1	5(20)
Phantom Pass	88.0	14.0	5(20)
Kaaimans River Mouth	75.9	34.0	5(20)
1991			
Brenton Lake	17.9	19.8	3(20), 1(19), 1(15)
Lake Pleasant	0.0	0.0	5(20)
Sedgefield	6.3	14.1	4(20), 1(18)
Phantom Pass	79.4	13.4	5 (4× 20, 17)
Kaaimans River Mouth	2.4	5.4	5(20)
1992			
Brenton Lake	38.1	19.7	5(20)
Lake Pleasant	75.5	19.9	5(20)
Sedgefield	32.6	17.5	5(20)
Phantom Pass	95.2	5.1	5(20)
Kaaimans River Mouth	93.1	3.7	4(20), 1(18)
1993			
Brenton Lake	97.0	2.1	3(20), 2(18)
Lake Pleasant	97.4	2.4	4(20), 1(13)
Sedgefield	94.0	3.8	4(20), 1(19)
Phantom Pass	97.7	5.2	5(20)
Kaaimans River Mouth	29.2	44.4	2(20), 1(18), 1(13)

Table 2. Mean percentage seed damage attributable to *Eurytoma* sp. associated with the widespread form of *A. asparagoides* in (a) the winter rainfall region of the Western Cape, (b) at one site within the aseasonal rainfall region of the Eastern Cape and (c) in the summer rainfall region (Drakensberg mountain range).

Date and localities	Mean percentage damage	Standard deviation	No. of samples (No. of fruits per sample)
(a) winter rainfall region (Western Cape)			
Nachtwacht – October 1992	69.9	21.1	4(20), 1 (19)
Nachtwacht – September 1993	83.4	14.9	4(20), 1(16)
Swellendam – September 1993	92.0	6.4	3 (20), 1(17)
(b) aseaonal rainfall region (Eastern Cape)			
Cannon Rocks – November 1992	63.0	22.6	3(20), 1(15), 1(11)
(c) summer rainfall region (Drakensberg mountain range)			
Tendele – October 1992	52.7	12.7	2(20)
Paradise Camp – February 1991	0.0	0.0	1(19)
Paradise Camp – March 1992	0.0	0.0	3(20), 1(14), 1(9)
Pilgrims Rest – March 1992	0.0	0.0	4(20), 1(19)
Kaapse Hoop – March 1992	0.0	0.0	4(20), 1(18)
Giant's Castle October 1992	95.9	4.0	5(20), 1(19)

field (A. Witt personal communication). The wasps were recorded from commercial asparagus in the Gauteng and Western Cape provinces.

Additional potential biological control agents

In addition, other potential agents have been located that have not yet received any attention, most notably a cecidomyiid fly, which galls the growth tips of the widespread form of *A. asparagoides* in the Knysna area. Identical cecidomyiid galls were found in this region on *A. plumosus* and another *Asparagus* sp. (probably *A. aethiopicus* L.) that may be caused by the same species of fly. Four noctuid moth species (*Agrotis* sp., *Euplexia augens* Felder & Rogenhoven, *Lycophotia oliveata* (Hampson) and *Cucullia terrensis* Felder & Rogenhoven) were collected from and reared on foliage of the widespread form of *A. asparagoides*. Details of their host specificity are unknown but may warrant further investigation. Lastly, a flea beetle (*Hespera* sp., Chrysomelidae) was recorded feeding on the foliage of the widespread form of *A. asparagoides* in the summer rainfall region. Details of its biology are not known.

The Western Cape form of *A. asparagoides* in South Africa

Distribution and habitat associations

The Western Cape form of *A. asparagoides* is a localized endemic restricted to the winter rainfall region of the Western Cape where it was generally encountered scrambling within shrubs both in low lying sandy areas and in rocky situations on mountains. In the eastern part of its range its distribution overlaps with that of the widespread form of *A. asparagoides,* but we never encountered the two forms growing together. The phenology of this species is similar to that of the widespread form of *A. asparagoides* in the winter rainfall region i.e. ripe fruits develop in October/November and the plants subsequently senesce completely over the dry summer.

Natural enemies

The Western Cape form of *A. asparagoides* is attacked by *Zygina* sp., *Z. snelleni* and *Eurytoma* sp., but *P. myrsiphylli* was not recorded in association with this form of the plant during our surveys (Kleinjan *et al.* 2004).

Substantial damage, caused by unidentified weevil larvae, was found on tubers of the Western Cape form of *A. asparagoides*. They are probably the larvae of an undescribed *Brachycerus* species, observed feeding as adults on the foliage of these plants.

In December 1992, tuber masses of the Western Cape form of *A. asparagoides* were excavated at five sites where bimonthly monitoring of plant phenology and associated insects had been conducted for at least one year. Damage attributable to weevil larvae was noted at all five sites. At one site, Silvermine, the estimated percentage of tubers attacked in ten tuber masses with between 13 and 129 tubers (average 57.8 ± 38.1 S.E.) ranged between 0 and 100% (average 49.4% ± 36.1 S.E.). The plant with 100% damage had died during the monitoring program. The nocturnal adults were rarely encountered during the monitoring program being recorded during winter at only three sites (Table 4). Larvae were recorded in excavated tuber masses at four sites but were most abundant at Karbonkelberg.

Preliminary observations in South Africa on the natural enemies of some *Asparagus* species that are weeds in Australia

Asparagus scandens and Asparagus declinatus

Both these species are South African endemics with restricted distributions (Obermeyer 1984). They are easily identified by the foliage and therefore published distribution records and habitat associations are likely to be reliable. In the vicinity of Cape Town, *Asparagus scandens* is particularly abundant in forest patches and is occasionally the dominant undercanopy plant species. Incidental observations during surveys on *A. asparagoides* suggest that it is not susceptible to the rust fungus. Similarly, the rust fungus has not been recorded during incidental observations on *A. declinatus*. The *Eurytoma* sp. discussed above and *Z. snelleni* were reared from fruit samples of *A. declinatus*. Only a single *Eurytoma* sp. individual was reared from fruit samples of *A. scandens*, and *Z. snelleni* was not recorded. Further sampling is required.

Asparagus plumosus

The plant commonly cultivated and sold in nurseries in South Africa as *A. plumosus* fits the description given by Obermeyer *et al.* (1992) except that the berry is black (not red as in the published description). *Asparagus plumosus* is closely related to *Asparagus setaceous* (Kunth) Jessop but these two species should be readily distinguished by the fact that *A. plumosus* has branches and cladodes that spread in a single plane. The published distribution records may require revision as *A. plumosus* occurs commonly in the vicinity of Knysna (Western Cape), but this is not reflected in the published distribution map (Obermeyer *et al.* 1992). The natural enemies discussed below are associated with the plant fitting the description of *A. plumosus* as described by Obermeyer *et al.* (1992) except that the berry is black.

A fungus, *Microcyclus kentaniensis* Doidge (Ascomycetes), was recorded during our surveys on *A. plumosus* at two localities in the Knysna area. This species was originally described from a specimen identified as *A. plumosus* that was collected at Kentani in the Eastern Cape (Doidge 1948). Two other herbarium records for this fungus exist for *A. plumosus* from the Limpopo Province of South Africa. Although sparse, these records suggest that the fungus is widespread in South Africa and likely to occur throughout the range of its host plant. The impact of the fungus on *A. plumosus* warrants investigation.

Table 3. Samples of fruit of the widespread form of *A. asparagoides* from which both *Eurytoma* sp. and parasitoids were reared.

Date	Locality	Total *Eurytoma* sp. adults	Parasitoids				
			Sp. 1	Sp. 2	Sp. 3	Sp. 4	Total
October 1992	Giants Castle	105	0	0	1	0	1
October 1992	Giants Castle	4	4	0	0	0	4
October 1992	Giants Castle	14	12	0	0	0	12
September 1993	Nachtwacht	23	0	1	0	0	1
October 1992	Nachtwacht	22	0	0	0	2	2
September 1993	Swellendam	65	0	2	0	0	2

Table 4. Records of *Brachycerus* sp. adults and probable larvae of this species associated with the western Cape form of *A. asparagoides*.

Site	No. of adults (month observed)	No. of larvae	No. of tuber masses examined
Silvermine	2 (May 1992)	1	10
Karbonkelberg	2 (May 1992, August 1992)	13	7
Red Hill	1 (July 1992)	0	3
Paarl	none	0	10
Sea Farm	none	1	11

The rust fungus, *Puccinia asparagi* DC., is also recorded as occurring on *A. plumosus* (Doidge 1950).

Two species of Cecidomyiid flies were recorded on *A. plumosus* in the Knysna area. Damage attributable to the first appears identical to that recorded on the widespread form of *A. asparagoides* in this area and it may be the same species. The other species causes galling of the cladode fascicles.

In the Knysna area, the stems of *A. plumosus,* are mined by a tephritid fly, tentatively identified as *Pycnella taomyoides* (Bezzi). We reared a specimen of this species from the stems of an *Asparagus* sp. (probably *A. aethiopicus*) in this area. The damage and pupal cases noted on *A. plumosus* appear identical to those on *Asparagus* sp. (probably *A. aethiopicus*). The specimen reared from *Asparagus* sp. (probably *A. aethiopicus*) is the only specimen known apart from the holotype and provides the first host record. Efforts to rear more specimens from *A. plumosus* and *Asparagus* sp. (probably *A. aethiopicus*) have been hampered by high levels of parasitism and the precise timing required for collection of material.

In addition, *Crioceris nigropunctata* Lacordaire (Chrysomelidae) has been recorded on cultivated *A. plumosus* in Cape Town where the beetles are occasionally abundant and responsible for substantial damage (C.A. Kleinjan personal observations). *Eurytoma* sp. and *Z. snelleni* were both recorded from *A. plumosus* during our surveys.

Asparagus densiflorus

Cultivars of *A. densiflorus* are popular horticultural plants in South Africa and elsewhere. This species is described by Obermeyer *et al.* (1992) as a 'common and variable species of the eastern region i.e. southern and eastern Transvaal, Natal and eastern Cape; also in Mocambique'. However, in the distribution map, only one locality within the southern and eastern Transvaal (now Mpumalanga) is shown. Given the abundance of closely related *Asparagus* species in South Africa and the documented variation in morphology of *A. densiflorus* and its habitat, a comparison of plant specimens from Australia with material from South Africa is essential if surveys for potential agents are to be considered.

The cladodes of *A. densiflorus* are mined by a fly *Ptochomyza asparagivora* Spencer (Agromyzidae) (S. Neser personal communication). This species was recorded during our surveys at Port Edward, Kwazulu Natal and is also present on cultivated plants in Cape Town where it is abundant and causes considerable damage to the cladodes. Preliminary indications suggest that the flies are subject to high levels of parasitism. Levels of host specificity are not known. In addition, the cladodes of *A. densiflorus,* are galled by eriophiid mites (S. Neser personal communication), but they do not appear particularly damaging.

In Cape Town, cultivated plants occasionally suffer extensive damage from the leaf beetle, *Crioceris nigropunctata* (C.A. Kleinjan personal observation). This species was predicted to become a pest of commercial asparagus in South Africa (Heinze and Pinsdorf 1962), however, no *Crioceris* species are recorded as pests of commercial asparagus in South Africa (Witt and Edwards 2002). The *Crioceris* sp. associated with the widespread form of *A. asparagoides* was recorded from *A. densiflorus/aethiopicus* (Witt and Edwards 2002) in the Knysna area. These plants should probably be identified as *A. aethiopicus*.

Adults of a *Brachycerus* sp. that appears identical to that collected on the Western Cape form of *A. asparagoides* were collected from cultivated *A. densiflorus* plants in Cape Town. Weevil larvae were located within the tubers. The larvae are destructive and consume several tubers. Tubers subjected to feeding often suffer secondary bacterial infection and are colonized by nematodes. Efforts are currently underway to rear larvae to adulthood to confirm that they are the juveniles of the *Brachycerus* adults noted on the plants. As adults have only been observed in winter on both *A. densiflorus* and the Western Cape form of *A. asparagoides*, these weevils are probably univoltine.

Eurytoma sp. and *Z. snelleni* were reared from fruit samples collected in Port Edward and a second noctuid moth, from the *Coccidophaga scitula* group, was reared from fruit samples of *A. densiflorus* taken at this locality.

Discussion

During the surveys of *A. asparagoides*, South African *Asparagus* species not placed within the genus *Myrsiphyllum* by Obermeyer (1984) needed to be identified from the descriptions of Jessop (1966). Identification of some species including *A. densiflorus, A. plumosus* (part *A. setaceous sensu* Jessop 1966) and *A. africanus* proved problematic principally due to the variable morphology of the species and the resultant inconclusive nature of the keys.

The situation is now somewhat improved with the keys published by Obermeyer *et al.* (1992) who recognized 81 species in South Africa, as opposed to 40 recognized by Jessop (1966), primarily because several of Jessop's synonyms were re-erected. However, inconsistencies still occur and the problem of variable morphology of species remains a problem particularly when specimens lack reproductive structures and no description of the root and rhizome system is present. As described above, considerable taxonomic complications arose on closer investigation of *A. asparagoides* including the recognition of an erroneous published distribution for this species and the presence of two distinct forms (possibly species) of the plant.

If further exploration on *Asparagus* species is considered then emphasis should be placed on defining the taxa occurring in Australia by direct comparison with South African material. Comparison of DNA between South African and Australian specimens is probably the most useful technique for delimiting the taxa and identifying the source of Australian plants.

If biological control of additional *Asparagus* weeds in Australia is contemplated, our surveys have shown there are several natural enemies associated with these species in South Africa that warrant further investigation.

Of particular interest is the presence of weevil larvae in the tubers of the Western Cape form of *A. asparagoides* and *A. densiflorus.* Confirmation is still required that they are the larvae an undescribed *Brachycerus* sp. The genus *Brachycerus* is large (about 500 species) with poorly known host associations (R. Stals personal communication). Only one species, *Brachycerus ornatus* Drury, has been studied in any detail and this species is apparently only associated with the ground lily, *Ammocharis coranica* (Ker Gawl.) Herbert. (Amaryllidaceae) (Louw 1990).

Unpublished data in the South African National Collection of Insects, Pretoria, suggest correspondence between the *Brachycerus* species groups delimited by Haaf (1957) and different taxonomic groupings within the Asparagales (R. Stals personal communication). In addition to the undescribed *Brachycerus* sp. collected on the Western Cape form of *A. asparagoides* and *A. densiflorus* in the vicinity of Cape Town, several other *Brachycerus* spp. were collected during our surveys. They include: *Brachycerus parilis* Haaf, a large species observed feeding on the widespread form of *A. asparagoides, Asparagus* sp. (probably *A. aethiopicus*) and *A. plumosus* in the Knysna area; *Brachycerus cornutus* (L.) and a second undescribed *Brachycerus* sp. collected on an *Asparagus* sp. in Namaqualand; *Brachycerus setipennis* Fahraeus collected on an *Asparagus* sp. in Kwazulu Natal and *Brachycerus tectus* Haaf collected from an *Asparagus* sp. in the Eastern Cape. All these species, including the two apparently undescribed species, are in Haaf's species group A (R. Stals personal communication). Unfortunately no details of the biology of these species have been published.

Also of note, is the presence of a complex of Cecidomyiidae associated with *Asparagus* species in South Africa that may have potential as biological control

agents. Particularly damaging is a species that targets the growth tips of the widespread form of *A. asparagoides, Asparagus* sp. (probably *A. aethiopicus*) and *A. plumosus* in the Knysna area. On *A. plumosus* the fungus, *M. kentaniensis,* warrants further investigation and the tephritid, probably *P. taomyoides*, appears to be particularly damaging, as is the leaf mining agromyzid on *A. densiflorus.*

It is unlikely that rust fungus *P. myrsiphylli* will be found in association with either *A. scandens* or *A. declinatus.* During the surveys on *A. asparagoides* these species were searched for the presence of rust whenever encountered and no symptoms were ever recorded.

The fruit and seeds of many South African *Asparagus* species are attacked by both *Z. snelleni* and the undescribed *Eurytoma* sp. and both these species have considerable potential in reducing the rate of spread of *Asparagus* weeds in Australia. These species were both recorded from *A. officinalis* and consequently a potential conflict with commercial asparagus growers may occur.

Conclusion

Prospects for future biocontrol programs against the other South African *Asparagus* species in Australia look promising although potential taxonomic difficulties with the plant taxa need to be addressed.

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Appendix 1. Grid references to localities mentioned in the text and tables.

Locality	Province	Grid reference
Cannon Rocks	Eastern Cape	33°45′S 26°31′E
Giants Castle	Kwazulu Natal	29°16′S 29°31′E
Kaaimans River Mouth	Western Cape	34°00′S 22°33′E
Kaapse Hoop	Mpumalanga	25°31′S 30°47′E
Karbonkelberg	Western Cape	34°03′S 18°20′E
Kentani	Eastern Cape	32°30′S 28°19′E
Knysna	Western Cape	34°05′S 23°05′E
Lake Brenton	Western Cape	34°04′S 23°02′E
Lake Pleasant	Western Cape	34°02′S 22°50′E
Nachtwacht	Western Cape	34°35′S 20°07′E
Paarl	Western Cape	33°44′S 18°56′E
Paradise Camp	Mpumalanga	24°52′S 30°53′E
Phantom Pass	Western Cape	34°01′S 23°00′E
Pilgrims Rest	Mpumalanga	24°56′S 30°48′E
Port Edward	Kwazulu Natal	31°03′S 30°13′E
Red Hill	Western Cape	34°12′S 18°25′E
Sea Farm	Western Cape	34°22′S 18°52′E
Sedgefield	Western Cape	34°02′S 22°48′E
Silvermine	Western Cape	34°06′S 18°26′E
Swellendam	Western Cape	33°59′S 20°16′E
Tendele	Kwazulu Natal	28°43′S 28°56′E