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Recent Developments in the Biological Control of Invasive Acacias in South Africa: *Melanterius ?servulus* (Coleoptera: Curculionidae) against *Acacia cyclops*

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Abstract

Several Australian tree species have become highly invasive and important weeds in South Africa. Biological control programmes have been launched against several species including: *Acacia longifolia* (Andr.) Willd., *A. pycnantha* Benth., *A. cyclops* A. Cunn. ex G. Don, *A. mearnsii* De Wild., *A. melanoxylon* R.Br., *A. dealbata* Link, and *Paraserianthes lophanta* (Willd.) Nielsen, (using gall-forming and seed-feeding herbivorous insects); and *A. saligna* (Labill.) H.L. Wendl. (using a fungal pathogen). The subject of this paper is the recent finding that *Melanterius* ?*servulus* Pascoe, a seed-feeding weevil which became established on *A. cyclops* in South Africa in 1994, has now proliferated at most of the release sites in the south-western part of the Western Cape Province. Feeding damage by the adult and larval weevils destroys up to 95% of the seeds on *A. cyclops*. Three factors have been identified that may influence the effectiveness of *M.* ?*servulus* as a biological control agent, namely: (i) limited dispersal abilities of the weevils; (ii) interference by birds, a native alydid bug and rodents which also feed on the *A. cyclops* seeds; and (iii) asynchrony in the phenologies of the weevils and their host plant.

Keywords: weed, biocontrol, seed-feeders, Curculionidae

Acacia cyclops A. Cunn ex G. Don is a shrubby leguminous tree originating from south-western Australia. It was first introduced into South Africa around 1835 (Roux 1961, Stirton 1978) to stabilize dunes in the south-western part of the Western Cape Province. Prolific seed production in the absence of natural enemies has facilitated the spread of the plants (Milton 1980) and *A. cyclops* has become one of the most widespread alien invaders in many of the coastal areas and in the lowland fynbos biome of the Eastern and Western Cape Provinces (Macdonald and Richardson 1986, Henderson 1995). Mechanical and chemical control procedures are unsatisfactory because of the immense, long-lived seed-banks in the soil and biological control is believed to be the only long-term solution to the problems caused by this weed (Donnelly 1992).

Limitations have been imposed on the types of biocontrol agents which can be used against Australian acacias because some species have useful attributes (Stirton 1978, Shaughnessy 1980, Dennill and Donnelly 1991), including *A. cyclops* which is a valued source of fire wood (Azorin, personal communication). As a result, only agents which reduce flower or seed-production are considered to be acceptable for this suite of weeds

(Dennill and Donnelly 1991, Donnelly 1992). Biological control programmes, using 2 gall-forming wasps (*Trichilogaster* species) (Pteromalidae) and 5 species of *Melanterius* (Curculionidae) against 7 invasive Australian *Acacia* species and *Paraserianthes lophantha* (Willd.) Nielsen (a closely related species), were initiated in South Africa during the 1980s (Dennill and Donnelly 1991, Dennill *et al*. 1999). The genus *Melanterius*, which comprises some 88 species, has played a predominant role in these programmes because both adults and larvae feed exclusively on the immature seeds of acacias and *P. lophantha* (New 1983, Dennill and Donnelly 1991, Donnelly 1992).

Surveys during the 1980s showed that an indigenous hemipteran bug, *Zulubius acaciaphagus* Schaffner (Alydidae), was feeding on and destroying up to 84% of the annual seed crop of *A. cyclops* in some areas of South Africa (Holmes and Rebelo 1988). However, the damage was too sporadic to be of value for control of the weed and the option of using a biocontrol agent from Australia was investigated. This resulted in the release of an agent, known as *Melanterius servulus* Pascoe, against *A. cyclops* in 1991 (Dennill *et al*. 1999). Recent evidence suggests that the identity of *M. servulus* is uncertain (Oberprieler, personal communication), and the agent is now referred to as *M. ?servulus*. The first release of *M. ?servulus*, near Yzerfontein (33º20'S 18º10'E), was unsuccessful because the introduction was made too late in the season, when no suitable pods were available for the weevils. Further releases of *M. ?servulus* were made during 1994 when approximately 200 adults were liberated at each of 16 sites in the south-western part of the Western Cape Province (Dennill *et al*. 1999). In this paper we record the successful establishment of *M. ?servulus* on *A. cyclops* at most of these release sites and we document the levels of mortality caused by the weevils 4 years after the initial releases. The prospects for successful biological control of *A. cyclops* are discussed.

Materials and Methods

Annual inspections were made during December at each of the 16 release sites, initially to confirm establishment of *M. ?servulus* and subsequently to make estimations of the levels of beetle damage on the seeds. Prior to December 1998, damage was assessed by scrutinizing pods *in situ* and estimating the proportion of seeds that had *M. ?servulus* adult feeding punctures or larval emergence holes. This procedure was followed so as not to disturb the seemingly few weevils that were present.

In December 1998, when weevil damage became noticeably more abundant, samples of pods were collected from 11 sites and processed in the laboratory to determine actual levels of seed mortality. At each site, approximately 30 pods were collected indiscriminately from each of 5 trees. A sub-sample of 10 pods was randomly selected from each batch of pods by removing the pods, unsighted, from a paper bag. Each pod was opened and a record was made of the number of: (i) seeds damaged by larvae (ie. those with *M. ?servulus* exit holes); (ii) seeds damaged by adult feeding (feeding scars were clearly evident on the outer and inner surfaces of the pod, and the corresponding seeds were flattened and undeveloped); (iii) non-viable seeds (ie. shrivelled, but not as a result of *M. ?servulus* damage); (iv) aborted seeds and; (v) seemingly 'healthy' seeds. The 'healthy' seeds were retained (between sheets of transparent, adhesive paper) and X-rayed (Softex Co. Ltd., Tokyo, Japan No. 6701) at 13 KVP and 9 mA for a duration of 60 seconds on plates (Agfa-Gevaert, 8x10" Osray-C film) which were developed in an automatic developing machine in the radiology unit at Stellenbosch Hospital.

Examination of the X-ray plates revealed 3 categories of seeds. Those which con-

Table 1.
Releases of *Melanterius servulus* and assessments of seed mortality caused by adult and larval weevils in combination.

Release site	No. weevils released	Year	% seed mortality	Comments
Napier 34º28'S 19º52'E	200	1994	<0.01	Very dusty on edge of gravel road
		1995	0	
		1996	<0.01	
		1997	0.1	Few pods available
		1998	**7**	
Baardskeerdersbos 34º34'S 19º28'E	200	1994	0	Pods very dusty
		1995	0	
		1996	0	
		1997	0	
		1998	**11**	Large portion of site burnt
Gordons Bay 34º09'S 18º52'E	200	1994	<0.01	
		1995	<0.01	
		1996	<0.01	
		1997	<0.01	
		1998	**24**	
Bredasdorp south 34º33'S 20º03'E	250	1994	0	Site cleared
		1995	0	
		1998	**0**	Pods from trees adjacent to site
Bredasdorp west 34º31'S 20º02'E	200	1994	<0.01	
		1995	<0.01	
		1996	<0.01	
		1997	0	
		1998	**23**	
Bredasdorp east 34º30'S 20º04'E	300	1994	<0.01	
		1995	<0.01	
		1996	<0.01	
		1997	<0.1	
		1998	**64**	
Struisbaai 34º44'S 19º39'E	250	1994	<0.01	Insects moved across road - release site chopped
		1995	<0.01	
		1996	<0.01	
		1997	<0.01	
		1998	**17**	
De Hoop 34º24'S 20º32'E	200	1994	<0.1	
		1995	<0.1	
		1996	<1	
		1997	?	Collected weevils for re-distribution
		1998	**62**	
Hangklip S 34º22'S 18º49'E	200	1994	<0.01	
		1995	<0.01	
		1996	<0.01	
		1997	0	No pods found
		1998	**74**	
Stanford 34º27'S 19º26'E	200	1994	<0.1	Weevils collected for redistribution
		1995	<0.1	
		1996	<1.0	
		1997	1-5	
		1998	**95**	
		1999		Site burnt
Hawston 34º24'S 19º07'E	200	1994	0	Site left prematurely and did not return
		1995	?	
		1997	?	Insects collected for restribution
		1998	**95**	

*Prior to 1998 all assessments of damage were visual estimates only – no destructive sampling took place tained *M.* ?*servulus* larvae were added to group (i), those with distorted contents were added to group (iii) and the remaining healthy seeds were added to group (v).

Results and Discussion.

Table 1 shows the 11 sites chosen for destructive sampling and evaluation of *M.* ?*servulus* damage and Figure 1 illustrates graphically where each of these sites is situated in the Western Cape Province. The remaining 5 (of the original 16) release sites were not surveyed because at 3 sites there were no signs of *M.* ?*servulus* damage (i.e. Hangklip N 34º22.207'S 18º49.424'E; Springfield Estates 34º45.042'S 19º58.789'E and a site near Gansbaai 34º44.094'S 19º37.479'E), 1 site was not revisited (Yzerfontein), and the last site (Langebaanweg) was being used for a separate ongoing project involving annual releases of weevils. *Melanterius* ?*servulus* adults, like other *Melanterius* species, feed and oviposit on developing pods whilst the seeds within are still soft and green. By December in South Africa, the majority of the *A. cyclops* pods have turned brown and the seeds have ripened and hardened and are no longer suitable for *M.* ?*servulus* oviposition. At this stage the pods are ideal for collection to assess seed mortality.

Despite similar numbers of weevils having been released at each site during 1994, the levels of seed mortality varied substantially between sites, ranging from 7% at Napier to 95% at Hawston and Stanford (Table 1 and Figure 1). The reasons for the differences between sites were not elucidated, but excessively dusty sites seemed to have lower levels of seed mortality. Also, in most cases the exact release sites were not recorded and

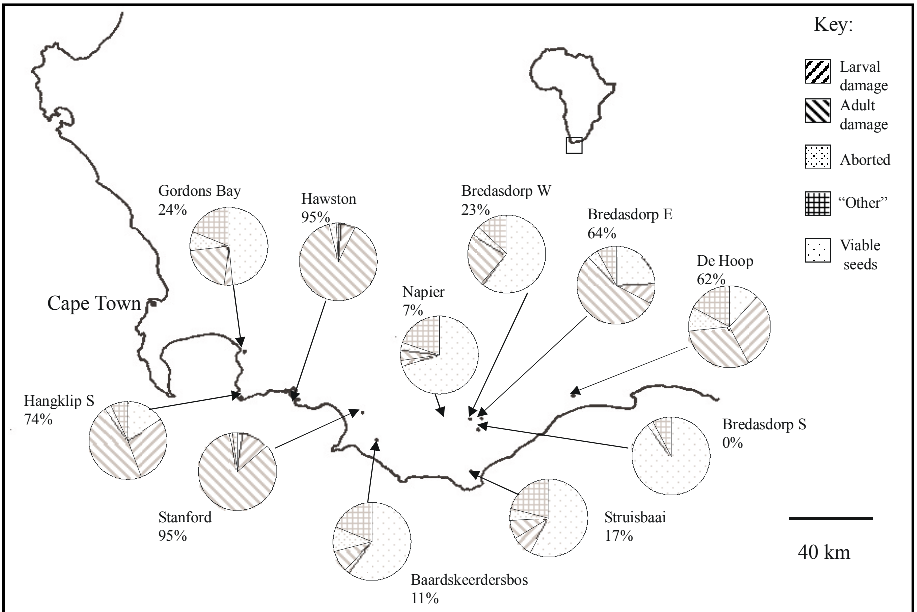

Fig. 1. Map of the south-western part of the Western Cape Province showing *M.* ?*servulus* release sites and percentage seed mortality resulting from adult and larval feeding.

plants were possibly sampled from the vicinity of the original release sites. *Melanterius* weevils are slow to disperse, at least when populations number are low (Dennill *et al.* 1999; Schmidt *et al.* 1999), and the levels of seed mortality may have been influenced by the distance between the trees that were sampled and the trees on which the weevils were originally released.

In general, levels of seed-mortality recorded were much higher in 1998 than in previous years (Table 1). Although this may reflect a sudden increase in the abundance of the weevils, it could be due to the fact that the visual estimates of damage are likely to be under-estimates. In particular, adult feeding damage is not always discernible unless the pods are dissected and, as can be seen in Figure 1, adult feeding in many cases accounted for the largest portion of the total seed mortality.

Despite the fact that *M. ?servulus* is able to account for very high seed-mortality levels on *A. cyclops* there are some other factors which could influence the eventual success of this biological control programme. Firstly, as already mentioned, the weevils appear to be slow to disperse and manual redistribution may be necessary. However in the case of *M. acaciae* Lea on *A. melanoxylon* R. Br., where manual redistribution of weevils was used to counteract slow dispersal, this seemed to be unnecessary because natural dispersal increased rapidly as the populations of the weevils increased (and available pods decreased correspondingly) (Dennill *et al.* 1999). The same trend may occur as *M. ?servulus* becomes more abundant.

Secondly, the utilization of *A. cyclops* seeds by birds, rodents and a native alydid bug, *Zulubius acaciaphagus* is a complication. Although feeding by these organisms on *A. cyclops* seeds is common (Glyphis *et al.* 1981, Holmes *et al.* 1987, Holmes and Rebelo 1988, Holmes 1990), it is not known what effect this is having on *M. ?servulus* larvae within the seeds. Certainly, birds remove the immature seeds from ripening pods when the *M. ?servulus* larvae would also be developing in them, thus hampering biocontrol, but both rodents and the alydid bug feed mostly on fully-ripened seeds at a stage when most *M. ?servulus* larvae have left the pods and fallen to the ground to pupate. In the case of rodents and *Z. acaciaphagus*, rather than hampering *M. ?servulus* as a control agent, their feeding activity could enhance the overall levels of seed mortality with no detriment to the weevils.

Thirdly, the overall success of *M. servulus* may be affected by asynchronies in the phenologies of the weevil and its host plant. Unlike the other invasive Australian acacias found in South Africa, flowering and pod-production on *A. cyclops* is aseasonal (Milton and Moll 1982). This feature may enable the plants to produce seeds when the weevils are inactive. Members of the genus *Melanterius* are univoltine. The adult weevils are reputed to be inactive and reproductively dormant from January to August and during these months they shelter under bark or in crevices with occasional bouts of activity to feed from extrafloral nectaries or flush foliage (New 1983, Donnelly 1992). Feeding on florets of the host-plant is apparently essential for reproductive development of *Melanterius* species (Donnelly 1992) and unless the weevils become active for prolonged periods it seems unlikely that they will utilize pods that are produced at times other than mid-summer. A study is currently underway to determine whether *M. ?servulus* on *A. cyclops* behaves differently to its congeners. The results will show whether the promising early indications with *M. ?servulus* will be sustained, or whether other agents may have to be considered to supplement this biological control programme.

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