Biological control of three cactaceous weeds, *Pereskia aculeata* Miller, *Harrisia martinii* (Labouret) Britton and *Cereus jamacaru* De Candolle in South Africa

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Some of South Africa's most successful biological control programmes have involved cactaceous weeds, many of which were reviewed in 1991. This review deals with three species, previously considered to be of minor importance, which have been the focus of biocontrol efforts because of their increasing importance. The programme against the primitive, climbing cactus, *Pereskia aculeata* Miller, has involved the release of the flea beetle *Phenrica guérini* Bechyné (Chrysomelidae, Alticinae). Despite earlier failures to establish them, the beetles have become abundant at one locality in the Eastern Cape, but it is still too early to assess their impact. Host-specificity tests on additional agents for *P. aculeata* resulted in the rejection of two moth species. The leaf-feeding *Epipagis cambogialis* (Guenée) (Pyralidae) displayed an unacceptably broad host range, while tests on the stem-boring *Maracayia chlorisalis* (Walker) (Crambidae, Pyraustinae), which proved difficult to culture in quarantine, were inconclusive. The programme against *Harrisia martinii* (Labouret) Britton (= *Eriocereus martinii* (Labouret) Riccobono) has been successful and the weed can be completely controlled by the mealybug *Hypogeococcus festerianus* (Lizer y Trelles) (Pseudococcidae) and the stem-boring beetle *Alcidion cereicola* Fisher (Cerambycidae) if the insects are regularly redistributed to uncontaminated or new infestations. Both of these insects also attack the related *Cereus jamacaru* De Candolle in the field and have controlled the weed successfully in at least one area where both insects are present. However, it needs to be determined whether the insects can be successfully integrated with the current chemical control programme against *C. jamacaru.*

Key words: *Alcidion cereicola,* biological weed control, *Epipagis cambogialis, Hypogeococcus festerianus, Maracayia chlorisalis, Pereskia aculeata, Phenrica guérini.*

The biological control programme against several cactaceous weeds in South Africa, including *Pereskia aculeata* Miller, *Harrisia martinii* (Labouret) Britton and *Cereus jamacaru* De Candolle, was reviewed by Moran & Zimmermann (1991), who regarded these three species to be of minor importance. These authors reported on the release of two agents, *Hypogeococcus festerianus* (Lizer y Trelles) (Pseudococcidae) and *Alcidion cereicola* Fisher (Cerambycidae) against *H. martinii* and mentioned that *A. cereicola* also accepted *C. jamacaru* as a host. Although *H. festerianus* was rated as being highly effective on *H. martinii*, the recency of the release of *A. cereicola* in 1990 precluded a consideration of its impact on either *H. martinii* or *C. jamacaru*. In addition, the review mentioned the impending release of *Phenrica guérini* Bechyné (Chrysomelidae, Alticinae), which was the first biological control agent to be used against *P. aculeata*. In this review, I update information on the distribution and importance of these three cactaceous weeds in South Africa and discuss the prospects for their biological control.

PERESKIA ACULEATA

Pereskia aculeata (Barbados gooseberry; Fig. 1) belongs to a primitive genus whose species differ from other Cactaceae in being woody and having well-developed leaves (Leuenberger 1986). All are indigenous to Mexico, the West Indies and Central and South America (Obermeyer 1976). The plant has been present in South Africa since at least 1858 (Moran & Zimmermann 1991) where it is used extensively as a barrier hedge (Haigh 1979) and on gravesites (Bruton 1981). In the early 1970s, it was reported as invasive (Pickworth 1972) and was later declared as a noxious weed (Anon. 1979). The current distribution of *P. aculeata* in South Africa is shown in Fig. 2.

The weed is extremely difficult to control conventionally. Triclopyr (butoxy ethyl ester; 480 g/l a.i.) is registered in South Africa as a 'knockdown

Fig. 1
***Pereskia aculeata*.**
(Drawn by G. Condy, National Botanical Institute, Pretoria.)

treatment' for the topgrowth of pereskia (Vermeulen *et al*. 1996). The dead plant material should then be removed and burnt in order to facilitate access for follow-up operations. However, the herbicides are not translocated within the plant tissue and every part of each plant thus must be treated to destroy infestations of the weed. In addition, trees covered by pereskia should be felled and foliar-sprayed and the weed's roots should be dug up and burnt (P.L. Campbell, pers. comm.).

Searches for potential biological control agents for pereskia have been largely opportunistic and have mostly occurred in combination with surveys of other weeds of South American origin. Several potential agents were encountered in Brazil and three species have so far been introduced into quarantine in South Africa. These include the flea beetle *P. guérini* (Erb 1988), the leaf-mining moth *Epipagis cambogialis* (Guenée) (Pyralidae) (Zimmermann 1990) and the stem-boring moth *Maracayia chlorisalis* (Walker) (Crambidae, Pyraustinae) (Erb 1991). An unidentified cerambycid was also found in dead *P. aculeata* stems at several localities in Brazil but, since it was uncertain whether it had caused the damage originally or whether it was a secondary colonizer of the dead wood (Erb 1988, 1991), it was never introduced.

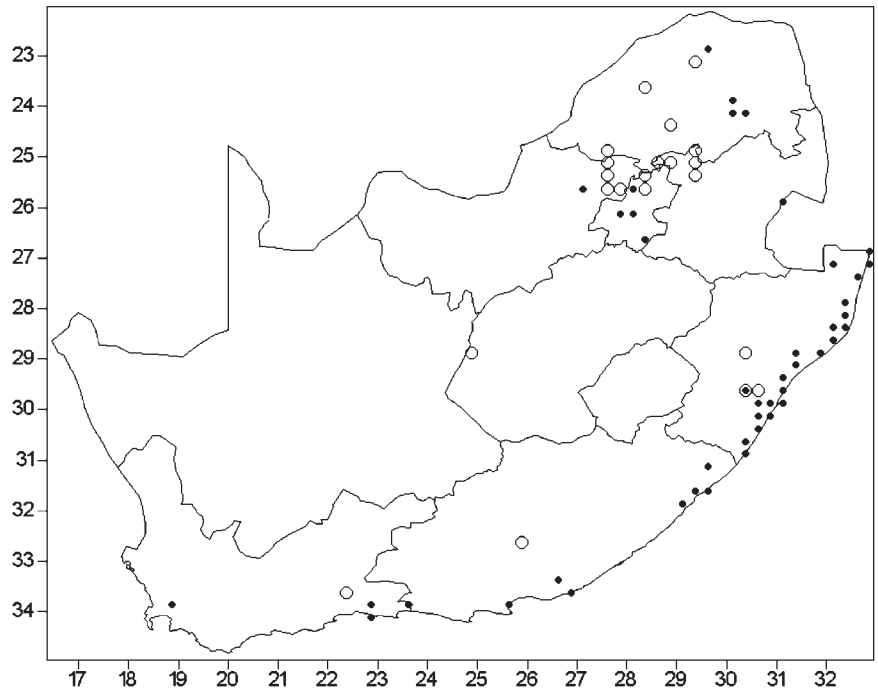

Fig. 2

Distribution of *Pereskia aculeata* (●)and *Harrisia martinii* (○)in South Africa.

(Drawn by L. Henderson, Plant Protection Research Institute, Pretoria.)

Opportunistic surveys were also undertaken in the Misiones Province of northeastern Argentina, where pereskia also occurs naturally. The leaf-mining *E. cambogialis* was recorded, although there were also suggestions of attacks on other unrelated plants. Several other promising insects, including unidentified species of Chrysomelidae and unidentified geometrid larvae, were also encountered in Argentina but none of these were introduced into South Africa. Observations in Guatemala indicated that pereskia was probably not indigenous there, as the plants contained many fruits but suffered little insect damage (S. Neser, pers. comm.).

Phenrica guérini

This species was originally described as *Nephrica guérini* (Bechyné, 1955) and subsequently transferred to the genus *Phenrica* (Bechyné 1956). All known specimens of *P. guérini* were collected in Brazil (Bechyné & Bechyné 1966). The laboratory culture of *P. guérini* was initiated from 10 adults collected on pereskia at Barra de São João (22.30S 41.59W), 140 km northeast of Rio de Janeiro, Brazil (Erb 1988). Another nine adults, collected two years later along the narrow landstrip between Lagoa de Marapendi and Praia da Barra de Tijuca (23.01S 43.17W) in Brazil, were later added to the culture (Zimmermann 1990). The culture was again augmented by some 40 adults collected at Barra de São João during 1991 (Erb 1991) and by another small collection from Brazil in 1994 (Olckers & Neser 1994).

Both adults and larvae feed on the leaves and growth tips of the plants. The eggs are deposited in neatly arranged groups on the undersides of leaves. Development from egg to adulthood took some 42 days in the laboratory (H.E. Sparks, unpubl.) and the larvae pupate in the soil. There are no host records for *P. guérini*. Most of the other 14 species of *Phenrica* were recorded on cultivated Fabaceae, on which they occasionally caused some damage (Bechyné & Bechyné 1966). Unpublished records by Bechyné indicate that plants in the families Amaranthaceae, Chenopodiaceae, Passifloraceae, Rutaceae and Malvaceae (the last unconfirmed) might also be hosts for *Phenrica* species (D.G. Furth, pers. comm.). None of the *Phenrica* species are listed as pests in Brazil (Silva *et al*. 1968).

Host-specificity trials indicated that *P. guérini* had a very narrow host range. The larvae did not complete their development on any of the non-

Table 1

Releases of adults of *Phenrica guérini* on *Pereskia aculeata* in South Africa between 1991 and 1997.

Province and release site	Number of releases	Numbers released	Year(s) of releases
KwaZulu-Natal			
Durban Municipality[1]	2	53	1991
Nshongweni[2]	2	58	1991
Amanzimtoti[3]	1	61	1992
Kwambonambi (Mondi Forests)[4]	1	70	1992
Kwambonambi (Sappi Forests)[5]	2	66	1992
Umzinto[6]	1	36	1992
Durban (The Bluff)[7]	1	70	1992
Harold Johnson Nature Reserve[8]	3	205	1992
Wentworth Forest Nature Reserve[9]	1	60	1992
Sezela Sugar Mill[10]	2	140[13]	1997
Eastern Cape			
Grahamstown[11]	4	200	1994
Port Alfred[12]	5	300[13]	1994/95

1–12: coordinates: 1: 29.53S 31.00E; 2: 29.52S 30.42E; 3: 30.53S 30.03E; 4: 28.40S 32.10E; 5: 28.40S 32.10E; 6: 30.40S 30.18E; 7: 29.54S 31.03E; 8: 29.14S 31.25E; 9: 29.55S 31.02E; 10: 30.41S 30.24E;11: 33.19S 26.32E; 12: 33.36S 26.53E.
13: establishment confirmed.

target plants tested, not even on the closely related *Pereskia grandifolia* Howard (H. de Beer, unpubl.). *Phenrica guérini* was thus cleared for release in South Africa in 1991 and subsequent releases are indicated in Table 1.

Six of the nine sites in the KwaZulu-Natal coastal region, where the first releases of *P. guérini* adults were made during 1991 and 1992, were monitored weekly for the first one or two months after release. Thereafter, they were monitored at least once a month, but this was suspended after eight months. Larvae were recovered at only two sites, but only until eight months after release at one site and until three months after release at the other. Infestations at two sites were destroyed shortly after the releases, while there were no indications of establishment at the remaining two sites. At the time, *P. guérini* was assumed not to have established, and no further surveys at or near the release sites have since been undertaken. Despite these apparent early failures, *P. guérini* became established in the Eastern Cape Province during 1995. Although no beetles were recovered at an inland release site at Grahamstown (33.19S 26.32E) one year after release, small numbers were recovered at a coastal site at Port Alfred (33.36S 26.53E) two years after release. At the latter site, the beetle population increased dramatically during 1997 and the beetles were particularly abundant in early 1998. It is, however, still too early to determine its impact on the weed.

Attempts to establish *P. guérini* at the Sezela Sugar Mill (30.41S 30.24E), also in the KwaZulu-Natal coastal region, commenced in 1997. A population was released in a large outdoor cage and increased sufficiently to allow the redistribution of small numbers of adults to adjacent infestations along the KwaZulu-Natal South Coast. However, it is still too early to confirm whether the beetles have become established at these sites.

Epipagis cambogialis

This species was previously described as *Mimorista cambogialis* (Guenée) (Silva *et al.* 1968) and *Chrysobatys cambogialis* (Guenée) (Mann 1969) and a description of the moth and its biology is given by Sauer (1938). The moth was first introduced into South Africa during September 1990. The first consignment consisted of 38 larvae and 10 pupae, collected on *P. aculeata* growing along the narrow landstrip between Lagoa de Marapendi and Praia da Barra de Tijuca (23.01S 43.19W) near Rio de Janeiro, Brazil (Zimmermann 1990), and this was later augmented by a second consignment of about 30 pupae from the same area (Erb 1991). Although the quarantine culture was lost, probably because of infection by microsporidia, the moths were reintroduced from Brazil in 1994 following collections around Rio de Janeiro, particularly at the Parque Chico Mendes (Barra de Tijuca) and at Grumari (Olckers & Neser 1994).

In the laboratory, the larvae feed within shelters that they construct by folding the leaves or joining

two leaves together and sealing the edges with silk. The lower epidermis and mesophyll of the leaves are normally consumed, leaving the upper epidermal layer intact, although the larvae occasionally tunnelled into succulent leaves and young shoot tips. Late instar larvae pupate between partially consumed leaves or in any corner or crevice in the cages. The life cycle took on average 35 days to complete. Larval feeding causes considerable leaf damage, which appears to far exceed that caused by *P. guérini*.

According to Sauer (1938), *P. grandiflora* is the host plant of *E. cambogialis*. However, other host records suggest a broader host range that includes several plants from families like Fabaceae, Portulacaceae, Cactaceae, Basellaceae and Amaranthaceae (Silva *et al*. 1968; da Cruz 1992). Mann (1969) similarly recorded *E. cambogialis* in southern Brazil and in northern and eastern Argentina on *Cereus pernambucensis* Lemaire, *Opuntia monacantha* Haworth and *Pereskia sacharosa* Grisebach (all Cactaceae).

During host-specificity trials in a quarantine greenhouse, the larvae developed to adulthood on several cactaceous species, *Anredera cordifolia* (Tenore) Van Steenis, *Basella rubra* Linné (both Basellaceae), *Portulacaria afra* Jacquin, three *Talinum* species and three *Portulaca* species (all Portulacaceae). Non-target plants that were accepted included two beneficial species as well as several indigenous species. One of the indigenous species, *Portulacaria afra*, was a cause for concern as it is a major component of the Valley Bushveld vegetation type that has considerable conservation value. However, first instar larvae suffered 80 % or higher mortality on *P. afra* and larval development seemed to depend, to a large extent, on the physiological condition of the test plant. For example, very few larvae developed on *P. afra* plants grown outside the greenhouse, while larval development on plants grown inside the greenhouse was often comparable to that on pereskia. The greenhouse-grown plants normally had younger and softer leaves with a darker green colour and this seemed to make them more palatable. The unacceptably wide host range of *E. cambogialis* and the potential risks to non-target native plants resulted in the decision to suspend further research on the moths.

Maracayia chlorisalis

This moth occurs in Guatemala, Costa Rica, El Salvador, Panama, Colombia, Venezuela, Ecuador and Peru (M.A. Solis, pers. comm.) where it appears to be associated with cactaceous species. In Colombia, it was recorded as a pest of *Cereus triangularis* Linné (= *Acanthocereus pitajaya* (Jacquin) Dugand) and was also found on *Hylocereus ocamponis* (Salm-Dyck) Britton & Rose (Zenner de Polania 1990). There is only one other known species of *Maracayia*, described from Surinam, but the host plant of this species is unknown (M.A. Solis, pers. comm.). Stems of *P. aculeata* containing larvae and pupae of *M. chlorisalis* were collected at Barra de Tijuca (23.01S 43.19W) and Barra de São João (22.30S 41.59W) in Brazil during November 1991 (Erb 1991) and again in May 1994 (Olckers & Neser 1994), for study in South Africa. If these are indeed *M. chlorisalis,* then these are the first records of this species from Brazil (M.A. Solis, pers. comm.). Despite several attempts to have specimens of the Brazilian moth identified by different specialists, its identity remains unconfirmed.

The Brazilian material was heavily parasitized and the insect proved difficult to culture in quarantine. Initial observations suggested that the eggs are deposited on the succulent, young shoots of *P. aculeata,* often in rows of up to 10 eggs. The larvae entered the plants through the base of the recurved spines on the stems, fed underneath the epidermis and later penetrated the vascular tissue where they fed on the cortex of the stems. The larvae pupated inside the hollowed-out stems and the total generation time was around 45 days. Although larval feeding caused the stems to become more susceptible to snapping off, feeding did not seem to severely affect the plants' growth in the laboratory. Damage was mostly restricted to the pith and the hollowed-out stems tended to elongate normally and produce normal side-shoots.

Preliminary attempts at host-specificity testing produced unreliable results because of the difficulties in rearing *M. chlorisalis* and the fact that the moth's oviposition requirements are still unclear. Eggs were only laid on the fast-growing, succulent, whip-like vines that typify pereskia during its active growing phase. However, the moths often failed to oviposit on these vines, even when large numbers of males and females were nourished with honey water. Total darkness during the night sometimes increased the number of eggs deposited, but this was not always observed. The culture has since died out in quarantine and a decision was made not to reintroduce the moth until its identity has been confirmed. Should the moth collected on *P. aculeata* in Brazil prove to be

the same species as the one that damages the succulent stems of *C. triangularis* in Colombia (Zenner de Polania 1990), then it would appear that the moth is not host specific and may be unsuitable for release.

HARRISIA MARTINII

Although *H. martinii* (Harrisia cactus; Fig. 3) was considered to be of minor importance and to have a restricted distribution in South Africa (Moran & Zimmermann 1991), the weed has since become more widespread (Fig. 2) and continues to increase in importance. The increased importance of *H. martinii* can be attributed to seed dispersal by frugivorous birds (De Beer & Zimmermann 1986) and the failure of herbicides to translocate to the jointed, tuberous storage roots (Mann 1967), resulting in regrowth from unaffected stem or tuber segments (Harvey 1977). The herbicides monosodium methanearsonate (MSMA) and triclopyr (butoxy ethyl ester) are currently registered as spray treatments for the control of *H. martinii* in South Africa, the former at a subsidized price, but follow-up stem injections of MSMA may be necessary (Vermeulen *et al*. 1996).

Two insect agents were released against *H. martinii* in South Africa, namely the pseudococcid *Hypogeococcus festerianus* and the cerambycid *Alcidion cereicola*. However, no formal post-release evaluations have been undertaken and, besides redistribution of the insects by Government Resource Conservation Inspectors, biocontrol efforts have largely been discontinued in South Africa.

Hypogeococcus festerianus

The mealybug *H. festerianus*, which occurs naturally from the Mendoza Province of Argentina to the Paraguayan Chaco and feeds on several cacti in the subtribe Cereanae (McFadyen & Tomley 1981), was first released in South Africa in 1983 (Moran & Zimmermann 1991). The sessile insects attack mainly the young, growing tissues of *H. martinii* and feeding results in contorted growth tips, reduced fruit production and die-back of stems (McFadyen & Tomley 1978, 1981; Moran & Zimmermann 1991). Any regrowth becomes rapidly infested.

Because natural dispersal of the immature stages (crawlers) occurs by wind and is slow, the insects' distribution can be increased considerably by the manual redistribution of infected plant material. There has been no need to maintain laboratory cultures because healthy plants are easily infected by placing contaminated plant material from the field onto them. Indications are that all releases of *H. festerianus* in South Africa have resulted in establishment. Despite heavy predation by coccinellid beetles in the field, the mealybug is a very effective biocontrol agent and has killed off large infestations of the weed in South Africa.

In many areas the dispersal of *H. festerianus*, especially during the last two growing seasons (1997/98 and 1998/99), has been exceptional. High rates of reproduction may have been stimulated by above-average rainfall, and the resultant growth flush, during these two summers. The insects have also dispersed between patches of *H. martinii* that were separated by several hundred metres of dense vegetation, in the relatively short period since release. This suggests that factors other than wind have been responsible, and it seems likely that birds or small mammals, feeding on contaminated fruit or stems, could also have helped to disperse the crawlers.

Populations of *H. festerianus* are well established at several sites throughout South Africa, including Camperdown (29.44S 30.31E), Cookhouse (32.44S 25.46E), Mostertshoek near Kimberley (28.45S 24.55E), Kameeldrift (25.39S 28.20E), Boekenhoutskloof (25.32S 28.29E), Pyramid (25.34S 28.17E), Rust-de-Winter (25.07S 28.45E), Marble Hall (24.57S 29.16E) and Koedoeskop (24.54S 27.30E). The damage caused by *H. festerianus* and its exceptional rate of spread has recently prompted the National Department of Agriculture to reconsider its subsidy of herbicides for the control of *H. martinii* and to rather rely entirely on biological control.

Alcidion cereicola

This stem-boring beetle is indigenous to Argentina and Paraguay (McFadyen & Fidalgo 1976) and has contributed substantially towards the biological control of *H. martinii* in Queensland, Australia (McFadyen & Tomley 1978). A field-collected colony of *A. cereicola* was obtained from the Queensland Department of Lands in June 1990. After additional host-specificity tests, the beetles were first released at Kameeldrift (25.39S 28.20E) near Pretoria in November 1990 (Moran & Zimmermann 1991), but damage only became apparent during the third summer after release.

Larval feeding destroys the vascular system and causes the plants to collapse, while secondary rot aggravates the damage. Although several dead plants, displaying typical damage by the stem borer, were found at the original release site,

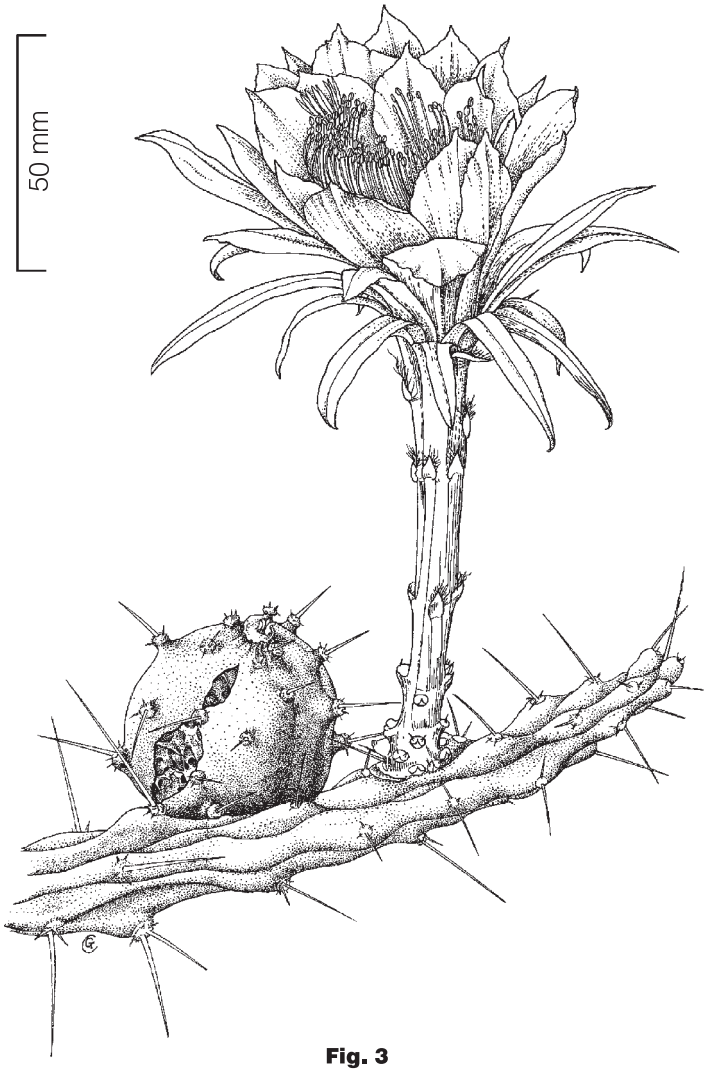

Fig. 3

Harrisia martinii.

(Drawn by G. Condy, National Botanical Institute, Pretoria.)

A. cereicola did not appear to contribute as much to the control of *H. martinii* as did the mealybug *H. festerianus*. Plants at the release site consisted mainly of young, succulent stems in which beetle larvae are known to have drowned (McFadyen & Fidalgo 1976). Larvae of *A. cereicola* are known to feed on and pupate in the tuberous roots of potted plants in the laboratory, which can severely limit regrowth from the roots. However, plants attacked in the field appeared to be regrowing from the tubers, confirming observations in Australia (McFadyen & Tomley 1978) that *A. cereicola* does not prevent regrowth from the roots.

Small laboratory cultures of *A. cereicola* were initially maintained at PPRI's Uitenhage and Pretoria Weed Laboratories, on severed stem segments and potted plants of *H. martinii.* Small numbers of adults were used to augment the field population at the original release site at Kameeldrift, which at first seemed not to have established. Mass-rearing was later discontinued when it became apparent that the beetles were well established on both *H. martinii* and *C. jamacaru* at this site. Stems of *C. jamacaru* containing eggs and larvae of *A. cereicola* were later redistributed to two other sites, Boekenhoutskloof (25.32S 28.29E) and Rust-de-Winter (25.07S 28.45E), in November 1997, where they were introduced into dense, mixed infestations of *H. martinii* and *C. jamacaru*. However, there were no signs of establishment

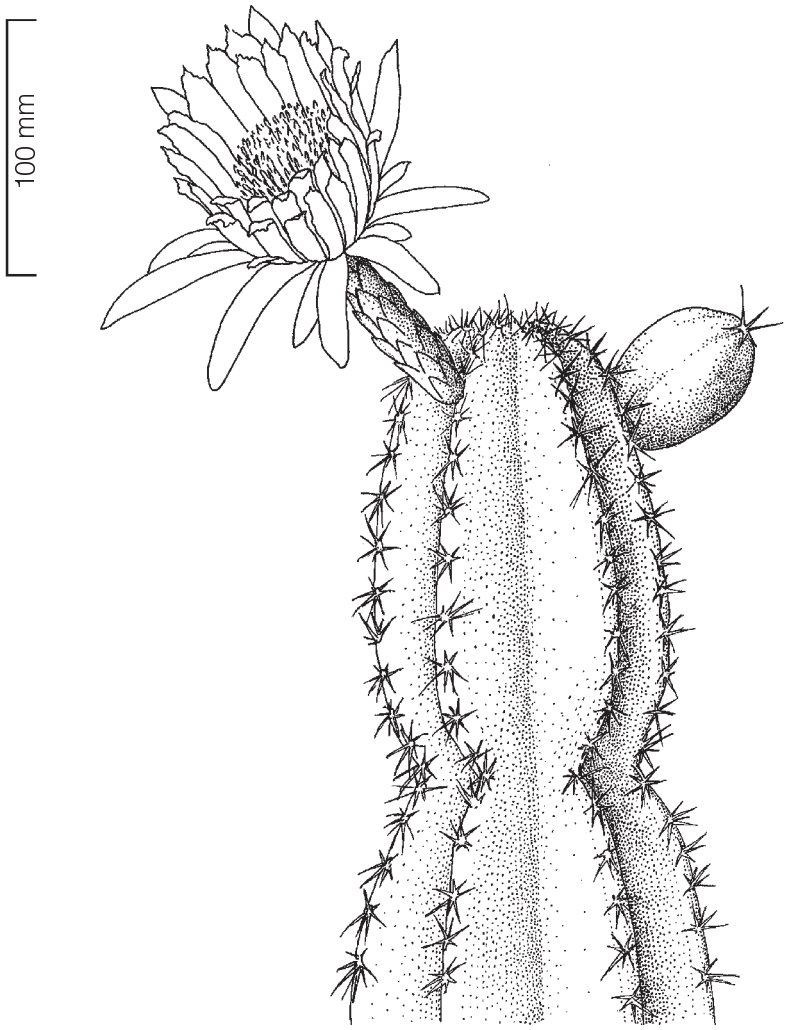

Fig. 4

***Cereus jamacaru*.**

(Drawn by G. Condy, National Botanical Institute, Pretoria; commissioned by Plant Protection Research Institute.)

on *H. martinii* at the former site during a follow-up visit in April 1998, or at the latter site during February 1999.

CEREUS JAMACARU

By 1987, infestations of *C. jamacaru* (Queen of the night; Fig. 4) were mainly restricted to the hot, dry regions of Gauteng and the Northern and North-West Provinces (De Beer 1987). The plant has since been recorded from all provinces in South Africa (Fig. 5), but large infestations are mostly limited to Gauteng and the Northern Province. One of the worst infestations in South Africa covers more than 3000 ha of farmland in the Moloto-Witnek district (25.28S 28.37E) and is believed to have arisen from a single specimen planted in a farm garden some 60 years ago. Densities of almost 40 000 plants per hectare have been recorded within this infestation (Taylor & Walker 1984).

Unlike *H. martinii,* this weed does not appear to be increasing in importance in South Africa. This is probably because *C. jamacaru* lacks the tuberous roots typical of *H. martinii* and is easily killed by stem injections or spray applications of the herbicide monosodium methanearsonate (MSMA) (Vermeulen *et al*. 1996). The National Department of Agriculture is at present conducting an extensive chemical control campaign in Gauteng, Mpumalanga and the North-West and Northern

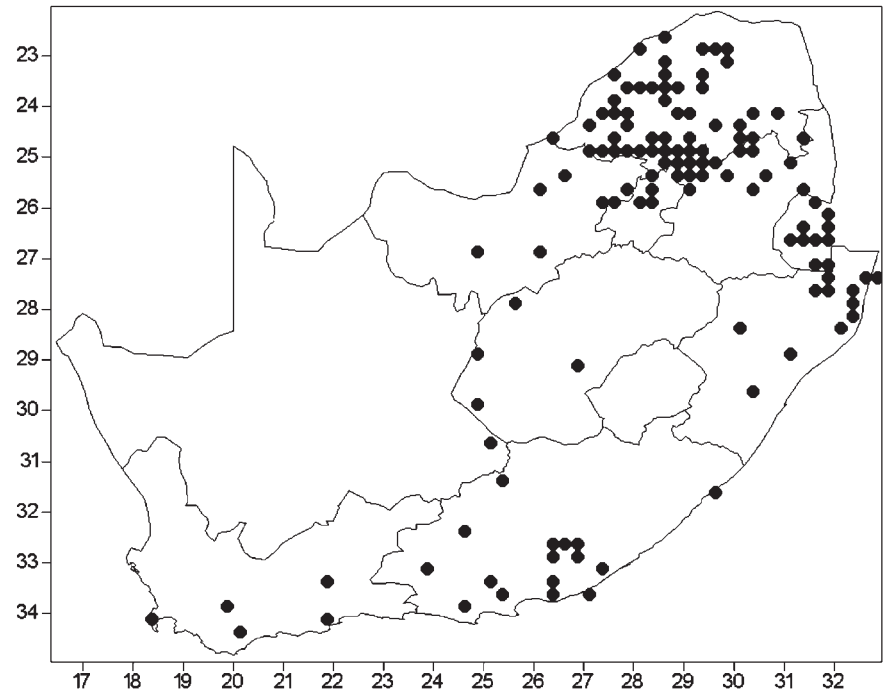

Fig. 5

Distribution of *Cereus jamacaru* in South Africa.

(Drawn by L. Henderson, Plant Protection Research Institute, Pretoria.)

Provinces. Chemical control on privately owned land has been encouraged by the sale of MSMA at a subsidized price. Although particularly dense infestations, as well as those on communal land, were initially reserved for biological control, the 'Working for Water' Programme (Department of Water Affairs and Forestry) has now included these infestations in the chemical control programme, by employing labourers to apply the herbicide (G.A. van der Walt, pers. comm.). Both insect agents that were released against *H. martinii* also attack *C. jamacaru* and are contributing substantially towards its control in at least one area in South Africa. Neither of the programmes against *H. martinii* and *C. jamacaru* has been adequately funded in South Africa and quantitative post-release evaluations have thus not been carried out.

Alcidion cereicola

The acceptance of *C. jamacaru* by *A. cereicola* (Moran & Zimmermann 1991) was not unexpected because, although this plant had never been reported as a host, the beetles had previously been reared from several other species of *Cereus* (Mann 1969). Host-specificity tests in South Africa indicated that *C. jamacaru* was a suitable host for *A. cereicola,* although the beetles seemed to prefer *H. martinii* during choice tests.

During the first release of *A. cereicola* at Kameeldrift (see above), adults were placed onto, and larvae inserted into, stems of *H. martinii* growing in an infestation comprising several cactus species, including *C. jamacaru*. Later that summer, some 20 larvae were inserted into the stem of a large *C. jamacaru* plant. During the third summer after release, damage by *A. cereicola* was evident on both *H. martinii* and *C. jamacaru,* and plants situated up to 200 m from the release site showed signs of larval feeding. In addition, large *C. jamacaru* plants had collapsed and even plants that had fallen over were attacked and destroyed. In contrast to *H. martinii*, there was no regrowth on *C. jamacaru* plants that were severely damaged by *A. cereicola.*

The beetles disperse well over short distances, and at the Kameeldrift release site all of the *C. jamacaru* plants on the 15 ha property were either killed or infested by larvae within seven years. However, dispersal at this site may have been increased by manual redistribution of the beetles by the landowner and their dispersal

beyond this site is unknown. The beetles have been reported to migrate up to 0.75 km in Queensland (McFadyen and Tomley 1978).

After the first release in 1990, no further releases of *A. cereicola* were carried out until 1997 when infested stems of *C. jamacaru* were transferred from the original release site into dense, mixed infestations of *H. martinii* and *C. jamacaru* at Boekenhoutskloof and Rust-de-Winter (see above). The Boekenhoutskloof site was revisted five months later, where signs of *A. cereicola* on *C. jamacaru* were evidenced by a few adult feeding and oviposition scars and by larval tunnels. When the site at Rust-de-Winter was revisited early in 1999, a few feeding and oviposition scars were seen on one plant only, but no larval tunnels were found. However, most of the older *C. jamacaru* plants in this area had been treated with herbicide and this could explain the apparent lack of larvae.

Hypogeococcus festerianus

The acceptance of *C. jamacaru* by the mealybug *H. festerianus,* after its release against *H. martinii* in South Africa, was expected because the insect had previously been recorded on several cacti in the subtribe Cereanae (McFadyen & Tomley 1981). Although *A. cereicola* established on *C. jamacaru* following deliberate innoculations, *H. festerianus* established on the weed unaided. Three summers after the release of *H. festerianus* on *H. martinii* at Kameeldrift, large numbers of mealybugs were noticed on *C. jamacaru* plants at the same site. On some of the plants, every areole contained a mealybug colony, while on others only the growth tips were affected. The stems of heavily infested plants showed conspicuous deformation and these plants produced very few fruits. Despite this, the mealybugs appear to be less damaging to *C. jamacaru* than the stem-boring *A. cereicola*. Almost all of the *C. jamacaru* plants at this site became infested by *H. festerianus*, but it is not known to what extent the landowner aided their distribution by manually dispersing infested plant material. In many other areas where *H. festerianus* was released on *H. martinii* (*e.g.* Rust-de-Winter, Marble Hall and Koedoeskop), the insects have now also colonized *C. jamacaru*. This is especially true of the large number of *C. jamacaru* seedlings that germinated in the wake of the intensive chemical control campaign against the weed. However, it is still too early to determine how long the infested seedlings will survive and whether they will eventually flower and produce seeds.

DISCUSSION

Despite the release of a biocontrol agent, *P. aculeata* seems likely to expand its range in South Africa and increase in importance in the near future. Laboratory observations suggest that *Phenrica guérini* is unlikely to reduce the vigour of the weed unaided, but this should be confirmed by quantitative post-release evaluations. The apparent failure of this agent to establish after the first releases in KwaZulu-Natal should also be re-investigated, following recent confirmation of establishment at Port Alfred and the rapid increase in the beetle population within three years. The success of establishment with future releases could be improved by releases of larger numbers of adults at each site and the initial confinement of the beetle populations to field-cages. The biocontrol programme has so far been opportunistic and searches for additional agents should be conducted in all countries where *P. aculeata* occurs naturally. Despite this, several promising insect species were identified in earlier surveys and candidate agents that should be prioritized for introduction include stem borers, seed feeders and species that inhibit seed production. Further research on the host range of *Epipagis cambogialis* seems unlikely to demonstrate that non-target native plants are not at risk and should thus not be resumed until more promising insects have been evaluated.

The two insect agents released against *H. martinii* and *C. jamacaru* have the potential to bring both weeds under complete biological control, provided that they are manually redistributed to uncontaminated or new infestations on a regular basis. When redistributing *A. cereicola,* infested stems of *C. jamacaru* have proved to be better than those of *H. martinii* because they remain fresh for longer and allow the larvae to complete their development. Although *H. festerianus* can be established following small releases, establishment of *A. cereicola* is dependent on sufficiently large starter colonies. Recent success with *H. festerianus* on *H. martinii* has fostered the belief that the Government-aided chemical control campaign against this weed should be discontinued. However, as long as herbicides and labour for the control of *C. jamacaru* are subsidized by Government, chemical control will probably remain the preferred control option for this weed in South Africa. Unfortunately, chemical control is antagonistic to *A. cereicola,* because the endophagous larvae are killed together with the plants. In addition, the herbicides do not address the

problem of seedlings germinating after treatments. The mealybug *H. festerianus* seems to be ideally suited for controlling regrowth and seedlings of *C. jamacaru*, although this still needs to be quantified. Despite insufficient funding, the programmes against *H. martinii* and *C. jamacaru* have been successful and have been implemented at relatively low cost.

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