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A Seed-feeding Insect Showing Promise in the Control of a Woody, Invasive Plant: the Weevil *Erytenna consputa* on *Hakea sericea* (Proteaceae) in South Africa

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Abstract

Hakea sericea, a fire-adapted woody plant from Australia, is an important weed in the species-rich vegetation of the Cape mountains. Prolific seeding may be regarded as the main reason for its success as an invasive plant. Larvae of *Erytenna consputa* destroy immature hakea fruits. The insect is strikingly adapted to its host and to surviving fires. The weevil was established in South Africa after the release of small numbers of field-collected, young adults from different climatic regions in Australia. Climatic matching was, however, not as important as host strain matching in the establishment of the weevil. Following establishment, *E. consputa* is greatly reducing seed accumulation by *H. sericea*, and starting to suppress the dense regeneration of the weed. Additional agents will probably not be required in the integrated control programme against this weed.

Les Insectes Granivores, Agents Efficaces de Lutte Biologique Contre les Plantes Ligneuses Envahissantes: Introduction du Charançon *Erytenna consputa* sur *Hakea sericea* (Proteaceae) en Afrique du Sud

Hakea sericea, une espèce australienne qui résiste aux incendies, est une important plante nuisible de la végétation très variée des montagnes Cape. La prolificité de ses graines est la principale cause de l'envahissement par cette plante. Les larves de *Erytenna consputa* détruisent ses fruits immatures, et l'insecte a une capacité exceptionnelle d'adaptation à son hôte et de résistance aux incendies. De petits nombres de jeunes adultes ont été recueillis dans diverses régions d'Australie pour être libérés en Afrique du Sud où ils se sont établis. Le climat n'a pas constitué un facteur déterminant dans l'établissement ou l'efficacité du charançon. L'élément le plus crucial était la lignée de plantes-hôtes sur lesquelles les insectes avaient été recueillis. Après son établissement, *E. consputa* s'est bien dispersée et a permis de réduire considérablement le nombre de graines de *H. sericea* et, par conséquent, la régénération des populations de plantes nuisibles incendiées. Il ne sera sans doute pas nécessaire de recourir a des agents supplémentaires pour assurer la lutte intégrée contre cette plantes nuisibles.

Introduction

Hakea sericea Schrader (Proteaceae) is a woody, perennial shrub from southeastern Australia. It was deliberately introduced into South Africa some 150 yrs ago and was initially widely planted in the southwestern to eastern Cape Province (Neser and Fugler 1978). It has since become naturalized, mainly in mountainous areas, over nearly half a million ha (Kluge 1983), often occurring in dense, impenetrable thickets. The seeds remain viable in woody follicles which accumulate over the years on the plant. It has been estimated that 75 million seeds/ha may be accumulated on 15-year-old stands of *H. sericea* (Kluge 1984). Following the death of the plant, usually after fire, all the seeds are released simultaneously. Neser (1968) regarded the prolific seed production of *H. sericea* in South Africa, in the absence of natural enemies, as the main reason for its invasiveness. This gives *H. sericea* a competitive advantage over the usually sparsely seeding native plants, and leads to more successful dispersal of the weed and to the establishment of its seedlings in niches that may have been occupied by the indigenous vegetation, or that may have remained vacant. Because of the adaptation of *H. sericea* to wind dispersal and to fires (accumulation of non-dormant, winged seeds that are released *en masse* after fires to germinate in the ash bed as soon as sufficient moisture is present), frequent fires favour *H. sericea* and lead to the rapid increase in density of the weed, to the point where the original vegetation is largely replaced and/or overshadowed.

From surveys of natural enemies in Australia (Neser 1968, 1984), two complementary seed-attacking species were selected and tested for release in South Africa. These are the weevil *Erytenna consputa* Pascoe (Coleoptera: Curculionidae) whose larvae develop in, and cause the death of, young fruits, and the moth *Carposina autologa* Meyrick (Lepidoptera: Carposinidae) that develops on seeds inside mature follicles accumulated on living plants (Neser and Annecke 1973; Neser and Kluge 1984). The aim of using seed-attackers was to reduce the numbers of seeds released after fires. This would allow the original vegetation to compete more successfully with regenerating *H. sericea* seedlings, and would help to prevent the occurrence of vacant niches where other invasive plants might get established if the hakea plants were removed too rapidly.

In this paper the establishment and effect of the first natural enemy to be successfully established, namely *E. consputa*, is considered, as are the attributes of the insect that contributed to its success, and to the important part it plays in the control of *H. sericea*.

Biology of *E. consputa*

The biology, phenology and host-specificity of *E. consputa* have been described by Neser (1968) and Kluge (1983). Adult weevils may live for two or three years, and are present on their host plant throughout the year, sheltering mostly in the dry husks of fruits attacked by larvae in previous seasons. They feed on buds and young growth, and on flowers and young fruits when these are available. Eggs are laid in or near young, developing fruits in spring and early summer. Larvae develop singly in, and destroy, one or more young fruits. A new generation of adults appears within three months, but eggs are only laid during the following fruiting season. Maturation of eggs in ovarioles is closely linked to the phenology of the host plant. Eggs are produced during the period when flowering and/or young fruits are present (Neser 1968). This effectively synchronizes hatching with the presence of immature fruits suitable to young larvae. Fecundated females are capable of producing fertile eggs in subsequent years without having to mate again, and may lay over 100 eggs/year (Kluge 1983). Adults are capable of strong flight, and may escape fires by flying off and locating surviving host plants from which they may colonize the next generation of seedlings. Even in the absence of live host plants, adults with a well developed fat body may survive for several weeks without food (Neser 1968).

Release and Establishment

Between 1971–81 about 8000 adult weevils were collected in Australia and released directly in small groups of 50–100 individuals/release at 126 sites throughout the *H. sericea*-infested area. The hakea infestations occur in areas with a Mediterranean-type climate (i.e. with dry summers) and extend into more temperate regions further east where the rainfall is more evenly distributed throughout the year. In an attempt to enhance the performance of weevils in different climatic regions in South Africa, releases were made with material from climatically similar areas in Australia.

E. consputa established successfully (i.e. colonies showed a consistent increase over at least four generations) at 80 of the sites, and at a monitored release site occurred over an area of about 9 ha after four generations (Kluge, unpubl. data). Extraneous factors such as accidental fires and clearing prevented establishment at 36 sites. *E. consputa* from the temperate Nerriga area in southeastern New South Wales established successfully at sites experiencing both temperate and Mediterranean-type climatic conditions. By contrast, the material from Wilson's Promontory in southern Victoria, where it rains predominantly in winter, established poorly. Eight of the ten releases where *E. consputa* failed to establish, for no apparent reason, were made with material from Wilson's Promontory.

In a 50 × 50 m study plot on a hakea-infested mountain slope at Goudini in the southwestern Cape, where a single release of only 20 *E. consputa* adults had been made in 1975, the annual fruit loss increased from 39% in 1979 to 81% in 1981. Concurrent studies on marked branches showed that the weevil was responsible for up to 86% of the total fruit mortality. A fire swept through this site in 1982 and 2 yrs later only 46 seedlings were counted in eight 0.5 × 50 m transects in which 459 plants had occurred before the fire (Kluge, unpubl. data).

Discussion

Somewhat surprisingly, insects from the temperate Nerriga area established readily in South Africa even in areas with arid summers. Since distinct strains of both *H. sericea* and *E. consputa* from different geographic areas in Australia have been recognized (Kluge 1983) it would seem that incompatibility of some strains with the form of *H. sericea* prevalent in South Africa, and not climatic matching, has been important in the establishment of *E. consputa* (Kluge, unpubl. data).

Reducing the seed crop reduces the number of seeds reaching any point in the distribution range of a plant (Harper 1977). From the widespread establishment of *E. consputa*, and the substantial seed loss reported here it can be concluded that the weevil is limiting the rate of spread of *H. sericea*. The reduction in plant density at the Goudini study site suggests furthermore that the level of seed predation being achieved by *E. consputa*, in combination with the high post-dispersal seed mortality as recorded by Richardson and van Wilgen (1984), is sufficient to reduce the density of subsequent *H. sericea* generations. This was the first demonstration of reduction in density of *H. sericea* after fire. In the past, before the introduction of *E. consputa*, weed density typically increased after fires.

The following attributes of *E. consputa* are considered to be important factors in its success as a biocontrol agent:

(a) Longevity and adaptation to survive fires. The regions in southeastern Australia where the insect originated and those in South Africa where its host plant became a serious weed problem are subjected to frequent fires. However, adult weevils are present on the plants throughout the year and have the ability to fly strongly, to find, and to survive on host plants that may escape the fires. They may also feed on non-fruiting seedlings until the latter reach the fruiting stage. This allows early colonization of young hakea infestations that develop after fires. Early colonization of young plants effectively reduces the accumulation of seeds on these plants, and eventually the density of regeneration of the weed after fire.

(b) The synchronization of egg-laying by females with the presence of fruits suitable for larval development maximizes damage to the fruit crop of the weed, even if the onset and duration of flowering varies from year to year and from place to place.
(c) The fact that females, after mating only once, are capable of producing normal complements of viable eggs for one or more years allows establishment of colonies even if females disperse widely. This may be an important contributing factor in the observed successes in establishing colonies of the insect with single releases of 20–50 adults.
(d) Once well established, population levels of the insect are related to, and eventually probably limited by, the number of fruits produced on the host plant. Superoviposition, for example, is not likely to result in a decrease of the number of individuals maturing on a given plant, as the larvae are cannibalistic. Populations of the weevil will be governed largely by fruit production of the weed, at a level where the attack of fruits may be maintained at 80% or higher judging by results from the study site. At this site the weevil population increased with the fruiting capacity of young plants (Kluge, unpubl. data).

Because of the large reduction in accumulated seeds brought about by the establishment of *E. consputa*, it is likely that the density of regenerating plants after fires, and thus of infestations, will gradually decrease, as demonstrated at the Goudini study site. Furthermore, if dense infestations are left as long as possible, many plants will die as a result of attack by the fungus *Colletotrichum gloeosporioides* (Penz.) Sacc. (Melanconiales) which is now known to cause severe mortality amongst *H. sericea* plants (Morris 1982, 1983). Where dense infestations are burnt or cleared manually after *E. consputa* has multiplied on them, and especially if refuges for the weevils in the form of surviving or deliberately protected plants are left, any regenerating seedlings will be subjected to early weevil attack.

Although the seed-attacking insects by themselves may not provide a quick solution to the hakea problem in South Africa, it is evident that they are already contributing to hakea control by suppressing further spread and by reducing the density of infestations around release sites. Their effect on seed production will also help prevent the recurrence of dense stands, thus obviating expensive follow-up work in areas that have been cleared mechanically. Furthermore the weevil is compatible with both the fungus *C. gloeosporioides* and mechanical clearing, and will become increasingly important in the three-pronged control programme against *H. sericea* (Kluge and Richardson 1983). Present indications are that additional natural enemies as suggested by Annecke and Neser (1977) will not be required.

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