CONSTRAINTS TO THE INTRODUCTION OF BIOCONTROL AGENTS FOR PRICKLY ACACIA (*ACACIA NILOTICA*)

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Summary. Prickly Acacia, *Acacia nilotica*, is attacked by over ninety different species of insect in Kenya. However, only a small number of species appear to fulfil the necessary criteria for biocontrol being both adequately specific and potentially damaging. I suggest that the gall midges are potentially the most damaging insect group and extensive field survey work in Kenya indicates the midges are host specific. However, the requirement of the Australian Quarantine and Inspection Service that potential agents must be tested against a long list of plant species makes testing of these insects, which are very short lived and dependent on developing buds and flowers difficult. This is particularly so for prickly acacia as it has not proven possible to get this weed and many related species to flower and pod in pots.

INTRODUCTION

Prickly acacia, *Acacia nilotica*, is an exotic species which was deliberately introduced into Queensland in the 1920s and 1930s and promoted as a shade and fodder tree. Although prickly acacia trees are still considered beneficial at low densities in some situations, undesirable thickets develop from the enormous soil seed bank after years of above average rainfall. Prickly acacia is particularly a problem on the fertile black soils of the Mitchell Grass Downs (1, 2). Approximately 7 million hectares of a total of 22 million hectares of the Mitchell Grass Downs are currently infested with prickly acacia (27). It is predicted that given a series of wet years, the entire Downs region could be lost to prickly acacia thorn forest resulting in increased soil erosion and a much reduced carrying capacity (27).

A five year biological control program based in Pakistan was initiated in 1980 and resulted in the introduction of two insects, a seed-feeding bruchid and a shoot-boring moth (20). Only the bruchid, *Bruchidius sahlbergi* Schilsky, has established. It is now widespread destroying up to 50% of prickly acacia seeds. However, the bruchid appears to be having a minimal impact on the spread of prickly acacia.

A three year biological control project was initiated in Kenya in 1989. I was based at Muguga, near Nairobi, for the project. Ninety-one different species of insect were found attacking prickly acacia in Kenya. However, only a few of these species appear to have potential for biocontrol. Potential insect biological control agents must fulfil two different criteria: they must be adequately host specific and they must be potentially damaging. From these perspectives prickly acacia presents perhaps more challenges for biocontrol than "the average weed".

Prickly acacia is very closely related to much of the Australian flora. There are three subgenera of Acacia. Most phyllodinous Australian species are in the subgenus Heterophyllum. Many, principally African species, are in the subgenus Aculeiferum. Prickly acacia and two native Australian species, *Acacia bidwilli* and *Acacia sutherlandii* and one naturalized Australian species considered a beneficial, *Acacia farnesiana*, belong to the subgenus Acacia. The above three Australian members of the subgenus Acacia also occur on the Mitchell Grass Downs. A very high level of host specificity, perhaps at the level of species specificity, is thus required of potential control agents. However, if great biological control potential can be demonstrated, insects which also feed on the three Australian acacias in the same subgenera might be considered for introduction. Harris (9) and Cullen (4) discuss the risks associated with releasing control agents capable of feeding on native plant species and generally conclude that damage is unlikely to be significant.

Also, particular problems are presented by prickly acacia being a tree. Amongst other difficulties, potted prickly acacia and related tree species usually do not flower or pod, which makes testing (which must be undertaken in quarantine) and mass rearing of insects dependent on developing flowers and pods, impractical at the present time. We are currently experimenting to overcome this problem. An additional consideration with prickly acacia is the presence of nine recognized subspecies with different geographic ranges in Asia and Africa. The weed in Queensland is considered to be *A. nilotica indica*, native to the Indian subcontinent. *A. nilotica leiocarpa* and *A. nilotica subalata* are the two subspecies native to Kenya and the subspecies from which the insects discussed in this report were collected.

I will now discuss the five groups of insects found in Kenya which appear to have most potential for biocontrol and outline the present position with these insects with particular reference to their level of host specificity and potential to damage prickly acacia. The insects are discussed in what I consider to be an ascending order of potential for biocontrol. However, my attempts at grouping and prioritizing should be understood in the context that biocontrol remains in many ways as much art as science (5,26). It has in the past proven impossible to predict which insect species will be most effective.

An additional limitation of the following study, and of relevance to all biocontrol work, is increasing evidence for the prevalence of cryptic (also known as sibling) species (22). Should we dismiss insects as inadequately host specific on the advice of taxonomists using morphological characters? For example, cryptic species are very common in scale insects were morphological conservatism appears to be a widespread phenomenon (18). I only tested four of the eight species of scale insect mentioned in this report, the remaining four were rejected on the advice of taxonomists who indicated they were cosmopolitan and polyphagous.

RESULTS AND DISCUSSION

Flower-feeding lepidoptera. The flowers of acacias in Kenya are almost exclusively utilized by lepidoptera (15). I reared forty-three different species of lepidoptera from the inflorescences of twenty-six different species of Kenyan acacia over a two year period (15). Field survey data indicated that no species of lepidoptera is specific to prickly acacia but most appeared restricted to the subgenera *Acacia* and *Aculieferum*.

If these flower-feeding insects were likely to be very damaging to prickly acacia, feeding on the three Australian species in the subgenus Acacia might be tolerated (see 17 for a precedence). However, given that over 99% of the flowers produced by prickly acacia are normally aborted (25) I suggest an unrealistically large percentage of flowers would need to be destroyed for the lepidoptera to have any impact on seed production. In addition, dissection of inflorescences in Kenya suggested that most lepidopteran larvae do not destroy all flowers in an inflorescence before moving on to the next inflorescence (Marohasy & Hongo, unpublished data).

It would thus appear this group of insects have limited potential for the biological control of prickly acacia, being inadequately host specific and unlikely to be damaging.

Biocontrol issues

Seed-feeding insects. I found a diverse complex of insects attacking the pods and seeds of prickly acacia in Kenya including: externally feeding hemiptera; lepidoptera and hymenoptera which feed internally on green seeds; lepidoptera which feed internally on mature seeds; and bruchids and a cerambycid which feed internally on mature seeds (15). Field survey data and literature records indicate that many of the lepidoptera and hemiptera are pest species (15). Most of the bruchids and cerambycids appeared restricted to the acacias but field data for many of the species, and host specificity testing of two species, indicates they are also capable of feeding on the seeds of members of the subgenera Aculiferum and Acacia (15).

Feeding by the beetles on the three Australian acacias in the subgenus acacia might be tolerated if the beetles could be shown to have much potential for biological control (4,17). However, in my opinion any insect which feeds on mature seeds is unlikely to be effective in Queensland because mature pods tend to be eaten by sheep and cattle as soon as they fall to the ground. Seeds in these pods will pass through cattle and remain viable in cow dung, but will be inaccessible to attack by beetles which will not search for seed in dung. In addition, it appears particularly high levels of seed predation are necessary to have any impact on the population dynamics of long lived perennials with long lived seeds, like prickly acacia (1,3,11,21).

Insects which attack unripe green seeds may be more effective control agents as these insects can access the seeds before they fall to the ground and are fed on by stock. The eurytomid wasp, *Risbecoma capensis* (Walker), is the most promising insect in this category for the biological control of prickly acacia (15). Field survey data and museum collection records indicate *R. capensis* is specific to the subgenera Acacia and Aculeiferum. This means only the seed of *A. farnesiana, A. bidwilli* and *A. sutherlandii* in addition to prickly acacia, are likely to be attacked in Queensland. However, extensive host specificity testing, specifically of the Australian acacias in the subgenus Heterophyllum, would be necessary to confirm this.

R. capensis requires young developing pods for oviposition and larval development. It is thus not possible to rear or test this species until techniques are developed to stimulate pod-set at least in prickly acacia.

Interestingly a seed-feeding Eurytomid, *Eurytoma attiva* Burks, has been successfully used to prevent recolonisation by the weed tree *Cordia curassavica* in Mauritius (12).

Leaf-feeding insects. Seventeen species of insect were found attacking the foliage of prickly acacia in Kenya (15). A more thorough and systematic search in Kenya would probably result in the discovery of many more leaf-feeding insect species.

Interestingly ten of the species are lepidopteran and seven of these belong to the Geometridae. Preliminary host specificity testing of two species of geometrid in Kenya, indicated that one species, *Tephrina new species*, is restricted to the subgenera Acacia and Aculiferum and a second, *Semiothisa inconspicua*, is species specific to prickly acacia (15). I recommend that both species be imported into Australia for further testing at the Alan Fletcher Research Station.

Detailed testing of the Kenyan leaf-feeding chrysomelid beetle, *Weiseana barkeri* Jacoby, was recently completed at the Alan Fletcher Research Station and a report recommending its release in Queensland has been submitted to the Australian Quarantine and Inspection Service. This beetle appears particularly damaging on *A. nilotica* subspecies *indica* (23,14). Continued high levels of attack by leaf-feeding insects have the potential to reduce the fitness of tree species (3). We are hopeful this species will have an impact on *A. nilotica* once released.

Phloem-feeding insects. A large number of phloem feeding insects were found attacking prickly acacia in Kenya. Field surveys and host specificity tests in Kenya indicated that the aphids, two species of Cicadellidae, and eight species of scale insect have an unacceptably broad host plant range being able to feed on Australian acacias and in some instances other leguminous species (15).

Two species of psyllid were found on prickly acacia. Field survey data indicated that one undescribed species was able to feed on several species of Kenyan acacia (subgenera Aculiferum and Acacia) in addition to prickly acacia. A second species, *Acizzia* new species, appeared restricted in its host range to prickly acacia (15). Two attempts were made in Kenya to establish a colony of the *Acizzia* to conduct host specificity tests but both attempts failed perhaps due to fluctuations in relative humidities and temperatures which could not be controlled, due in part to electricity rationing. Muguga, in the Kenyan highlands, is considerably cooler than the arid regions of Kenya were prickly acacia grows.

Following approval from Australian Quarantine services, a shipment of psyllids was sent to the Alan Fletcher Research Station. These insects laid lots of eggs but the first instar nymphs all died without feeding. Given that the psyllid nymphs tend to be more specific than psyllid adults (10), it is possible that *A. nilotica* subspecies *indica*, the subspecies on which they were reared at the Alan Fletcher Research Station is not a suitable host.

Gall midges. The Kenyan acacias are host to an interesting complex of gall midges. I found twenty-eight species galling different species of Kenyan acacia. These species, their galls and acacia hosts are described in Gagné and Marohasy (8). Extensive field survey work established that all except for one species are monophagous (8). Five species attack prickly acacia. I believe three of these species, *Acacidiplosis spinosa* Gagné, *Acacidiplosis imbricata* Gagné and *Aposhizomyia acuta* Gagné, have considerable potential for the biological control of prickly acacia (15).

A. spinosa and *A. imbricata* gall the developing inflorescences, replacing seed pods. To appreciate the biocontrol potential of these midges it is necessary to have some understanding of the reproductive biology of acacias. Acacias and many other leguminous species produce many more flowers than they have the resources to mature (24). Tybirk (25) estimated that in prickly acacia 0.3% of flowers develop into pods. Flower abscission and pod maturation is probably selective, depending on the order of pollination, the number of developing seeds, pollen source, and available resources (24). However, it appears that prickly acacia trees can not abort the galls (as they can abort excess flowers) and that these galls act as energy sinks, consuming resources which would otherwise be available for pod maturation. Successful biocontrol of *Acacia longifolia* has been achieved in South Africa using a galling hymenoptera which operates in a similar way (6). Dennill (6) reports that the wasp sometimes committed *A. longifolia* to the production of 200% more galls per branch than the normal quota of pods. Dennill (6) dubbed this phenomena "forced commitment". Because of "forced commitment" *A. spinosa* and *A. imbricata* have perhaps more potential than other Kenyan insects for the biological control of prickly acacia.

I was unable to rear *A. spinosa* in Kenya. The midges would mate in cages but would not oviposit on two year old potted plants of prickly acacia (13). Given the great potential this insect has for biocontrol it would be worth further attempts at rearing in very large cages and with large flowering plants.

A. imbricata is closely related to *A. spinosa*. It may have less potential for biological control principally because the artichoke-like galls formed by this species are much smaller than the spiky galls of *A. spinosa*. The larger the gall, the greater the energy sink and the greater the potential stress on the host plant (6). This gall midge appears to have a broader distribution than the spiky gall midge, being also present in South Africa and Zimbabwe. I did not attempted to rear or test this species.

A. acuta forms a large lumpy gall, typically at the stem apex, inhibiting stem elongation. It is known that stem elongation in *A. nilotica* occurs immediately before the development of buds and flowers and that buds and flowers are only produced on green extending shoots (19). Through the inhibition of stem elongation this midge can thus effectively stop the production of flowers.

I was unable to rear this insect in Kenya (13). It would be worth further attempts at rearing under more controlled temperatures and relative humidities, in larger cages and with larger plants with larger stem-ends.

CONCLUSION

Only eight of the ninety-one insects found attacking prickly acacia in Kenya appear to have potential for biological control. Of these species, the psyllid, *Acizzia* new species, may be too host specific and the wasp, *R. capensis*, and the geometrid, *Tephrina* new species, may be inadequately host specific. The leaf-feeding beetle, *W. barkeri*, and the leaf-feeding geometrid, *S. inconspicua*, appear suitable for release in North Queensland. The gall midges, *A. spinosa*, *A. imbricata* and *A. acuta*, all appear species specific (8), however, because of a combination of Australian Quarantine and Inspection Service requirements, our current inability to rear the midges and our inability to get potted acacias to flower and pod, the use of these midges as control agents for prickly acacia remains an elusive objective.

Interestingly only three of the seventy-two species of insect found during the biocontrol project in Pakistan (20) were also found on prickly acacia in Kenya. When plants have extensive geographic ranges it is not uncommon that different insect species are found in different parts of their range (7,16,26). Given prickly acacia's broad distribution across the African continent, central Asia and the Indian subcontinent, it is reasonable to expect many more potential biological control agents await discovery in regions distant to Kenya and Pakistan (15).

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