New biological control opportunities for prickly acacia: exploration in India

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Summary Prickly acacia (*Acacia nilotica* subsp. *indica*), a multipurpose tree in its native range, is a Weed of National Significance in Australia. It is widespread throughout the grazing areas of western Queensland and has the potential to spread throughout northern Australia. Biological control research has been in progress since the 1980s, but with limited success to date. Climatic modelling and genetic studies have indicated that the search for biological control agents should be concentrated in India, the source of the prickly acacia populations in Australia. Hence, a project was initiated in India to conduct surveys in Tamil Nadu and Karnataka States in southern India, and Rajasthan and Gujarat States in northwest India. Surveys in India commenced in July 2008, and the survey sites include both natural groves and forestry plantations. So far, 77 insect species and 14 diseases have been recorded in Tamil Nadu and Karnataka, while 14 insect species and 11 diseases have been documented in Rajasthan and Gujarat. Among them, a leaf-webbing caterpillar, a scale insect, two species of leaf-feeding weevils and a rust fungus infecting leaves and inducing galls on rachis and pods have been prioritised for host specificity studies

Keywords Prickly acacia, *Acacia nilotica* subsp. *indica*, survey, biological control, India.

INTRODUCTION

Prickly acacia (*Acacia nilotica* subsp. *indica* (Benth.) Brenan), a Weed of National Significance in Australia is widespread throughout the natural grasslands of western Queensland. In the Mitchell Grass Downs of western Queensland, over 7 million ha and 2000 km of bore drains are infested with this weed (Mackey 1997). Prickly acacia is also present in the coastal regions of Queensland, the Northern Territory and Western Australia, and has the potential to spread throughout northern Australia (Mackey 1997). Mechanical and herbicide treatments are available to manage this weed, but they are relatively expensive. Prickly acacia is susceptible to herbivory (Dhileepan *et al*. 2009). Hence, effective biological control, a low cost and permanent alternative, is considered by many to be the only hope of long term sustainable control of this weed (Dhileepan 2009).

Biological control of prickly acacia was initiated in the early 1980s, with surveys in Pakistan, Kenya and South Africa (Palmer 1996). So far six species of insects have been released in Australia. Only two of these, a seed-feeding bruchid *Bruchidius sahlbergi* Schilsky from Pakistan and a leaf-feeding geometrid *Chiasmia assimilis* (Warren) from Kenya and South Africa, have become established (Dhileepan 2009). The seed-feeding bruchid is the only agent that occurs in all areas where prickly acacia is found, including western Queensland where the largest populations of the plant are located. However, its impact on prickly acacia populations remains very low (Radford *et al*. 2001). The leaf-feeding geometrid moth, on the other hand, only became established in a few coastal sites in northern Queensland, but not in the Mitchell Grass Downs (Palmer *et al*. 2007). The need for effective biological control agents continues to be a priority in the Mitchell Grass Downs, where the introduced agents have either not established or are ineffective.

Genetic studies indicated that the invasive *A. nilotica* population in Australia is *A. nilotica* subsp. *indica*, which is native to India and Pakistan (Wardill *et al*. 2005). The probability of finding additional agents from Pakistan is low given the extensive nature of previous surveys there. India is the only native range of *A. nilotica* subsp. *indica* yet to be explored. Matching the climatic conditions of localities of prickly acacia in western Queensland with regions in India indicated that most of the areas in India are climatically suitable, with the state of Rajasthan being the most suitable (Dhileepan *et al*. 2006). The occurrence of several native subspecies of *A. nilotica*, along with other native and non-native *Acacia* species, including species native to Australia, highlights the advantage of

conducting surveys in India where the field host-specificity of potential agents could be determined. Hence, surveys in India were initiated to select potential biological control agents for prickly acacia.

MATERIALS AND METHODS

***Acacia nilotica* in India** *Acacia nilotica* is a multipurpose tree that both occurs naturally and is cultivated widely throughout India. It is used in agroforestry, social forestry, reclamation of wastelands and rehabilitation of degraded forests. In traditional agroforestry systems, *A. nilotica* provides fuel, fodder, gum, tannin and timber. Among the various subspecies of *A. nilotica* that occur naturally in India, *A. nilotica* subsp. *indica* is the most prominent and widespread subspecies. In addition, other species of *Acacia*, including species native to Australia also occur widely in India, and in some areas co-occur with *A. nilotica* subsp. *indica*.

Collaboration A preliminary survey was carried out in 2004 in the states of Rajasthan, Chhattisgarh, Karnataka, Kerala and Tamil Nadu to identify potential collaborative agencies and natural prickly acacia infestations in India. The Institute of Forest Genetics and Tree Breeding (IFGTB) based at Coimbatore, Tamil Nadu, and the Arid Forest Research Institute (AFRI) based at Jodhpur, Rajasthan, were selected as suitable collaborators to conduct surveys in southern (Tamil Nadu and Karnataka) and northwest (Gujarat and Rajasthan) India, respectively.

Project initiation Funds for the project were secured from Meat and Livestock Australia (MLA) in July 2007. Approval from the Indian Government was obtained in November 2007, and contracts with the two collaborating research agencies in India were signed in February 2008. The project began in July 2008.

Survey sites After obtaining necessary information and approvals from relevant state forestry departments, suitable survey sites were identified in Tamil Nadu, Karnataka, Rajasthan and Gujarat States to conduct field surveys in protected forest areas. In Tamil Nadu and Karnataka survey sites are predominantly forestry plantations in tank beds, and isolated plants on roadside and tank bunds of agricultural lands (Figure 1). Survey sites in Rajasthan and Gujarat include both natural groves and forestry plantations (Figure 2) and cover a range of age groups from seedlings to mature trees.

Survey methods The survey efforts in Tamil Nadu were more systematic and rigorous than in Gujarat and Rajasthan, where different districts and areas were

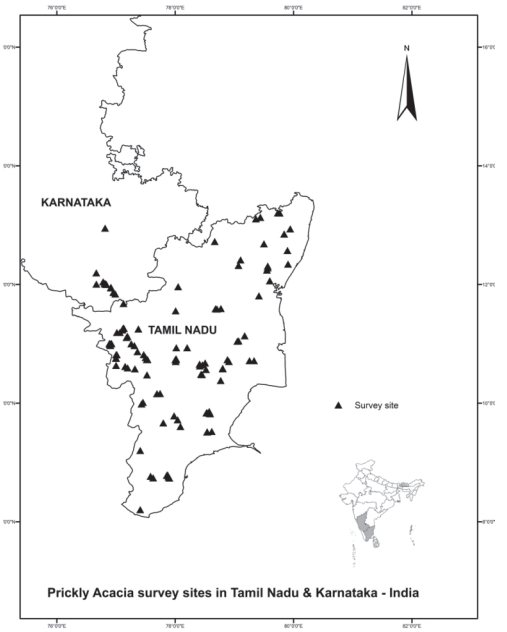


Figure 1. Survey sites in the Indian states of Tamil Nadu and Karnataka.

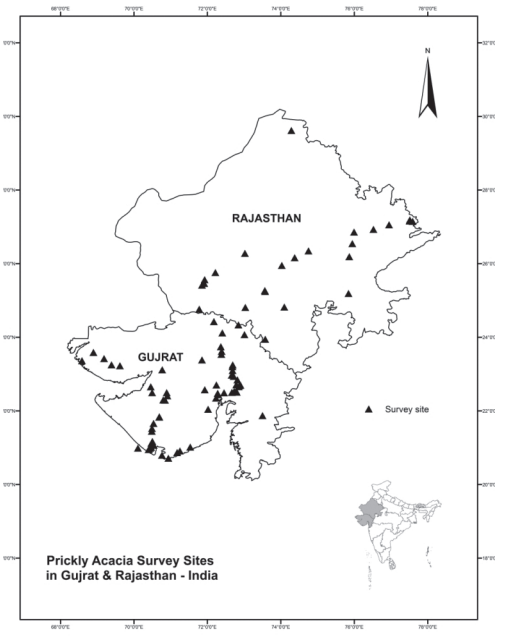


Figure 2. Survey sites in the Indian states of Gujarat and Rajasthan.

covered at different months on the basis of accessibility. In Gujarat and Rajasthan four pre-determined sites within each state representing varied climatic regions were sampled at quarterly intervals. During the surveys, other acacia species nearby were also sampled to monitor the field host specificity of various insects and plant pathogens recorded on *A. nilotica*.

RESULTS

In the states of Tamil Nadu, Karnataka, Rajasthan and Gujarat, *A. nilotica* subsp. *indica* was the most prevalent and widespread subspecies. In Tamil Nadu, subsp. *tomentosa* occurred with subsp. *indica* in some survey sites. In Karnataka, subsp. *cupressiformis* co-occurred with subsp. *indica* at Chamrajnagar district bordering Tamil Nadu. In Gujarat, subsp. *hemispherica* was prevalent in protected nature reserves and national parks (e.g. Gir Forest) and along the southern coast. In Rajasthan, subsp. *cupressiformis* was widespread and co-occurred with subsp. *indica* throughout the state.

In southern India, surveys were conducted in 64 sites in Tamil Nadu and eight sites in Karnataka (Figure 1). In northwest India, surveys were conducted in 22 sites in Rajasthan and 48 sites in Gujarat (Figure 2). So far, 77 species of insects and 14 diseases have been recorded on *A. nilotica* in Tamil Nadu and Karnataka. In Rajasthan and Gujarat 14 insect species and 11 diseases have been recorded.

Most of the insect species, such as the defoliating weevils (*Myllocerus* spp.) and bagworms (*Pteroma* spp.), are known to have a wide host ranges. Many of the pathogens recorded, such as die back (*Botryodiplodia theobromae*), root-rot (e.g. *Ganoderma lucidum*, *Macrophomina phaseolina* and *Fusarium* sp.), leaf blight (*Phyllosticta* sp.) and powdery mildew (*Oedium* sp.), are also known to have wide host ranges. An exception is the rust (*Ravenelia acacia-arabicae* Mundkur & Thirumalachar), which infected leaves and induced galls on the rachises and green pods of *A. nilotica* subsp. *indica* in Tamil Nadu. Unidentified leaf rust (*Ravenelia* sp.) on *A. nilotica* subsp. *indica* collected from Talala and Tarapur in Gujarat appear specific to subsp. *indica* in the field.

In southern India (Tamil Nadu and Karnataka), a leaf-webbing caterpillar (*Phycita* sp.), a scale insect (*Anomalococcus indicus* Ayyar), two leaf-feeding weevils (*Dereodus denticollis* Boheman and *D. mastos* Herbst) and a rust fungus (*R. acacia-arabicae*) infecting leaves and inducing galls on the rachises and pods have been prioritised for further studies based on field host range. The host specificity of these agents has yet to be determined.

Laboratory colonies of the prioritised insects have been established at IFGTB, and preliminary host specificity tests using various *Acacia* spp. native to India are in progress. Fumigated seeds of 17 Australia *Acacia* spp. have been sent to India for inclusion in host specificity tests. Attempts to standardise inoculation methods and maintain rust infection on potted prickly acacia plants are in progress at IFGTB and AFRI.

DISCUSSION

In India, available information on insects and plant pathogens associated with *A. nilotica* has been gathered from the perspective of enlisting forestry plantation and nursery pests (Madhavan Pillai *et al*. 1995). Identification of both insects and pathogens is proving difficult because taxonomic expertise is scarce and moving specimens internationally is difficult. Although many of the collected insects and pathogens are yet to be identified, the results so far indicate that insects recorded in India and in particular the prioritised insects from southern India are distinct, and do not appear to overlap with those reported from Pakistan.

So far, four insect species and one gall-inducing rust fungus (all from southern India) have been prioritised for detailed host specificity tests. A shoot-tip gall inducing insect that was found only during September-November in Gujarat was initially considered a promising agent, but is not being pursued for host specificity studies due to difficulties in collecting adults for identification and colony establishment. Potential of the new leaf rust collected recently in Gujarat as a potential biological control agent will be evaluated after identification.

Our future goal is to import the prioritised insects to Australia for detailed host specificity tests. Applications seeking approvals to export live agents to Australia were submitted by AFRI and IFGTB to the National Biodiversity Authority (NBA) of India in July 2009. The NBA has advised that we are exempt from requiring approval since the research project is a collaborative one between the Indian and Queensland Governments. Currently, we are seeking a formal approval from the Department of Environment and Forestry (DE&F) in India, to export biological control agents to Australia. Once formal approval to export insects from India is received, applications seeking permits to import the four prioritised insects into Australia for detailed host specificity tests will be lodged with the relevant Australian authorities.

Our current quarantine facility is not suitable for screening plant pathogens. Hence the rust fungus will not be imported into Australia immediately. We anticipate that the QC3 level quarantine facility being constructed as part of the Queensland Ecosciences

Precinct will be ready in mid-2011. We are currently exploring the feasibility of conducting overseas a preliminary host specificity test involving 10 to 15 Australian *Acacia* species. If the rust is found to be host specific in the preliminary host test, the rust can be imported into Australia for full host specificity tests in the new QC3 quarantine facility.

ACKNOWLEDGMENTS

We thank Meat and Livestock Australia for funding the study, Dr N. Krishnakumar (Director, IFGTB) and Dr T.S. Rathore (Director, AFRI) for the facilities and support; Dr V.V. Ramamurthy (Indian Agricultural Research Institute) and Dr George Mathew (Kerala Forest Research Institute) for insect identifications; and Dr Dane Panetta, Dr Bill Palmer, Di Taylor (Alan Fletcher Research Station) and Dr Shane Campbell (Tropical Weeds Research Centre) for comments on the manuscript.

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