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General News

New Hope for Sustainable Control of Russian Knapweed in North America

In 2008 and 2019, USDA-APHIS (US Department of Agriculture – Animal and Plant Health Inspection Service) and the Canadian Food Inspection Agency (CFIA) approved field release of two biological control agents against Russian knapweed (*Acroptilon repens*): the gall wasp *Aulacidea acroptilonica* and the gall midge *Jaapiella ivannikovi*. Both agents have since been released and successfully established in North America, raising hope that the dominance of Russian knapweed, which has been crowding out North America's native plants for the past 100 years, will be soon reduced and its further spread slowed down or even stopped.

Mistakenly introduced to North America from Asia in the late nineteenth century, Russian knapweed has since spread across 45 states in the USA and is also considered noxious in Alberta, Canada. It propagates by vegetative and sexual means. North American populations produce about four times more seeds than those in the native range[1], a difference at least partly due to significant herbivore pressure on seed output in the native range. While recruitment of seedlings within established *A. repens* patches is rare, it is the most important mechanism by which new sites are colonized within the invaded range. Viable seeds are a common occurrence in the faeces of cattle and wildlife which, according to Ron Lang (recently retired from USDA-APHIS) appear to play an important role in spreading *A. repens*. Moreover, despite the fact that an earlier paper claiming to have identified a secondary metabolite in Russian knapweed with allelopathic properties was retracted, there is growing ecological evidence that many North American plants are poorly adapted to Russian knapweed. For example, Ni *et al.* [2] reported that when they grew North American and European plant species together with Russian knapweed in pots, they found that the North American plants produced only 8–40% of the biomass compared to when growing alone. The impact of Russian knapweed on European plants was significantly smaller than that on North American plant species.

Since large-scale chemical control is detrimental to the environment and uneconomic on low-value land, first attempts to control this invasive species by biological means were made in the 1970s. The first agent released against Russian knapweed was the nematode *Subanguinea picridis*. Unfortunately, even though laboratory experiments suggested that this agent can have considerable impact on growth and seed output of Russian knapweed, it has not proven to be successful in the field.

A team from CABI identified the wasp and midge as natural enemies of Russian knapweed in its original habitats of central Asia and Turkey. With the help of partners Biotechnology and Biological Control Agency (BBCA, Italy), Montana State University and the University of Wyoming, USA, Agriculture and Agri-Food Canada (AAFC), Çukurova University, Turkey, and the Uzbek Academy of Sciences, Uzbekistan, they have conducted detailed research to ensure that these insects will successfully check the spread of Russian knapweed in North America while having no adverse effects on other plants or animals.

Long-term pre-release studies revealed that the two shoot-galling insects are highly specific and cause significant impact on Russian knapweed. In a field experiment conducted in the native range in Uzbekistan, attack by *A. acroptilonica* reduced shoot length by 21%, above-ground biomass by 25% and seed output by 75%, while attack by *J. ivannikovi* reduced shoot length by 12%, above-ground biomass by 24%, and seed output by 92% [3].

First releases of the biocontrol agents were made in Wyoming, Montana, Colorado and Alberta, and establishment has been repeatedly reported. First assessments of the impact of the gall midge on Russian knapweed at a post-release monitoring site in Wyoming by Lars Baker and Nancy Webber (Fremont County Weed & Pest, Wyoming) revealed impact levels comparable to what has been predicted from the pre-release studies; seed output per shoot was reduced by 91% and above-ground biomass by 34%. However, care should be taken in extrapolating from estimates of the impact on growth and seed output of individual Russian knapweed shoots to the long-term impact at the population level. The impact of the two gall-forming insects on Russian knapweed in North America ultimately depends on the population size these biological control agents reach in the introduced range, a factor that remains difficult to predict in biological control.

While the two biological control agents can significantly reduce the seed output of Russian knapweed, thereby slowing down or even stopping the further spread of this aggressive invader, they will hardly be able to kill large Russian knapweed clones. Hence, successful management of Russian knapweed in North America may require optimizing the integration of biological control with other management options, including small-scale physical or chemical control measures.

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[2]Ni, G-Y., Schaffner, U., Peng, S-L. and Callaway R.M. (2010) *Acroptilon repens*, an Asian invader, has

stronger competitive effects on species from America than species from its native range. *Biological Invasions* 12, 3653–3663.

[3]Djamankulova, G., Khamraev, A. and Schaffner U. (2008) Impact of two shoot galling biological control candidates on Russian knapweed, *Acroptilon repens*. *Biological Control* 46, 101–106.

Contact: Urs Schaffner,
CABI, Delémont, Switzerland.
Email: u.schaffner@cabi.org

Tamarisk Biocontrol Programme Enters New and Uncertain Phase

Tamarix biocontrol takes off

The *Tamarix* biological control programme is one of most successful, and controversial, weed biocontrol efforts ever undertaken. In particular, the perceived complex interactions between tamarisk (also called saltcedar) biocontrol and endangered species currently impinge on other weed biocontrol programmes nationally, with a heightened level of scrutiny beyond what many consider a 'safe and reasonable' level of caution. There is recent cause for optimism that some of the conflicts may be partly resolved through a combination of riparian restoration initiatives and a rigorous monitoring programme to validate the safety of the programme for sensitive riparian ecosystems.

Adventive populations of several *Tamarix* species and hybrids infest roughly a million hectares in western North America, with diverse impacts to wetland ecosystems including displacement of native riparian woodlands and riparian-dependent wildlife species, erosion and sediment deposition damage in stream channels, groundwater depletion in arid regions, and greatly increased fire hazard in floodplains, which historically provided fire-resistant barriers to wildfire spread. Conventional control methods were costly, environmentally damaging and unsustainable, leading to efforts to develop biocontrol for suppressing this widespread shrub. The history of the programme, largely led by Drs. Jack DeLoach (USDA-ARS [US Department of Agriculture – Agricultural Research Service] Temple, Texas) and Ray Carruthers (USDA-ARS Albany, California) with many collaborators loosely organized as the Saltcedar Biocontrol Consortium, was described along with some of the early results in a previous *BNI*[1], and this report provides an update on the programme since then.

The tamarisk beetle *Diorhabda elongata* (*sensu lato*) was the first and thus far only insect to be approved and released for the biological control of tamarisk. The original experimental releases in 2001 followed almost a decade of pre-release evaluation of non-target risks of this chrysomelid leaf beetle (two other insects, the tamarisk weevil, *Coniatus tamarisci*, and a mealybug, *Trabutina mannipara*, both received approval by the Technical Advisory Group on the Biological Control of Weeds but were never released). Several 'ecotypes' of *D. elongata* were used in pre-release and overseas evaluations so when it became clear these may comprise a species complex, a revision of the taxonomy of tamarisk-feeding *Diorhabda* revealed five sibling species of *Tamarix* specialists[2]. The biocontrol programme used four of these, three of which are established in North America. Those include populations of the central Asian species *D. carinulata* (northern tamarisk beetle) originating from western China and Kazakhstan and now widespread in Nevada, Utah, Colorado and Wyoming with establishment in Oregon and Idaho. *Diorhabda carinata* (larger tamarisk beetle) from Uzbekistan was released in Texas but is not well established, whereas *D. sublineata* (subtropical tamarisk beetle) from Tunisia was released in 2009 along the Rio Grande in Texas and did establish. *Diorhabda elongata* (*sensu stricto*; Mediterranean tamarisk beetle) was released in Texas, California and New Mexico and is established in Texas and northern California.

The first evidence of leaf beetle establishment was at the Humboldt Basin of northern Nevada, where within three years of its 2001 release *D. carinulata* had expanded at an unanticipated rate to defoliate tamarisk on roughly 10,000 ha across three hydrologic basins. The associated reduction in photosynthetic activity resulted in groundwater savings of approximately three million cubic metres (2500 acre-feet)[3]. In warmer regions to the south savings may be even greater, with longer growth seasons and higher water demands by tamarisk, and with two and often three generations of the herbivores in a year. Similar large-scale dispersal and defoliation by *D. carinulata* were subsequently observed at other release sites, including the Walker River in central Nevada, Big Horn River in Wyoming, and the Sevier River in central Utah[2]. The Utah research site was the source of beetles transferred to the Colorado River and tributaries such as the Dolores River in Utah and western Colorado, where similarly extraordinary strength and extent of establishment took place. Repeated defoliation causes gradual dieback of the host plants and depletion of stored metabolic reserves over a period of several years, while outright mortality has been observed after three or more years at these sites, up to 75% or more in parts of the original Humboldt Basin release area and over 50% at one site in western Colorado[4].

Elements of ecosystem recovery have also been noted, although because target decline and subsequent responses are incremental over a period of many years, much work remains to comprehensively document the benefits, as well as the risks, of *Tamarix* suppression. Native willows increased in cover where *Tamarix* dieback on the middle Colorado River reduced competition, while Texas researchers indicate enhancement of forage plants where biocontrol has reduced *Tamarix* canopy density; and, unfortunately but not surprisingly, increases in other noxious weeds like Russian knapweed (*Acroptilon repens*), perennial pepperweed (*Lepidium latifolium*) and *Bassia* spp. already present in the *Tamarix* understorey at Nevada experimental sites. Especially relevant to wildlife agencies has been the increase in diversity and abundance of migratory birds in the presence of leaf beetles at our Walker

River (Nevada) release site[5] in response to food resource enhancement owing to the beetles themselves, as well as larger generalist predators (Coccinellidae, Reduviidae, Arachnida, etc.) that increase in response to this abundant new resource.

Widespread target defoliation and beetle population expansion were encouraging signs indicating the potential value of *Diorhabda* in *Tamarix* suppression. In 2005 an implementation programme was initiated through the USDA Animal and Plant Health Inspection Service (APHIS), whereby hundreds of thousands of beetles were collected from Nevada and distributed to dozens of sites in ten western US states. The implementation process was to be monitored to answer questions concerning the benefits and risks of a major biocontrol programme. From 2005 to 2008 the programme was successful and offered a unique opportunity to study the establishment and impact of a biocontrol agent, as well as offering states the opportunity to obtain a valuable management option for tamarisk.

Diorhabda *goes south*

In the initial releases, *D. carinulata* establishment only occurred in areas north of ca. 38° North latitude, and only where central Asian *T. ramosissima* and its hybrids, but not *T. parviflora*, were the dominant infesting taxa. The latter species originates in the Mediterranean region, and is not recognized as a host by the ovipositing central Asian adult beetles[6]. Other congeners were better able to use this species, and modest establishment is documented in northern California where *T. parviflora* is common[2]. At other locations predation on adult and/or larval beetles by generalist predators, particularly ants but even land crabs, appeared to inhibit establishment. But the primary relationship related to establishment success or failure involves the induction of over-winter diapause in *D. carinulata*. Bean *et al.*[7] documented that shortening daylengths in the fall cause beetles to enter reproductive diapause, after which they reduce activity level and build food stores before descending into the litter where they are quiescent until green-up the following spring. In southern regions this daylength cue comes too early, causing beetles to enter the litter in mid-summer, resulting in nutritional stores being depleted before the end of winter.

Other ecotypes or species of *Diorhabda* imported from more southerly sources than the Chinese/Kazakh *D. carinulata* (origin 43–44° North) were better able to establish in southern latitudes of North America, particularly in Texas where three other species of *Diorhabda* are now found[2], with strong establishment of *D. sublineata* and extensive defoliation along 100+ km of the lower Rio Grande. The latter population was the source of some international concern when epidemic population sizes caused defoliation of athel (*T. aphylla*), a non-target evergreen form of *Tamarix* widely used as a shade tree. In subsequent years this unintended effect will probably recede, as was observed in Nevada when horticultural tamarisks were temporarily damaged. Political sensitivities required substantial effort to quell, so many years of cross-border communications with Mexican biologists by DeLoach and his Texas collaborators were well spent.

At the same time, an important finding has been the evolution of a new photoperiodic response by *D. carinulata*, illustrated from sites along a latitudinal gradient from Wyoming to New Mexico. After about five years in the field with ten to 15 generations, the day length required for diapause induction decreased by as much as 54 minutes in southern locations[8]. This has facilitated further southward expansion as the beetles, which were originally univoltine south of roughly the border between Arizona/New Mexico and Utah/Colorado. They are now multivoltine at those locations enabling the colonization of northern Arizona and northern New Mexico by the beetles experiencing natural selection for better phenological synchrony with their host plants. In addition to decreasing day length requirements for reproductive activity there has also been evolution of greater temperature sensitivity in the response to photoperiod. Natural selection for improved diapause timing has shifted the phenology resulting in increased efficacy of *D. carinulata* along with its southward progress; good news for tamarisk managers, but unwelcome to some wildlife biologists.

Beetles and flycatchers collide

In 2006 tamarisk leaf beetles were transferred by county weed managers from the Sevier River, Utah test site into the Virgin River watershed of southwest Utah, bringing them for the first time into the breeding zone of the south-western willow flycatcher, *Empidonax traillii extimus*. This subspecies is a federally listed Endangered Species whose decline was ironically related, in part, to replacement of native cottonwood–willow riparian woodlands by invasive tamarisks. Nonetheless, documented nesting of the flycatcher in tamarisk trees in parts of the southwestern USA meant that interference with tamarisk within the breeding range of the bird triggered Consultation with the US Fish & Wildlife Service (FWS). The concern that *Tamarix* biocontrol would alter habitat of the flycatcher had also been the reason for several years delay between APHIS approval of *Diorhabda* introduction in 1996 and its eventual release in 2001, and then only in areas 200 miles away from any known nesting by the bird in tamarisk.

The widespread 2008 dispersal of *Diorhabda* in the Utah portion of the Virgin River ratcheted wildlife agency concerns to a higher level, particularly as this was further south than establishment was anticipated. The fact that beetles were evolving to colonize even further south into flycatcher territory was too much for some, and in 2010 led to the re-initiation of a lawsuit by the Center for Biological Diversity against federal agencies (APHIS, FWS) to halt the biocontrol programme, even though the beetle was already literally ‘out of the box’. Public service announcements and a national media campaign by wildlife agencies and other opponents of the biocontrol programme created a mini-furor, causing the extraordinary response by APHIS, though possibly understandable under the circumstances, to cancel its implementation programme. Standing permits were rescinded, existing monitoring programmes were cancelled and all pending permit requests denied indefinitely, with threats that transport of agents could lead to quarter-million dollar fines. This was despite no evidence of harm to the bird, yet the same year a wildfire partly fuelled by tamarisk destroyed two active south-western willow flycatcher nests in the same Virgin River watershed where the controversy was focused. The agency furthermore raised the bar on other weed biocontrol programmes lest similar controversies arise elsewhere, even though this amounted to a virtual zero-risk requirement for approvals that many in the weed biocontrol community felt could jeopardize the availability of biological control as a realistic tool for managing weed invasions.

Part of the initial controversy was that USDA and collaborating researchers were unrealistically expected to also develop and fund restoration following tamarisk biocontrol, the fear being that agent introductions would lead to the rapid mortality of plants before native vegetation could recover, and that in many human-altered western riparian areas conditions were too inhospitable for native plants to recover. On the other hand, doing nothing would lead to an unsustainable situation in which a weed/fire cycle was now set up leading inexorably to even further dominance by tamarisk[9]. More rational would have been for resource managers to pursue longer-term objectives of improving both riparian condition and wildlife populations through targeted restoration. Coincidentally, our research group including scientists from the University of California and the US Geological Survey were already evaluating the effectiveness of conventional tamarisk control and restoration projects in the Virgin River, so we were poised to document the process and impacts of *Diorhabda* as it moved through the watershed from Utah into Arizona and Nevada. Those efforts did reduce the threat of wildfire, but also degraded habitat for wildlife. Specialists were recruited from other institutions, including the Colorado Department of Agriculture, University of Nevada, Arizona State University and the University of Utah, to expand the ecological breadth of the monitoring programme, with hopes that real data on both the positive and negative responses to tamarisk biocontrol would counter the speculation that interfered with rational policy, and eventually allow federal agencies to re-enter negotiations over the perceived threats of biological control to the south-western willow flycatcher[10]. Despite difficulties in securing agency support, monitoring continues with participation from additional organizations (Desert Botanical Garden, University of Arizona, Desert Research Institute, Northern Arizona University, Utah State University and others).

The other reason for optimism regarding both biodiversity protection and the *Tamarix* biocontrol programme involves direct action to facilitate riparian recovery where the flycatcher is at risk. Dismayed by the inability of federal agencies to act, a private foundation, the Walton Family Foundation, stepped in to support restoration in the Virgin River watershed and eventually other south-western river systems where similar conflicts lay down the road. A Technical Advisory Committee was organized by the Tamarisk Coalition composed of researchers, conservation and restoration interests and agencies, particularly the FWS, to map a way forward for enhancing riparian habitat in the context of tamarisk suppression by biological control. The first grants were awarded this year and are already being spent on growing native plant materials and installing plants in priority locations, anticipating future occupancy by the bird. Restoration efforts will be guided by a Science Team to evaluate hydrological and ecological conditions throughout the Virgin River watershed to target sites where growing conditions favour both desired vegetation and avian occupancy, while avoiding sites likely to be damaged by future flooding. The latter is in response to severe losses in 2010 flooding of habitat actively restored following another major flood in 2005… and that near St George, Utah, had been the only case of active restoration leading to occupation by the south-western willow flycatcher! This programme is described more fully in a paper[5] derived from the recent 'Biocontrol for Nature' symposium organized by Roy van Driesche and friends that is being published in the journal *BioControl*.

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By: Tom Dudley[a] and Dan Bean[b]

[a]Marine Science Institute, University of 'California, Santa Barbara, CA 93106, USA.
Email: tdudley@msi.ucsb.edu

[b]Colorado Department of Agriculture,
Palisade Insectary, Palisade, Colorado, USA.
Email: Dan.Bean@ag.state.co.us

Lantana: the Battle Can Be Won

A recent paper in *PLoS ONE*[1] discussing "a battle lost?" against *Lantana camara* and the "futility of eliminating lantana", arguing instead for "adaptive management", has attracted considerable attention from the invasive species community.

The paper makes interesting reading because of the way in which information was collected. Familiar as we are with systematic reviews that rely on online resources, it was refreshing to read that authors Bhagwat *et al.* sifted through Oxford's Bodleian Libraries to find reports mentioning lantana, published by forestry and land management departments in Australia, India and South Africa from the 1800s until the present. For India, they also searched in government libraries in Bengaluru, Chennai and Nilambur for references relating to the Nilgiri Hills (the focus area in that country). This laudable exercise turned up over 3000 records (only 500 via databases), which the authors estimate represent over 75% of records on invasion and management of lantana in these countries. These were whittled down to 116 suitable for analysis: 53 from Australia, 22 from India and 41 from South Africa. After going to so much effort to produce this unique set of references, and using it for a novel historical study of lantana's spread, how did they evoke such an emotive response?

The paper is liberally sprinkled with the term 'eradication'. This "naive use of the word", to quote CABI's Dick Shaw[2] and echoed on blogs and listservs, includes the authors' assertion that "the established paradigm is to expend available resources on attempting to eradicate invasive species." It is possible they were distracted by language in their references, and extrapolated from 'eradication' in the context of legislation requiring individual land managers to eradicate or control lantana on their piece of land, or in forest department reports on tackling infested areas, to a country-wide context. Repeatedly, the authors confuse or fail to apply appropriately the terms 'eradication', 'containment' and 'control'. They state that, "the number of reports about control increased in the 1970s in Australia ... and South Africa ... suggesting that substantial effort was made to eradicate lantana around this time". However, they misinterpret the aims of the programmes, which focused on control not eradication. The window of opportunity for eradication is limited – and has long since closed for lantana in the three countries in this study.

More worrying for Shaw is what he sees as a trend in "publishing negative pieces on invasive [species] management, leaving us with the feeling we should give up and accept what opportunist ecologists now call novel ecosystems." Hence, a reason for examining the paper here. Bhagwat *et al.*'s central argument is that the substantial effort put into "eradicating" lantana in Australia and South Africa has not stopped it spreading, so it is time to admit defeat and come up with a new approach: "While legislation and management have aimed at controlling the density and spread of lantana, there is limited evidence for success of such control measures." They do not consider what would have happened if no control was implemented and lantana was left to its own devices. Even slowing the spread of an invader may be important. A study in Australia showed a 9:1 benefit:cost ratio for a 5% reduction in lantana[3], indicating that even small reductions lead to significant economic savings, through reduced control costs and/or greater control efficiency.

Bhagwat *et al.*'s analysis shows poor understanding of classical biological control. They fail to take account of the time lag between release, establishment and impact of a biocontrol agent, often measured in decades. Michael Day (Biosecurity Queensland), author of the lantana chapter in CSIRO's new book on biological control of weeds, points out that the sheer area of infestations, as well as issues such as climate, biotypes and ecology, mean success is going to be slow. Day says it is not surprising that lantana was still spreading up until the 1970s in Australia, as much of the biocontrol effort was conducted after the 1960s and populations of new agents would still be increasing. Records suggest lantana spread has slowed, and is being contained to existing areas[4,5]. Bhagwat *et al.*'s data, he argues, allow them to plot how lantana has invaded over the years, but analysis of impact of intervention is only meaningful from the date of major initiatives (taking into account whether efforts were sustained) – or in the case of biological control, when agents began to have an impact.

The authors seem to express incredulity that "rapid invasion of lantana has even [sic] instigated legislation for its control in Australia and South Africa". They make the assumption that legislation pertains mainly to chemical or mechanical control and underplay its importance in preventing the importation and dissemination of *L. camara* and its cultivars, and providing a framework for the introduction of biocontrol agents. It also provides landowners who effectively manage lantana with the means to 'force' neighbours to do the same in order to reduce the probability of re-invasion. Legislation is not the pariah here, but there is often a lack of will by authorities to actually enforce the letter of the law. CABI's Arne Witt points out that none of the countries neighbouring South Africa has legislation or management programmes for lantana. Many people living in rural areas in southern Africa have it growing – as hedging or ornamentals – so the propagule pressure is huge: "However much you do as a country there is always going to be re-invasion," he says. "You can't assume it's the control measure that is failing. It's people failing to adequately implement control, and people's behaviour can change."

Bhagwat *et al.* deem lantana control a failure "despite intensive management" with no consideration given to reasons. Day questions how they quantified degree of intervention: "it seems by number of papers on the topic" although it is more realistic to quantify effort (area cleared and kept clear, dollars spent, etc.) as the determining factor influencing success. (And given their reference base, the number of source documents could conceivably reflect changes in reporting requirements.) Although Bhagwat *et al.* discuss the high costs of lantana management and lantana-related losses, they do not consider the impact of control. An evaluation in South Africa indicated an 8- to 34-fold benefit:cost ratio for its lantana biocontrol programme[6]. Babu *et al.*[7] highlight how lantana may impact adversely on communities and create an imperative for control. The case study from the Corbett Tiger Reserve in India describes successful eradication and habitat restoration of two lantana-invaded sites to productive grasslands and mixed woodlands using native species. This enhances habitat quality for herbivores whose populations are vital prey for top carnivores such as tigers, and reduces human–wildlife conflict.

Bhagwat *et al.* describe the well-documented adverse impacts of lantana and attempt to balance them with an unconvincing case for positive qualities, e.g. that lantana can prevent erosion (its shallow root system makes it less effective than deep-rooted trees and native species) and extracts have medicinal potential (the literature is awash with similar claims for many species). They provide no data on the benefits of utilization. Their description of adaptive management as "an iterative, ongoing process of learning and responding to environmental conditions while acknowledging their dynamics, uncertainty, and changes over time" gives no indication of why it should be an improvement on existing strategies. They concede that lantana will need to be controlled under some circumstances and that better tools are needed – specifically mentioning biological control in this context – but they see adaptive management as the cornerstone. To illustrate how this could operate they turn to India, describing how, in the absence of legislation and control programmes seen in the other two countries, "local communities have adapted to the presence of lantana ... a whole new cottage industry has sprung up in areas where lantana is now abundant" and a larger-scale paper industry. K. V. Sankaran, Director of India's prestigious Kerala Forest Research Institute which is located in the Western Ghats, does not recognize the situation they describe and voices astonishment at the idea that lantana might be managed by exploitation. Witt says that no widespread weed has been controlled through utilization alone anywhere in the world – even guava, with its much sought-after fruits, is still invasive in Africa and Indian Ocean islands. Sankaran has some years of experience of working with lantana in the field and recently returned from the Mudumalai Wildlife Sanctuary in Tamil Nadu – close to the authors' study area – where he saw "vast stretches of just lantana as the only undergrowth in the forest – impenetrable thickets. No human effort can clear it. This is just one example." Lantana has also invaded the majority of India's pastureland and without management will continue to invade productive ecosystems. Sankaran differentiates lantana thickets associated with human habitation, which may be amenable to extirpation, from extensive ecosystem invasions, and points out that Bhagwat *et al*'s adaptive management model would not fit into the framework of India's forest laws. He says that the utilization they describe is currently limited to a small fraction of the forest-dwelling communities in north-eastern (Assam and neighbouring) and south-western (especially Karnataka) states, and they use only the thick stems. He adds, "I hope and pray that this is not practised by more people since it promotes spread of the weed [and] lantana regrows vigorously from the rootstock wherever the stems are removed." The proponents of lantana cottage industries say that it is comparable to species such as cane and bamboo which is normally used for such purposes. But since it is not easy to work with lantana and the other species give more attractive and durable products, it is not a preferred choice.

Witt picks up on this point, saying that Bhagwat *et al.* are missing a significant economic issue: resource-poor people are likely to exploit a readily available but poor resource while more affluent people will not. So the model the authors describe would not work in Australia, for example, and there are dangers in seeing it as a sustainable management strategy anywhere. There are numerous examples where invasive species have been utilized because they are readily available and cheap. Water hyacinth (*Eichhornia crassipes*) was promoted as animal feed by the Chinese Government in the middle of the last century during a period of dire economic difficulty but was abandoned when the economy recovered and better feed was affordable, leaving a massive weed problem as it continued to take over waterbodies. In Africa, *Opuntia* (cactus) hedges are used by poor people while wealthy people use wire fences – the latter being more convenient and easier to maintain. Ironically, poor rural communities in some areas, who used cactus as a living fence, have now abandoned their homesteads as a result of cactus invasions, and reverted back to using thorny branches as a barrier, something they did prior to the introduction of cactus. They have learned the hard way that utilizing an invasive alien plant may generate a problem.

While cross-disciplinary studies can be useful and even inspirational, authors generally take care to understand the basics of the discipline they are entering. Bhagwat *et al.* state that in India there is a change "in management strategy from eradication to control and acceptance", arguing that this "reflects not only a realisation of the futility of eliminating lantana altogether, but also increasing cognisance of its ecosystem effects, both positive and negative." More likely, it reflects the framework for managing an invasive species used by scientists and practitioners in the field and as laid out in Article 8h of the Convention on Biological Diversity: the time for eradicating lantana is long past and control has been the name of the game for a very long time. This fundamental mistake means that although the paper provides interesting historical data on the spread of lantana, it says little useful about its management past, present or future.

Alan Urban of the Plant Protection Research Institute in South Africa is appalled by Bhagwat *et al.*'s suggestion that the Old World should "embrace" lantana, and the novel (i.e. transformed) ecosystems it creates, on the grounds that "eradication" (meaning control) does not seem feasible, and that lantana can be utilized for medicine, basket-making, paper-making, etc. This implies that we should simply accept the 'green tide' of lantana, and 'kiss' indigenous biodiversity and ecosystem services goodbye. Yet it has been shown that active, persistent, integrated mechanical–plus–chemical control achieves the local extirpation of lantana, which enables the restoration of invaluable indigenous ecosystems[7,8,9]. Biocontrol is of enormous value in reducing the frequency and cost of this strategy. Newly released biocontrol agents such as the herringbone leaf miner, *Ophiomyia camarae*, and the flower gall mite, *Aceria lantanae*, are providing marked, additional suppression of lantana, especially in the hot and humid coastal zone[10], demonstrating that lantana biocontrol can be improved. There is still a desperate need to select and release additional agents, specifically ones adapted to continental climatic conditions with a dry winter. The contributors to this article agree that, with continued research, it should be possible to improve integrated management of lantana throughout the Old World.

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Contributors: Arne Witt (a.witt@cabi.org),
Michael Day (Michael.Day@deedi.qld.gov.au),
Alan Urban (UrbanA@arc.agric.za),
K. V. Sankaran (sankaran@kfri.org) and
Dick Shaw (r.shaw@cabi.org).

More Mikania Biocontrol Agent Releases in the Pacific

Following introduction of the rust *Puccinia spegazzinii* against *Mikania micrantha* to Papua New Guinea (PNG) and Fiji, and its rapid spread in PNG (*BNI* [32(1), March 2011), funding from USDA-APHIS (US Department of Agriculture – Animal and Plant Health Service) is allowing the rust fungus to be introduced against the invasive climber in Guam, where it is estimated to infest some 130 ha. The introduction will be made by Dr Gadi V. P. Reddy (University of Guam) with Dr Christy Leppanen and team at the Western Pacific Tropical Research Center – Chemical Ecology and Entomology Laboratory. Working in collaboration with Secretariat of the Pacific Community (SPC) in Fiji, Dr Reddy's team has obtained a permit to release the strain of *P. spegazzinii* that was released in Fiji and PNG. Live spores of *P. spegazzinii* will be cultivated on Guam for release into the field. Dr Reddy anticipates that the fungus will thrive in the hot humid conditions on the island and reduce the severity of the mikania. The rust fungus will also be released in the Commonwealth of the Northern Mariana Islands.

Source: University of Guam.

Heather Beetle Outstrips Herbicide in New Zealand

Over the last ten years *BNI* (22(1), March 2001, and 29(3), September 2008) has reported on the at times unsure progress of the heather beetle (*Lochmaea suturalis*), which seemed a very promising agent for a conservation target when it was first released for control of heather (*Calluna vulgaris*) on the Central Plateau of New Zealand's North Island in 1996. Landcare Research scientists put a good deal of effort into finding out why the agent was slow to establish and spread, and now it seems perseverance is paying off.

According to a report in the latest issue of Landcare Research's *What's New in Biological Control of Weeds?*[1] several large beetle populations have slowly built up and are currently attacking large areas of heather in and around Tongariro National Park following releases in 2001. In fact, as at 2012 beetles have now damaged or killed more than 200 ha of heather but given the total infested area stands at more than 50,000 ha there is still a long way to go.

The results of a field experiment set up in 2007 have shown that the biocontrol agent out-performs herbicide application for controlling heather because of absence of non-target damage from the beetles. While two years of herbicide applications reduced heather cover by 90%, over the same period the beetles on their own reduced it by 99%, and a combined treatment gave a similar result (99.9%); in a control plot with neither herbicide treatment nor beetles, heather continued to spread and become denser. However, although all treatments gave acceptable results in terms of heather control, the herbicide treatment reduced cover by native woody and herbaceous dicots, with some species no longer found (although it did eliminate another invasive weed, *Pilosella officinarum* – mouse-ear hawkweed). In biocontrol plots, other woody and herbaceous dicot species initially maintained their presence and have now clearly benefited from heather removal five years on.

The team is continuing to try and increase the spread of the beetles throughout the Central Plateau, conducting experiments and refining releases in the light of results. For example, they are currently assessing whether boosting foliar nitrogen at new release sites helps to establish beetles by 'kick-starting' populations, and whether beetle feeding behaviour means that heather density/patchiness affects beetle performance. There are also plans to increase the genetic diversity of the *L. suturalis* population in New Zealand with beetles from more closely climate-matched areas in Scotland; given the painstaking efforts it took to produce a microsporidian-free population for the first time round, Landcare Research plans to reduce the risk of contamination this time by importing males only from Scotland, and discarding them once mated with females from the existing line.

[1]Wilson-Davey, J. (2012) Biocontrol beats herbicide for heather control. *What's New in Biological Control of Weeds* No. 59 (February), pp 6–7. Landcare Research New Zealand Ltd 2011.

Contact: Paul Peterson, Landcare Research, Private Bag 11052, Palmerston North 4442, New Zealand.
Email: petersonp@landcareresearch.co.nz

Biological Control of Weeds in Australia: the Book

Between 1903 and 2010, a total of 73 weeds – over 90 species – were targeted for biological control in Australia, and more than 200 insect and pathogens were released as biocontrol agents against them. A 648-page book published in April 2012 by CSIRO[1] provides a comprehensive account, chapter by chapter, of biocontrol activities in and for Australia against these invasive weeds over that period, authored by Australian and international experts. It demonstrates the far-reaching economic, environmental and scientific benefits that biological control has provided for Australia, together with its important future role.

The example of classical biological control of prickly pears (*Opuntia*) in Australia by the cactus moth *Cactoblastis cactorum*, imported from the New World, helped to set the future for the approach in Australia and many other countries. By the 1980s Australia was a world leader in terms of weed species targeted and new agents introduced. Importantly, there have been no serious negative non-target impacts in Australia, which is at least in part a reflection of the country's expertise and leading role in developing rigorous risk assessment and biosecurity measures. Economic assessments have shown that biocontrol of weeds in Australia up to 2005 provided a benefit:cost ratio of 23:1 for the agriculture and health sectors, with environmental benefits on top of that.

Australia also led the world with the first deliberate introduction of a plant pathogen as a biocontrol agent, the rust fungus *Puccinia chondrillina,* released in 1971 against skeleton weed *Chondrilla juncea*, which over a 15-year period was brought under control in south-eastern Australia. This success underlines a recurring theme in the book – that classical biological control is a long-term commitment. It also underscores the importance of international collaboration – and the significant role that CSIRO's biological control and exploration labs in Montpellier, France, and formerly in Vera Cruz, Mexico, have played. As Paul Barro (CSIRO Theme Leader for Invasive Species and Plant Biosecurity) says, "Biocontrol successes can take 15 or 30 years to reach full effect, and while not all efforts succeed they invariably complement other measures and the cost benefits are indisputable."

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