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A new record of *Parthenium hysterophorus* from the United Arab Emirates

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Parthenium hysterophorus L. commonly known as parthenium weed has been recorded for the first time in the United Arab Emirates (UAE) by the authors. Addition of parthenium weed to the introduced flora makes UAE the third nation in the Gulf countries (GCC), after Oman and Yemen where the weed has been recorded. During the recent floral survey, a total of four mature plants of *P. hysterophorus* were recorded from a garden on the Hamryah coast, Sharjah, UAE (N: 25.47843˚ and E: 55.49994˚, Alt.: 1.5 m asl.). Plant species such as *Launaea nudicaulis*, *Chloris virgata*, *Carthamus tinctorius*, *Senecio glaucus* and *Heliotropium kotschyi* were all growing in association with parthenium weed at this site.

The climate of the UAE is characterized by high summer temperatures (up to 50˚C in July), low humidity and low rainfall. The average, annual rainfall in the mountain region is only 140-200 mm and along the east coast (100-140 mm) is generally higher as compared to the west coast only 60 mm where parthenium weed was recorded. The presence of this highly invasive plant under the hyper-arid climates of the UAE indicates its great tolerance to the harsh climatic conditions.

Indeed, parthenium weed is among the top ten worst weeds of the world and has been listed in the global invasive species database. It is considered troublesome and has caused adverse ecological, economic and social impacts worldwide. As the UAE is experiencing fast growth and development, and undertaking mega commercial and agricultural exchange projects, there is an increased possibility of spontaneous introductions of other new plants to the country's flora. It is believed that the introduction of parthenium weed to the UAE was accidental and possibly through the importation of agricultural products. However, introduction of this plant by natural means may also have occurred as it is present in one neighbouring country Oman and nearby Yemen. Human-mediated seed dispersal, grazing livestock and motor vehicles have all been shown to disperse weed seeds and these are all other important introduction and spread pathways.

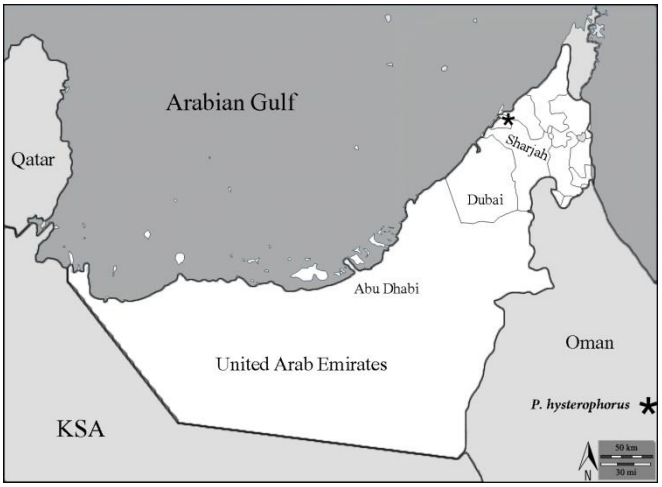

Figure 1: Map showing the site within the UAE where parthenium weed was recorded.

Based on a literature search, it appears that weed introductions can have profound impacts up on the regional economy and the ecological integrity of native plant species/communities. The introduction of

parthenium weed in the GCC may seriously affect the crop productivity in these countries, countries that are already suffering from a critical shortage of fresh water. Further research is therefore needed to monitor the spread, population dynamics and to evaluate the threat posed by parthenium weed and other weed species to the native, and especially to the rare and threatened plants and their habitats in the UAE. For effective management, all known populations of parthenium weed need to be eradicated and , the sites cleared and monitored for a number of years for theany emergence of new plants from the soil seed bank.

Figure 2: Herbarium specimen of parthenium weed collected from Sharjah.

Killer weed found at foot of Mt Kinabalu

The Star Malaysia, 20 Dec 2014

The invasive weed parthenium weed has made its way to the foothill of Mount Kinabalu, underscoring the pervasiveness of the plant throughout Malaysia. A small patch of the weed was detected in Kampung Lasing Ranau, said Sabah Agriculture Department Director Idrus Shafie. Idrus and his team were the first to discover it here after the the plant, also known locally as rumpai miang Mexico, had been discovered in Peninsular Malaysia earlier this year. To destroy the weed and to prevent it from spreading to other areas in the valley is of high importance adding that his Department was already determining the severity of the infestation in Sabah. “We are working with all district personnel to create awareness” of this weed. “We are also liaising with the Health Ministry to identify the health hazards posed by this weed,” said Idrus, who added that flyers were being distributed to farmers in the region to educate them on the dangers posed by the weed. Agronomists in Sabah are now taking immediate steps to manage the populations so far found

Figure 1: The invasive weed parthenium weed ***s* has made its way to the foothill of Mount Kinabalu, underscoring the pervasiveness of the plant throughout Malaysia.**

Variable field establishment and a new biocontrol agent for *Parthenium hysterophorus* in South Africa

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Although *Parthenium hysterophorus* (parthenium weed) has invaded more than 34 countries globally, causing severe economic consequences in some, only a limited number of countries (Australia, India, South Africa, Ethiopia, Tanzania) so far have actively adopted biological control as a management option. This is despite the fact that the use of introduced, selective natural enemies from the origin of the plant has been demonstrated to be an effective, sustainable control method to manage parthenium weed infestations in Australia for several decades.

In South Africa, parthenium weed has invaded the northern and eastern regions, which experience sub-tropical conditions. Spread continues here, as well as in neighboring countries, and more widely along the eastern length of the African continent. In an attempt to curb the plant’s spread in South Africa, biological control efforts commenced in late 2003, based on the successes obtained in Australia. In 2010, the summer rust fungus *Puccinia xanthii* var. *parthenii-*

hysterophorae (Pucciniales: Pucciniaceae) was first released in South Africa, adding to the effects of the existing *Puccinia abrupta* var. *partheniicola* (Pucciniales: Pucciniaceae). Multiple releases of the summer rust fungus, *P. xanthii*, against parthenium weed were undertaken during the past two growing seasons (November to February; 2013/14 and 2014/15) in Mpumalanga and Kwazulu-Natal (KZN) Provinces. Whole, heavily rust infected parthenium weed plants (called 'Trojan' plants) were placed in the field at 1 to 2 m intervals with an average of 9 'Trojan' plants per site (Fig. 1).

Figure 1: Alana Den Breeyen and Andrew McConnachie implementing field releases of 'Trojan' *Puccinia xanthii* infected parthenium weed **plants.**

Release sites were monitored twice during the growing season for disease incidence. Since its release in 2010/11, the summer rust has established and spread to surrounding parthenium weed plants at most of the release sites in Mpumalanga Province. Successful establishment of *P. xanthii* was observed for the first time in January 2014 at the entrance to the iSimangaliso Wetland Park in KZN (Fig. 2). Follow up monitoring at this site in November 2014 determined that the summer rust fungus survived throughout the dry winter season and managed to re-infect emerging plants in early summer. In March 2015, a survey was undertaken along the N4 highway between Malelane and Komatipoort in Mpumalanga Province to determine the extent, if any, of the natural spread of *P. xanthii.* The summer rust fungus was present in low to medium incidence (Fig. 3) on all parthenium weed populations surveyed every 5 – 10 km for approximately 40 km (Fig. 4). In the coming season, permanent, secure sites will be established in both Provinces to monitor the long-term impact of the summer rust fungus on parthenium weed populations in South Africa.Subsequent to the introduction of *P. xanthii*, the stem-boring weevil *Listronotus setosipennis* (Coleoptera: Curculionidae) and the leaf-feeding beetle *Zygogramma bicolorata* (Coleoptera: Chrysomelidae) were approved for release, after being shown to be suitably host specific, and released from mid-2013 onwards. Since then, about 14,100 *L. setosipennis* adult weevils have been released into 75 sites and about 23,800 *Z. bicolorata* (mostly adults) have been released at 132 sites in the Provinces of KZN and Mpumalanga, with releases still continuing. Following initial release and after *Z. bicolorata* and *L. setosipennis* had persisted through a full summer and winter season, establishment in South Africa could be confirmed for the first time, during late 2014. Their establishment was however limited in some cases, particularly for *Z. bicolorata*. Several release sites had been disturbed or destroyed between seasons, and establishment was not observed at several unaffected sites either.

Figure 2: First symptoms of successful establishment of the summer rust *Puccinia xanthii* on parthenium weed **in KwaZulu-Natal Province.**

Figure 3: *Puccinia xanthii* pustules on parthenium weed plants **along the N4 highway between Malelane and Komatipoort, Mpumalanga Province.**

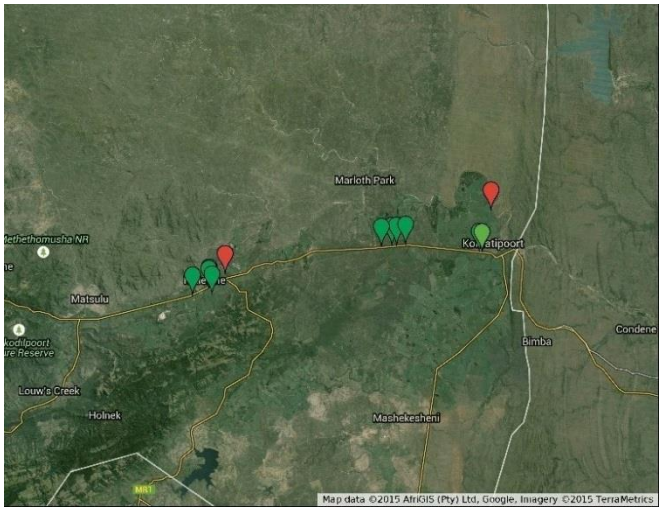

Figure. 4: Map of the natural spread of the summer rust fungus *Puccinia xanthii* from the original release sites (red pins) in Mpumalanga Province.

Establishment was in fact observed at some sites that had been mechanically cleared, so disturbance is unlikely to be accountable for the non-establishment in all cases. In November and December 2014, *L. setosipennis* was found to have established at about 42% of 24 release sites assessed, with better results in Mpumalanga Province (established at 64% of sites) than in KZN (23%), possibly due to regional differences in rainfall and temperature patterns. At that time, *Z. bicolorata* establishment was limited (found at only 9% of 46 sites assessed), only observed in Mpumalanga Province and not at any of the sites assessed in KZN. Release sites were revisited in February 2015; *L. setosipennis* was again similarly present at 44% of 25 sites assessed (present in 36% of sites evaluated in KZN and 55% of Mpumalanga Province sites). Establishment of *Z. bicolorata* had improved slightly, at 19% of 54 sites, this time present in both KZN (11% of sites) as well as Mpumalanga (31% of sites). So, field establishment of *Z. bicolorata* was particularly poor, despite the fact that the beetles had been present at 50-60% of release sites in KZN and Mpumalanga at the end of the first summer of release (Feb. 2014). Establishment at sites from the second season of releases (2014/2015) is still to be assessed, following a full year in the field. Investigations are underway to determine factors that may be influencing the establishment of *Z. bicolorata*, and alternative field release techniques are being investigated in an attempt to improve success. Thermal tolerances of *Z. bicolorata* and *L. setosipennis*, and the spread and impact of the agents in the field are also being investigated.

The rearing of large numbers of *L. setosipennis* is labour intensive, so in November 2014, the Weed Biocontrol Unit at the South African Sugarcane Research Institute near Durban began assisting with the production of *L. setosipennis* for field release, following training by ARC-PPRI and the provision of a starter culture. First releases from this supplementary culture took place in August 2015, together with weevils reared by ARC-PPRI, providing larger numbers per release which should enable wider establishment.

To complement the effects of the leaf and stem-attacking biocontrol agents, the niche of seed production was targeted to reduce further weed spread. In December 2014, after host range testing demonstrated a very high degree of specificity, the seed-feeding weevil *Smicronyx lutulentus* (Coleoptera: Curculionidae) (Fig. 5) was approved for release in South Africa. This was to be the fourth biocontrol agent to be deliberately introduced onto parthenium weed in South Africa. This tiny weevil, at just 2 mm adult length, inserts eggs into young, developing flower buds (Fig. 6), completes larval development within the developing seeds, before pupating in the soil, with adult emergence triggered with the onset of spring rainfall. First releases were conducted around Hluhluwe in KZN on January 14th 2015 (Fig. 7), and about 9,000 adults were released at 32 sites in KZN and Mpumalanga Provinces until May 2015, when field sites became unsuitable due to the onset of the dry season. Mass-rearing of *S. lutulentus* is now underway at ARC-PPRI Cedara, with large numbers readily reared, and releases will continue this coming season with the onset of rainfall. Preliminary assessment of field establishment will be conducted during summer 2015/16, followed by the evaluation of spread and impact of the weevil.

In compliance with the guidelines of the National Strategy for the Management of *parthenium* weed in South Africa, developed during 2014, biological control release efforts are focused in the asset protection zones. Currently, these designated zones are regions in the north of KZN and the eastern part of Mpumalanga Province, based on the extent and density of parthenium weed infestations there. Chemical control efforts in this zone are suggested to be largely confined to only the sides of road networks, around schools and clinics, and with herbicide assistance programme for some landowners, due to the unmanageable extent of infestations, leaving the remainder to be managed through biological control. Research in quarantine continues on the host range testing of the root-crown boring moth *Carmenta* sp. nr. *ithacae* that was imported from field established sites in Queensland, Australia in 2014, with the expectation that it would be suitable for release in South Africa at some future time.

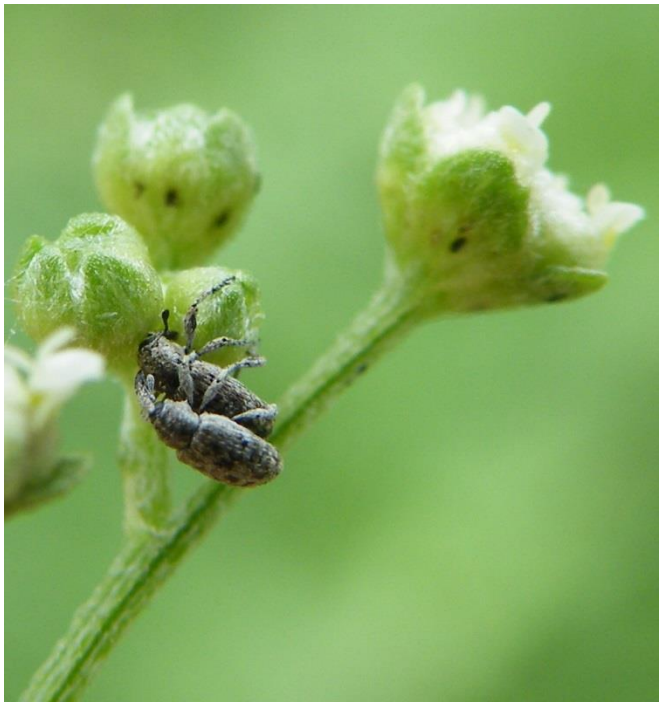

Figure 5: Adults of *Smicronyx lutulentus*, the seed-feeding weevil, on parthenium weed shoot tips with young flower buds.

Figure 6: Oviposition on *P. hysterophorus* by *Smicronyx lutulentus*. Eggs are inserted into young flower buds.

South Africa has about 2,300 native species within the Asteraceae family, and *Carmenta* is now being assessed on a sub-section of closely related native and economically important Asteraceae species. Regional and international cooperation for the biological control and management of parthenium weed is vital for other affected countries. Indeed, many technology transfer biocontrol projects on other weeds have demonstrated considerable cost savings. The South African biocontrol programme run by ARC-PPRI continues to cooperate with East African countries for the development of parthenium weed biocontrol on the continent, providing technical advice and starter cultures of biocontrol agents. ARC-PPRI is a partner in the USAID-funded Integrated Pest Management Innovative Lab project on biological control of parthenium weed in East Africa, a new project coordinated by Virginia State University, which runs from 2015 until 2019, incorporating Ethiopia, Kenya, Uganda and Tanzania. The project aims to build on progress from the previous two phases, initiated in 2005, by newly introducing biocontrol agents into the partner countries, and expanding on existing activities.

Figure 7: First field release of *Smicronyx lutulentus* on parthenium weed in South Africa (near Hluhluwe, KZN Province) on 14 January 2015, by ARC-PPRI Cedara parthenium weed team.

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Approval of the South African national strategy for the management of famine weed (*Parthenium hysterophorus*)

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Due to the growing concern over the increasing extent and impacts of *Parthenium hysterophorus* (locally referred to as famine weed) in South Africa, and the need for a national, coordinated management approach, a National Strategy for the Management of Famine Weed was developed during 2014 and approved on the 26th of July 2015 by the Department of Environmental Affairs Natural Resources Management Programme (DEA NRMP). The strategy was compiled in line with South Africa's National Environmental Management: Biodiversity Act (NEMBA) legislation, which calls for management plans to be developed for all category 1b invasive species in South Africa. The strategy was developed during 2014 with 78 participants, representative of various stakeholders, providing input at workshops and on several draft versions of the document. An implementation plan was also developed to outline stakeholder roles, responsibilities, and describe an action plan with time frames, but funding constraints for full implementation currently restrict the approval of this document. It was decided to use the common name "famine weed" in the national strategy and implementation plan instead of "*Parthenium hysterophorus"* for reasons explained by Macdonald (2014).

After reviewing numerous strategies for the management of other species, the Grice *et al*. (2011) framework for geographic differentiation of management objectives for invasive species was adopted as the most appropriate model to guide the formulation of the famine weed national strategy for South Africa. Each metropolitan and local municipality in the country was divided into one of five zones (Fig 1) using the Grice et al. (2011) decision tree. Each zone is described below with management actions and targets to be achieved. The zones are as follows:

- **Prevention 1 zone**: areas where famine weed is not yet present, and where habitat is unsuitable for invasion by the species;
- **Prevention 2 zone**: areas where famine weed is not yet present, but where suitable habitat exists (applicable if > 1% of the municipality has a medium to high probability for invasion);
- **Extirpation zone**: areas where famine weed exists in localized, low-density populations, and where local eradication is deemed feasible;
- **Containment zone**: areas invaded by famine weed, and where extirpation would not be possible, but where containment is still feasible;
- **Asset Protection zone**: areas with widespread, dense infestations of famine weed, where containment is not feasible. Locally eradicate new infestations wherever possible; to contain further spread of existing infestations, or reduce their extent where possible; and to reduce the impacts on selected assets in areas where containment is no longer possible.

It was recognized that the achievement of these goals would require interventions that would: increase awareness of the problem among stakeholders, enabling them to recognize the species in areas where it does not yet occur, to appreciate the potential impacts of the plant, and to understand the available management options; ensure that biological control is used to the fullest possible extent to reduce the impacts of famine weed and to supplement other control methods; and encourage the use of sound management practices that would reduce the risks of further invasion in degraded areas.

In 2003, South Africa became the first African country, and only the third country worldwide to implement a biological control programme against famine weed (Strathie *et al*. 2011). This research will be continued and expanded, and the distribution of approved agents will be strengthened through the proposed use of mass-rearing facilities. Of the more than 34 countries where famine weed has invaded, only Australia has managed to achieve a reasonable degree of control, largely due to the use of biological control. The need for research is recognized in the strategy and it is proposed to establish a research forum, under the auspices of a programme steering committee, to co-ordinate and review research and to foster information and technology transfer.

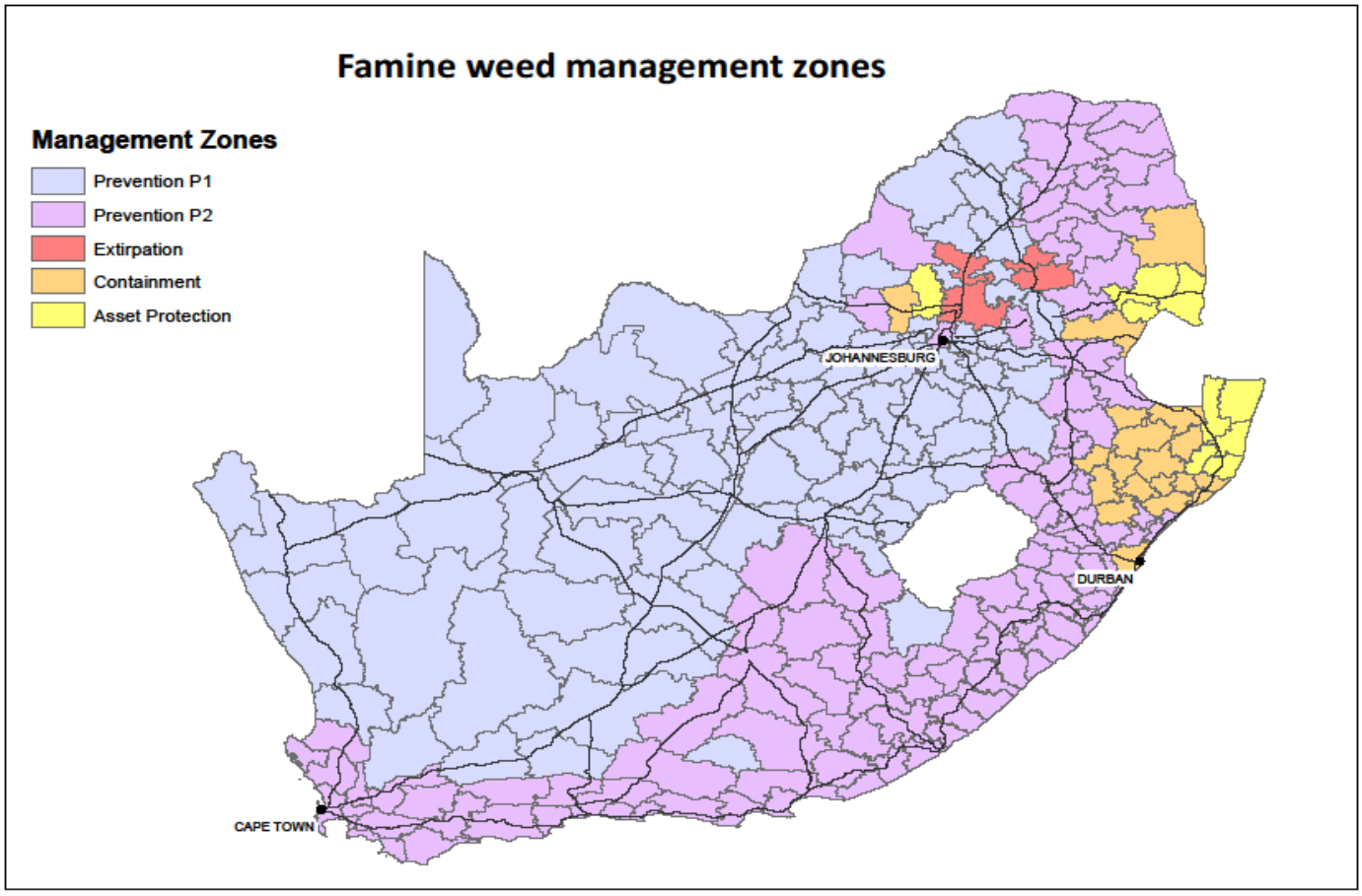

Figure 1: South Africa's famine weed management zones.

Performance indicators were set for each goal in the strategy to be achieved. The implementation plan provides management targets for each performance indicator, and assigns responsibilities and timeframes to enable achievement of each action. Baseline data are currently not available (for example, accurate estimates of the extent of invasion are not available, and there is much uncertainty regarding the availability of funding to support the different interventions). The intent, therefore, is to use the performance indicators as a starting point to establish baseline values, with the view to political engagement that would lead to agreed targets at a later stage.

The implementation plan provides for the establishment of a national programme, overseen by a national coordinator, and guided by a multi-departmental steering committee. It lists appropriate management actions to be taken in each zone, details how biocontrol research and implementation is to be expanded, and details the monitoring and evaluation to take place to ensure progress against the goals. Co-ordination of the current activities of various stakeholders, as well as limited availability of funding resources, are current challenges restricting the full roll-out of the outlined actions.

This work has been submitted for publication, and the strategy document will be made publically available. The development of a national strategy to manage famine weed is a welcome relief for all stakeholders in South Africa who have been working in isolation to control the plant, or who have witnessed the spread of the weed and raised concerns. The challenge now lies in taking the national, coordinated management of famine weed from paper to action.

Grice AC, Clarkson JR, Calvert M (2011) Geographic differentiation of management objectives for invasive species: a case study of *Hymenachne amplexicaulis* in Australia. Environmental Science and Policy 14: 986-997.

Macdonald IAW (2014) What's in a name? The conscious decision to choose "famine weed" as the English common name for the invasive alien plant *Parthenium hysterophorus* in South Africa. International Parthenium News 10, 2 – 4.

Strathie LW, McConnachie AJ, Retief E (2011) Initiation of biological control against *Parthenium hysterophorus* L. (Asteraceae) in South Africa. African Entomology 19: 378–392.

Impact of *Parthenium hysterophorus* on farm lands in Wajaale

Article prepared by **Steve Adkins** with information taken from a report written by **Abdi Khaliq Ahmed Maal** and **Daaha Mohamed Abdi**, Faculty of Agriculture and Natural Resource Management, Gollis University, Hargiesa, Somaliland.

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It can now be confirmed that *Parthenium hysterophorus* has spread to Somaliland in Somalia and is causing great concern significantly degrading grazing and agricultural lands and affecting wildlife habitat. A 2010 survey by Birding Africa has shown that the weed has invaded the vast Wajaale clay plains area adjacent to the town of Tog Wajaale on the Somaliland/Ethiopia border. The plains are the only known habitat for Archer's Lark **(***Heteromirafra archeri***,)** not recorded elsewhere with certainty since its discovery in Somaliland in 1922. In addition the weed has become widely distributed in other regions including Gabiley, Awdal, and Marodi jeh (Fig 1). The weed has been present for about four decades and is continuing to affect crop and pasture production, human health, animal health and the environment.

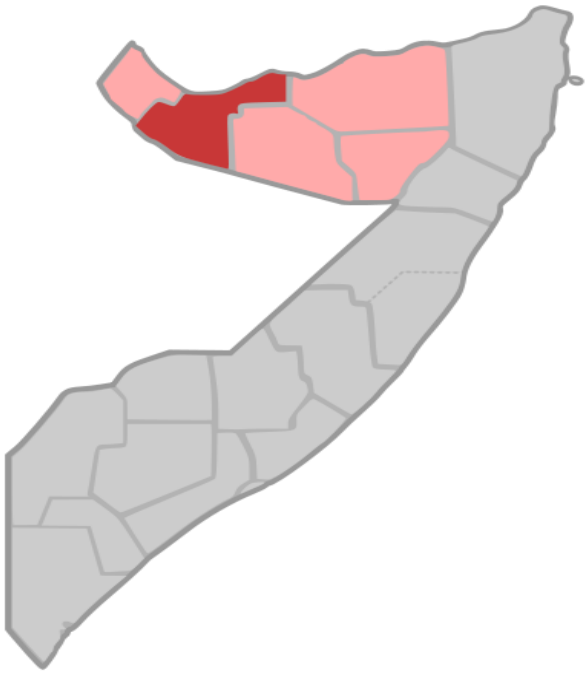

Figure 1: The area shown pink on the map is Somaliland and the region where parthenium weed is most abundant is shown in red.

The Somali people gave it the name "Kelidii Noole" which means it does not allow other vegetation to grow alongside it in peace. Farmers in West regions in Somaliland suggest this weed came from Ethiopia in 1977 at the time of the war between Ethiopia and the Somali Democratic Republic. At the border of the two countries soldiers used the weed as a way of stopping bleeding.

Disease control means knowing the enemy

Catherine Norwood

Identifying the insects that transmit crop diseases and the plants that host disease between cropping seasons is a crucial part of the research effort that will help manage and control the spread of both established and exotic viruses.

Work being carried out by the Queensland plant pathologist Murray Sharman is helping to unravel the factors associated with the spread of tobacco streak virus (TSV), which has proven to be one of the most damaging viral diseases of oilseed crops in Queensland in recent years. Parthenium weed has now been identified as a significant secondary host.

"TSV has caused annual losses of about 20 % across the central Queensland sunflower industry since 2004," says Mr Sharman, who works with the Department Agriculture and Fisheries. "It is transmitted in virus-infected pollen, which is often moved into crops by feeding thrips." GRDC-funded research has shown that soybeans, cowpeas, mungbeans, faba beans, safflower and peanuts are all susceptible to damage by TSV. There were significant losses in mungbean crops in early 2007.

While more than 20 weeds species have been identified as hosts of TSV, the most important host, which is always associated with disease outbreaks, is parthenium weed (*Parthenium hysterophorus*). TSV can also remain viable on parthenium weed seed for several years. Parthenium weed is mostly restricted to the central highlands region of Queensland, and crop losses caused by TSV have also been restricted to this area. "Good farm hygiene is vital to restrict the movement and establishment of both parthenium weed and TSV into other growing regions," Mr Sharman says. "GRDC research has demonstrated that some sunflower hybrids have effective tolerance to TSV, providing good options for growers in the central highland region. Other TSV management strategies include controlling parthenium weed particularly at

planting, and not planting crops adjacent to large areas of parthenium weed."

GRDC Research Codes DAQ00154, DAQ00172
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The wide occurrence of Parthenium weed associated disease and its potential insect vectors in the Punjab, Pakistan

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Parthenium weed (*Parthenium hysterophorus* L.), a herbaceous plant, is one of the 10 worst invasive weeds in the world. Primarily, it was present in tropical America and native to Central/South America entering the Indian subcontinent accidentally in the mid1956. Due to its fast growth, high reproducibility and adaptability to different climatic and soil conditions, parthenium weed has become the most prevalent, most feared noxious invasive weed species that is widely distributed in both arable and grazing lands worldwide (Adkins and Shabbir, 2014) and is very difficult to control. Parthenium weed has an allellopathic effect on other plants and is also known to cause asthma, bronchitis, dermatitis and hay-fever in man and livestock. The weed can also be a good host to many plant pathogens; and can spread disease by insect vectors and induce disorders in the physiology, morphology and flower sterility of other plants.

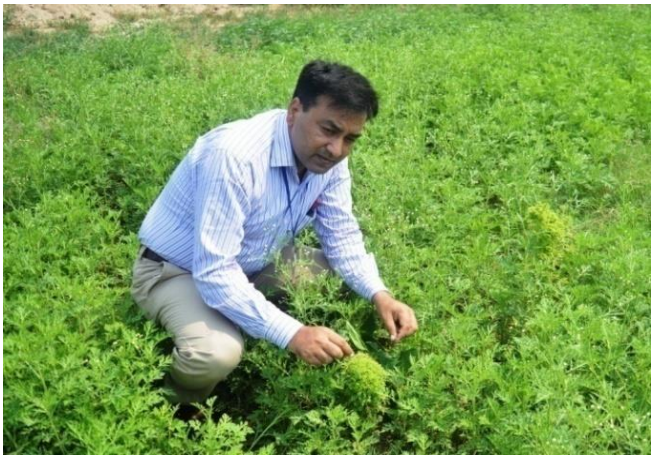

Figure 1: Dr Jam N Ahmad observing parthenium weed phytoplasma in Faisalabad (Punjab) at UAF, PARS Campus). Photo by SJN Ahmad.

Figure 2: Severe infestation of parthenium weed phytoplasma in roadside fields at Multan (south Punjab) on the Lahore highway (Kabirwala bypass). Photo by SJN Ahmad.

In Pakistan, different strategies are being examined to control this invasive weed. One way is to provide some level of controlby phytoplasma. Phytooplasma are minute phytopathogenic, wall less, phloem inhabiting bacteria in the class Mollicutes. They are transmitted by phloem sap sucking insect vectors as well as through dodder, grafting and tubers but cannot phytoplasma cannot be transmitted mechanically. Phytoplasmas cause devastating damage to plants causing loss in biomass and the quality of products including flowers. Phytoplasma infected parthenium weed plants are characterized by excessive branching (witches´ broom), reduced plant height and leaf size, as well as through their modification of floral structures into leaf-like structures (phyllody) and this lead to sterility. In Pakistan, the parthenium weed phytoplasma can be quickly spread to different parts of Pakistan (Ahmad et al., 2015).

Figure 3: Close-up of the symptoms of phytoplasma on parthenium weed plants (above) and its inflorescence (below) in Faisalabad. (Photo by SJN Ahmad)

Many insects are observed to feed on parthenium weed including the nymphs and adults of the mealy bug (*Ferrisia virgata*), as well as mites, beetles and leafhoppers. Since the leafhopper field density was positively correlated with the incidence of parthenium weed phytoplasma disease the thought is that this disease is transmitted by leafhoppers with active transmission up to 55% in different regions. Previously, the association of phytoplasma disease with parthenium weed had been observed in various countries such as in Ethopia, India Australia and China. Despite their economic importance and unique biological features, phytoplasmas remain al poorly characterized plant pathogen. During a survey conducted in Punjab, Pakistan, the phyoplasma disease was observed on parthenium weed but also on many other plants (Ahmad *et al*. 2015). .The molecular confirmation of phytoplamsa presence in infected parthenium weed samples was confirmed by Polymerase Chain Reaction and the agent associated with the phytoplasma, and putative insect vector, have also been confirmed. The control of parthenium weed through the distribution of the phytoplasma is not considered to be a good strategy as infected parthenium weed would act as a source of infection for neighbouring crops.

Impact of *Zygogramma bicolorata* Pallister on *Parthenium hysterophorus* over past 25 years of introduction: Ecological indicators and people perception in North India

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Establishment, prevalence and abundance of released agents over space and time is a crucial milestone for any biological control programme but ultimate success can only be demonstrated by evaluating the post-release ecological impact. Ever since its introduction in 1983, the Mexican beetle, *Zygogramma bicolorata* Pallister has successfully established in India (Gupta *et al*., 2002, 2006, 2010; Dhileepan 2009; Bali, 2014). However, in the current climate of skepticism, it is increasingly important to quantify post-release impact in reducing target weed populations in the introduced range. We therefore assessed post-release impacts of the beetle using standardised approaches (CRC Weed Management, Australia, 2008) at a number of sites of differing abundance. We also assessed its post release ecological responses and quantified the impact in term of the benefits produced for associated plant communities, ecosystems, the economy and society in general. For ecological impact we compared the plant height, plant density, flower production, total plant biomass, viable soil seed bank, percent defoliation and population build-up of *Z. bicolorata* in beetle-excluded sites (control) and naturally infested sites using the quadrate method (Greig-Smith, 1983; Wittenberg *et al.,* 2004). The cover abundance (the proportion of individual species) of the plant species encountered in each of the quadrates (1 m^2) was recorded using the following established procedure (Wittenberg *et al.* (2004). Fifty sample sites were selected and the above ground biomass of the herbaceous species harvested from a total of 10 sample quadrates per site. The biomass samples were dried for 48 hours at 70^0C and weighed to determine oven dry weight. Species diversity within the vegetation and the seed bank was assessed using the Shannon-Weiner index (Krebs, 1989). Appropriate pictures of parthenium weed infested field were shot after release at regular intervals and compared with a series of pictures of

the same field available in scientific records. Data was subjected to statistical analyses following appropriate tests for comparison of means. A formal survey was also conducted to gather primary and secondary data on the impact of parthenium weed on the composition and diversity of plant species and on livestock health and their products. To gather information on people perception about this weed and its bio suppression, purposive sampling procedure was followed to identify and select the respondents. A total of 400 respondents with an average age of 54 years (ranging 30-80) were selected based on their awareness about the aggressive colonization of the pastures and its impact on their livestock and on themselves. A structured questionnaire was prepared to collect adequate information regarding parthenium weed and the overall impact of *Z. bicolorata* on this weed. Furthermore, observations were made and group discussions were held with development agents, health officers, community leaders and district officials.

Our findings suggest that the release and dispersal of *Z. bicolorata* offers a plausible explanation for the rapid parthenium weed decline in North India especially in Jammu and Kashmir, Punjab and Himachal Pradesh (Table 1). For the past 25 years, the beetle has dispersed over an area of more than 9 hundred thousand km^2 in north India (nearly half of total geographical area). However, outbreak population densities for the last 5 years were recorded in sub-tropical regions particularly in the outer plains. Since its release at the original site, the beetle population has increased significantly over the years from 0.80± 0.05 beetles per plant in 1994 to 6.8±1.2 in 2014. A significant negative correlation between beetle density and parthenium weed population and the soil seed bank/m^2 in all the sites was also observed which indicated that the beetle is associated to significant suppression of this weed. Photographs of a field heavily infested by parthenium weed taken before, during and after release of the leaf-feeding beetle *Z. bicolorata* showed a considerable decline in weed population (Fig 1). Scientific data suggested that the beetle has led to significant reduction in individual plant characters such as plant height (32.1-55.6%), flower heads (55.8-76.3%) and flower biomass (53.6-70.5%). Besides, a declining trend was also observed in weed density which decreased from 76.6±14.8 to 35.2± 1.3 with an overall reduction in viable soil seed bank ranging from 1,484.7±25.2 to 464.0±11.5 in subsequent years to 2014. With an objective to assess the impact of beetle on grazing fields, we found that at all sites, reductions in above plant parameters resulted in increased richness of native vegetation that replaced this weed over these years. The major species that replaced the target weed were *Cyanodon dactylon, Cyprus rotundus, Xanthium strumarium, Cannavis sativa, Cassia tora, Cassia auriculata* and *Casia occidentalis* (Fig 2). At the original site of release, the introduction of the beetle led to a 74.3 % increase in grass biomass as a result of heavy defoliation of parthenium weed while at the other sites, it increased by 48.3 to 52.5 %. A significant reduction in the soil seed bank in the beetle released sites was also observed at all the locations (Fig 3).

Table 1: Post-release ecological impact of *Z. bicolorata* at different levels after 25 years of beetle release.

LEVEL	WHAT TO MEASURE	Actually measured	Before	After
Plant	Growth (number, size and biomass of the plant) Reproduction (number and biomass of flower) Survival Beetle density and damage level	Plant Height (cm) Plant Biomass (gm) Plant density (Nos./ m^{-2}) Flower head (Nos.) Flower biomass (gm) Beetle density/plant and Per cent defoliation	113.96 ± 1.33^a 121.91 ± 1.32^a 76.60 ± 14.84^a 962.15 ± 14.84^a 15.78 ± 0.29^a 0.08 ± 0.05^a 0.00 ± 0.0^a	63.38 ± 1.16^b 68.15 ± 1.34^b 35.19 ± 1.31^b 224.86 ± 1.31^b 4.66 ± 0.22^b 6.8 ± 1.2 b 74.95 ± 2.18^b
Population	Photo references Weed density or cover Seedling recruitment and survival Viable seed bank density Weed stand size and spread	Plate Seedling density reduction (%) Seedling survival reduction(%) Soil Seed Bank (Nos./ $m^{-2)}$ Weed stand and spread/m^2	Plate 0.00 ± 0.0 0.00 ± 0.0 1484.70 ± 25.22^a 76.60 ± 14.84^a	Plate 71.81 % 56.38% 463.98 ± 11.51^b 35.19 ± 1.31^b
Ecosystem	Species richness and abundance of desirable plant species Biomass productivity Species richness of desirable plant species (weeds)	Desirable plant species Biomass/gm/m^2 Diversity Evenness	0.34 ± 0.08^a 91.36 ± 4.46^a 1.326 ± 0.02^a 0.571 ± 0.10^a	0.83 ± 0.20^b 374.00 ± 1.55^b 2.61 ± 0.79^b 0.854 ± 0.007^b

*Mean within column before and after release superscripted by different letter are significantly different

Figure 1: Parthenium weed **stand before (1989) and after (1999) the release of *Z bicolorata* (Plate 1 & 2). Defoliation by beetle leading to re- establishment of native vegetation (3 & 4).** Parthenium weed **stand after 20 years of beetle release (2009) at original site (5).**

Figure 2: Assessing the biomass, species richness and evenness after 25 years of release (Plate 1-4). Ecological indicator of success: Dominance of *Cassia tora* after 25 years of beetle release in 2014 (Plate 5)

Fig 3. Depletion of viable soil seed bank of parthenium weed **weed leading to increased abundance of native plants (above). Increased biomass of grass in pastures after 25 years of release (below).**

Goat-feeding on Parthenium weed in Uttarakhand, India

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The state of Uttarakhand in India represents a geographical area with altitudes ranging from 200 m to up to more than 2,400 m above msl. Its agro-climatic conditions are highly diversified. The climate varies from sub-tropical to temperate. The annual rainfall ranges from 1,200-2,500 mm. In the *Tarai* and *Bhabar* regions, the climatic conditions and highly productive soils favour luxuriant growth of many weed species. In wastelands and roadsides, the infestation levels of parthenium weed are very high. The weed is also present in the higher hills up to 1,500-1,800m above msl. It germinates, grows, flowers and produces seeds almost throughout the whole year, completing three to four life cycles in a year. Almost all the districts in the plains and most of the hilly districts suffer from its infestation. Since it is confined to roadsides, uncultivated areas and wastelands, there is hardly any effort to contain its menace.

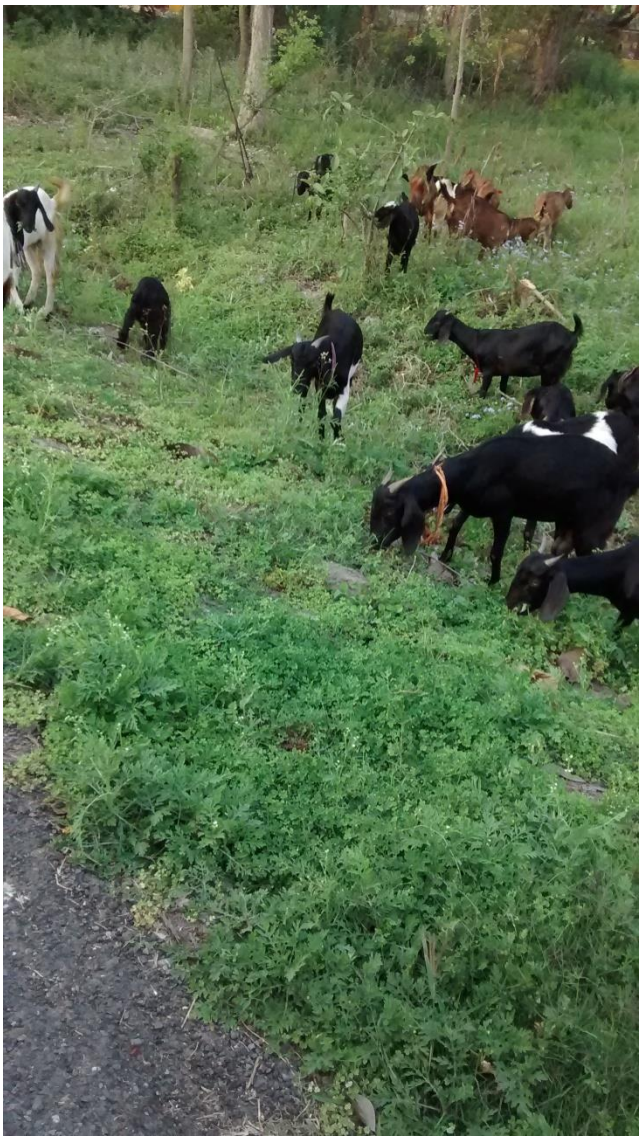

Figure 1: A herd of goats feeding on parthenium in a field at Pantnagar, India. The foreground shows a carpet of the noxious weed. (Dated 23rd March, 2015).

There are reports of livestock feeding on this weed. Recently, while visiting a friend, the author came across a field heavily infested with this weed. The field is earmarked for horse riding activities inside the

university campus. However, there was luxuriant growth of weeds including parthenium in the field. It was in the month of March. The flush of parthenium weed growing in the field was in its flowering stage. A herd of goats were found grazing in the field. A closer look revealed that the goats were eating the flowering branches of parthenium weed along with the leaves. The photographs clearly show this activity.

It supports earlier reports of livestock particularly goats feeding on this noxious species. Since the herd of goats belonged to a casual visitor, it was not possible to follow up and monitor the effect of parthenium weed on goat health. It will be worth investigating its effect on these animals.

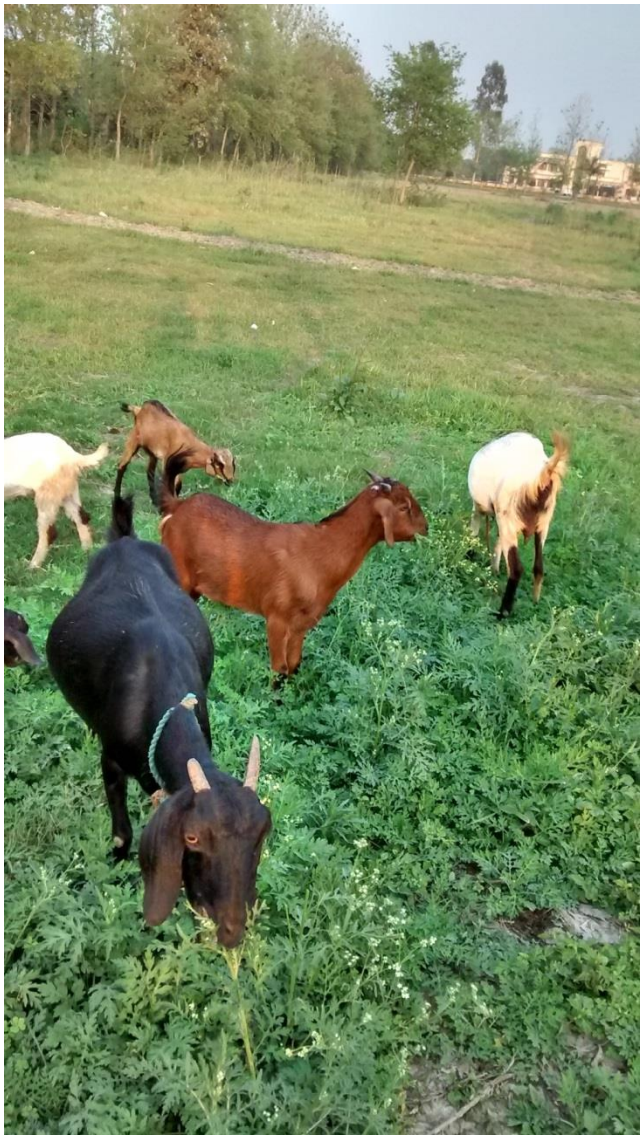

Figure 2: Goats grazing on parthenium weed in a heavily infested field at Pantnagar , India (March 2015).

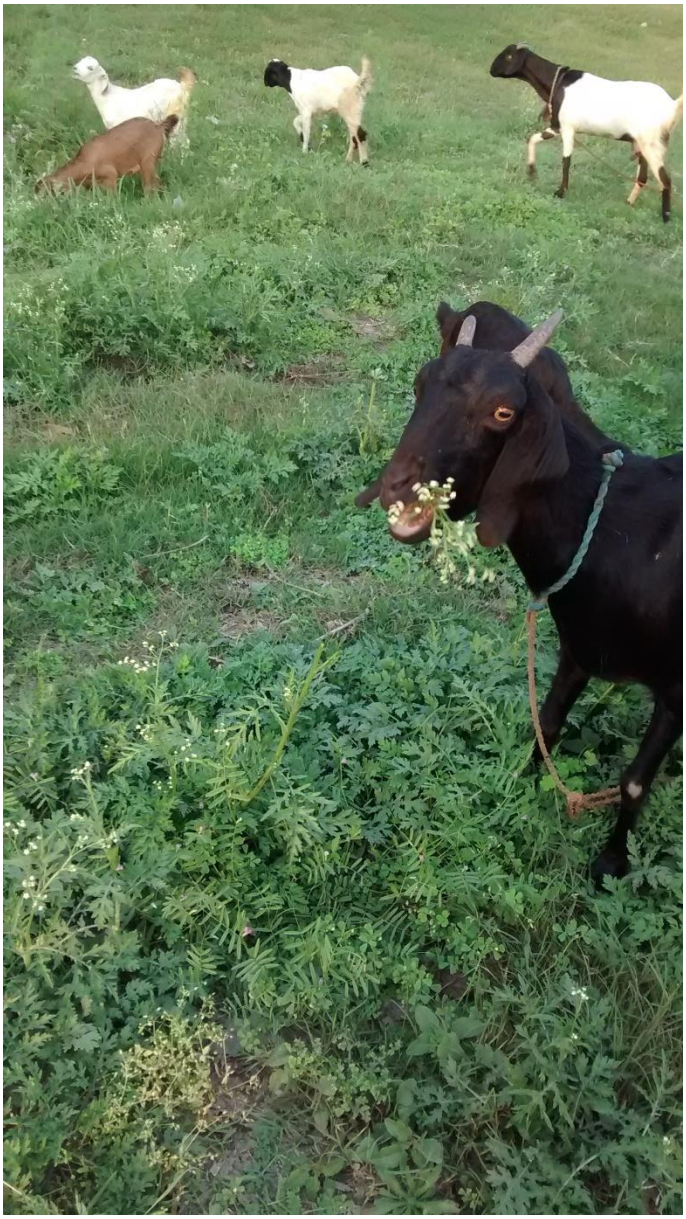

Figure 3: A flowering branch of parthenium weed being eaten by a goat. (March, 2015, Pantnagar, India).

SAURAHA DECLARATION

International Conference on Invasive Alien Species Management (ICIASM) March 25 – 27, 2014, Sauraha, Chitwan, Nepal

An important International Conference was held in Sauraha, Nepal in March 2014 to discuss the problem of Invasive Alien Species and their Management in Nepal. A number of papers highlighted the growing

problems of mikania vine and parthenium weed. At the end of the Conference the following declaration was made.

We the participants of the aforementioned conference:

Recognize: The detrimental impacts that invasive alien species (IAS) has on native biodiversity, local community and the overall ecosystem diminish the productivity of ecosystems including forest, agriculture and rangeland. These IAS may have irreversible and unpredictable economic and environmental impacts. In addition, the species like *Mikania micrantha* and *Parthenium hysterophorus* may harm humans, animals and plants health.

Every country has been impacted by IAS, which has imposed the cost to society altering ecosystem services. The threat is both local and global. The increasing movement with global travel and trade render every landscape on the earth vulnerable to new infestations. However, measures have to be taken at national and local level. The IAS may become more aggressive in the future in the context of global climate change that deserve a regional and global effort to control their further expansion and reduce their abundance in the invaded areas.

Since, the effects of invasive plants are multidimensional, the coordinated efforts of all concerned stakeholders are essential to control the spread of IAS.

Adverse effects of the invasion of IAS including *Mikania micrantha* and *Lantana camara* especially on grasses, herbs, shrubs and small trees are the serious concerns to deal with the habitat management of the key mega faunal species like rhinoceros, and tigers.

Information on sources, identities, and pathways, and lessons from the past control efforts are essential to develop appropriate strategy to manage IAS. Moreover, all nations need to strengthen their technical capability to apply modern technologies, and develop national IAS strategy.

Therefore, we

Conclude that

There is an urgent need to develop a comprehensive national strategy in each country to maintain native ecosystem by controlling and managing IAS.

Thus, we:

Encourage

Support for better coordination at regional and global level, and capacity development of concerned stakeholders in IAS management.

Establishment of partnerships among the stakeholders including government, non-government and community-based organizations, academicians and the general public, at local and national level for developing and implementing IAS management strategy to fight against the IAS.

Young people to take up and carry out research works.

Develop National IAS strategy in all countries.

Call upon

National, regional and international research and development agencies to make resources available to better coordinate and develop the capacity for IAS management, in order to meet the immediate needs of both developing and developed countries.

Develop IAS strategy and incorporate IAS management into national biodiversity strategy and action plan giving special focus on control of IAS, containment and asset based protection.

Greater attention to the management of habitat shift of mega faunal species including rhinoceros and tiger that will be increasingly important as the pristine and important habitats erode

and fragment due to various factors including climate change.

Finding livelihood opportunities of local communities, poor and marginalized communities to cope the adverse situation created in the infested ecosystem.

Devising the appropriate strategies for mitigation, adaptation and resilience of ecosystems and local communities in the context of possible compounding effects of invasive species along with the climate change.

At last, we:

Commit to

Integrate multiple sectors in IAS management
Create networking
Initiate IAS management at local level
Adopt adaptive learning in IAS management
Share Information
Maintain native ecosystem

Upcoming Conferences on Weed Science and Invasive Species

25th Asian Pacific Weed Science Society Conference

Dates: 13-16 October, 2015
Venue: Hyderabad, India
http://isws.org.in/apwss.aspx

19th International Conference on Aquatic Invasive Species

Venue: Winnipeg, Manitoba, Canada
Dates: April 10-14, 2016.
http://www.icais.org/index.html

7th International Weed Science Congress

Dates 19-25 June 2016
Venue: Clarion Congress Hotel Prague, Prague, CZECH REPUBLIC
Website: www.iwsc2016.org

20th Australasian Weeds Conference (20AWC)

Venue: Perth, Australia
Website: http://www.20awc.org.au/
Dates: September 11-15 2016

Recent Publications

Kriticos DJ, Brunel S, Ota N, Fried G, Oude Lansink AGJM, Panetta FD, Shabbir, A and Yaacoby T (2015) Downscaling Pest Risk Analyses: Identifying Current and Future Potentially Suitable Habitats for Parthenium hysterophorus with Particular Reference to Europe and North Africa. *PloS one* 10(9): e0132807. doi:10.1371/journal.pone.0132807.).

Nyasembe, V. O., Cheseto, X., Kaplan, F., Foster, W. A., Teal, P. E., Tumlinson, J. H., & Torto, B. (2015). The Invasive American Weed Parthenium hysterophorus Can Negatively Impact Malaria Control in Africa. *PloS one*, *10*(9), e0137836.

Shrestha, B.B., Shabbir, A., Adkins, S.W. (2015). *Parthenium hysterophorus* in Nepal: a review of its weed status and possibilities for management. Weed Research (Oxford) 55: 132-144.

Mahmoud, T., Gairola, S., & El-Keblawy, A. (2015). Parthenium hysterophorus and Bidens pilosa, two new records to the invasive weed flora of the United Arab Emirates. *JN Biol Control Rep*, *4*(1), 26-32.

Jabeen, R., Prentis, P., Anjum, T., & Adkins, S. W. (2015). Genetic structure of invasive weed Parthenium hysterophorus in Australia and Pakistan. *International Journal of Agriculture and Biology*, *17*(2), 327-333.

Belgeri, A., & Adkins, S. W. (2015). Allelopathic potential of invasive parthenium weed (Parthenium hysterophorus L.) seedlings on grassland species in Australia. *Allelopathy Journal*, *36*(1).

Brunel, S., Panetta, D., Fried, G., Kriticos, D., Prasad, R., Lansink, A. O., Shabbir, A. and Yaacoby, T. (2014) Preventing a new invasive alien plant from entering and spreading in the Euro-Mediterranean region: the case study of *Parthenium hysterophorus*. EPPO Bulletin (Wiley), 44: 479–489.

Safdar, M. E., Tanveer, A., Khaliq, A., & Riaz, M. A. (2015). Yield losses in maize (Zea mays) infested with parthenium weed (Parthenium hysterophorus L.). *Crop Protection*, *70*, 77-82.

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For contributions, please send your news items/articles to the following address;

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