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***Editorial team*:**

Dr Runping Mao (Editor in Chief)
Prof Steve W Adkins

Regional Representatives:

Dr. Asad Shabbir (Australia)
Lorraine Strathie (Africa)
Sangay Dorji (Asia)

***Produced by*:**

Tropical & Sub-Tropical Weed Research Unit, The University of Queensland, Australia.

In collaboration with IOBC working group and APWSS working group on biological control and management of parthenium weed.

Editorial

Dear colleagues,

We appreciate that this has been a very difficult year for all our network members and others around the world. Turmoil is emerging in many parts of our planet and our climate is deteriorating rapidly. Our Editorial Team Members have experienced surging numbers of COVID-19 in their home countries and most recently devastating floods have occurred in Australia, only 3 years after the country was alight with bush fires. Meanwhile in other parts of the world, war and inflation are hitting the lives of ordinary people, researchers not exempted. The Editorial Team has been very grateful to all our contributors producing excellent reports, despite these everyday life impacts, and allowing us to bring out the first 2022 issue of the International Parthenium Weed Newsletter.

The IPaWN has now reached its 10-year anniversary, and as we enter our second decade a change in the Editorial Team is being made, bringing on fresh, new, and younger faces.

It has been an honour to have Dr Asad Shabbir serve as our Editor-in-Chief since the start of the Newsletter. During the 10 years of his service, he has made an immense contribution to the IPaWN and our Newsletter by collecting and collating reports and designing and publishing the final Newsletter. He has also provided us with eight original reports on his own research.

About a hundred articles have been published in our Newsletter under his guidance, with news from over 30 countries. Maps developed by Asad have also been included in many articles, which have been particularly useful in demonstrating the global spread and distribution of parthenium weed. Asad undertook his MPhil at the University of the Punjab, Lahore and then his PhD at the University of Queensland on the impact and management of parthenium weed, with a particular focus on biological control. He is widely published on the topics of biology, ecology, and management of parthenium weed and now works at the University of Sydney and retains his strong interest in parthenium weed research. Asad will continue working with on the Newsletter as our Australian regional coordinator.

Dr Runping Mao entered the research team at the University of Queensland in 2016 and graduated after undertaking the much-needed research on the dispersal and population dynamics of parthenium weed. Apart from her two original research papers on dispersal of seed by wind and water, Runping has also published two lengthy reviews on the global spread of parthenium weed and the impact of climate change on the weed's biology and management. She will become our new Editor-in-Chief from 2022, and work in collaboration with our regional coordinators to bring the latest news on parthenium weed related research.

The new Editorial team will endeavour to deliver a biannual Newsletter, but this will require contributions from you. Also, in this new edition, we would like to introduce a new column: Parthenium Perspectives. This column will focus on the innovative methods, thoughts, and outstanding publications on parthenium weed ecology, distribution, and management. Finally, we would like to thank all the network members for their support and encouragement.

Please keep sending in your news articles!

Enjoy the read!

Runping Mao
Steve Adkins

Parthenium Perspectives

Adaptive Natives under Parthenium Pressure

A recently published research paper in the *New Phytologist* entitled '**Native plant species show evolutionary responses to invasion by *Parthenium hysterophorus* in an African savanna**' has been attracting attention on the relationship between plant invaders and the native plant community. The researcher, Ayub M.O. Oduor from Department of Applied Biology, Technical University of Kenya, conducted a series of field experiments in the Nairobi National Park, Kenya, selecting seven native plants and parthenium weed which is currently invading the national park. The author decided to test the hypothesis that native plants may evolve under the selective pressure from alien plant attack – especially from the worldwide invasive parthenium weed. Native plants may become more 'experienced' when facing the invader and perform better in good environmental conditions such as high soil moisture and nutrients, while the 'inexperienced' native plant populations cannot compete as well as the 'experienced' conspecific natives against parthenium weed in drought.

The research paper was published online on 25 June 2021, and was included in Volume 233, Issue 2 of *New Phytologist*.

Soon after its online publication, a commentary on this article written by Daniel Z. Atwater and Ragan M. Callaway, was also published under the title '**Extended consequences of selection by exotic invaders on natives**' and included in the *Forum* in the same issue of the journal. The commentary authors highlighted the knowledge gap explored by this study and discussed plant plasticity in response to environment factors and presence of an aggressive invader. The original article and the commentary both valued the perspective of plant evolution at the same time as plant invasion, and discussed the invasion scenarios, route of natural selection and the long-term outcome: it can be distinct when environmental stresses are present or absent. The commentary concluded: 'At the heart of every extended consequence of adaptation to an invader ……there is a tradeoff, and these tradeoffs are mediated by traits.'

Would native plants evolve in your region with parthenium weed? What would the selective pressure be on the natives and other introduced plants and would this be different under the looming pressure of parthenium weed? There are of course more questions than answers in the ecology of invasive plants. These interesting works can be found at:

https://nph.onlinelibrary.wiley.com/doi/10.1111/nph.17574
and
https://nph.onlinelibrary.wiley.com/doi/10.1111/nph.17830.

Survey to Document the Current and Potential Spread of the Invasive Parthenium Weed in Dhofar, Oman

Mahaad Issa Shammas
Civil and Environmental Engineering Department, College of Engineering, Dhofar University, Salalah, Sultanate of Oman
E-mail: mahad@du.edu.om
Edited by S. Adkins

The Dhofar Governate

The Dhofar Governorate is in the southwestern corner of the Sultanate of Oman. The Governorate has an area of nearly 100,000 km^2 and is considered to be the largest of all the Governorates in the country (Figure 1). The mountains are dangerously steep, high, and inaccessible while on some parts rise steeply with cliffs and narrow valleys between hills and mountains. These areas are covered by grassy uplands and diversified with wide park-like valleys and forests. The Dhofar region is known for its rich biodiversity and its associated ecosystem services that are provided to the environment and for human wellbeing. The biodiversity of the Governorate has been threatened by overgrazing, climate change, habitat fragmentation, and urbanization. Recently, invasion of alien species, particularly parthenium weed, has emerged as a new threat to the unique ecosystems, and human and animal health of the Governorate (Shammas, 2020, 2021).

Parthenium weed – an emerging environmental concern for the Governorate

His Excellency, Sayyid Mohammed bin Sultan Al Busaidi, Minister of State and Governor of Dhofar, issued a Ministerial Decision No 189/2020 to form a joint working group to deal with parthenium weed in the entire Dhofar Governorate. So far, the Government has allocated an annual budget to deal with this weed. The team is presently undertaking research on the invasion mechanisms of the species and developing strategies to manage the weed. They have formulated plans to coordinate with the private sector to ensure the integration of community effort. For almost 2 years, and during the monsoon seasons, this team in coordination with the local community has initiated campaigns (July-September 2021) to hand remove (uproot) parthenium weed (Figure 2).

Grant Approval by the Research Council of Oman

The Research Council of Oman (TRC) has recently allocated sufficient funds to investigate, the current and potential distribution, and the impact of parthenium weed in Dhofar. This one-year (2021-22) study is to be led by the principal investigator (the author) in collaboration with one member of the Dhofar University. Dr. Asad Shabbir, University of Sydney, an overseas collaborator, will act as an advisor on research activities, particularly in relation to suitability of the weed for the Oman climate.

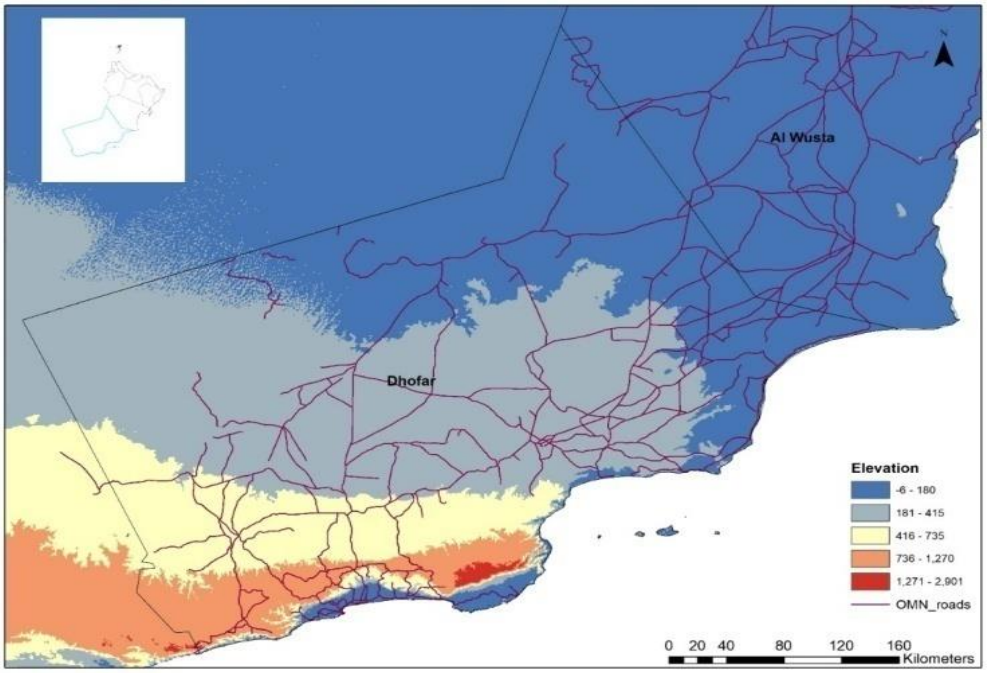

Figure 1. A geographical map of the Dhofar Governorate, Oman showing elevation and the road network (map credit - Asad Shabbir).

Current Management Approaches

The weed is now considered as noxious, as it grows in a wide variety of habitats in the entire Dhofar Governorate (Figure 2). Manual uprooting of parthenium weed before flowering and seed set is the most effective method. Successful management can also be achieved when the weed is ploughed at the rosette stage, before it sets seed, followed by the sowing of a crop or direct seeding of a perennial pasture. Most management activities involve hand weeding, though unpleasant, risky and time consuming, people still prefer these methods since they can more closely monitor the land areas where parthenium weed is invading (Figure 2). The burning strategy of the uprooted and dried parthenium weed plants is also employed and undertaken at the Dhofar municipality dumpsites. This approach has been observed to results in a decreased infestation of parthenium weed. For the longer-term effective management of the weed, integrated approaches are needed (Adkins and Shabbir, 2014; Shabbir *et al.*, 2020).

Figure 2. Different habitats invaded by parthenium weed (A-B), and manual removal of the weed with community participation (C-D) in Dhofar governorate.

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The stem-boring weevil *Listronotus setosipennis* introduced to Ethiopia to control the invasive weed parthenium, *Parthenium hysterophorus*, has established with evident impact

Wondi Mersie[1], Lidya Alemayehu Chala[1] and Rangaswamy Muniappan[2]

[1] Virginia State University, P. O. Box 9061, Petersburg VA, 23806
[2] Virginia Tech, 526 Prices Fork Road, Blacksburg, VA, 24061
E-mail: WMersie@vsu.edu

The stem-boring weevil, *Listronotus setosipennis* (Coleoptera: Curculionidae) was introduced into quarantine facilities in Ethiopia in 2010 and field-released in 2016 to manage the invasive weed *Parthenium hysterophorus*, commonly referred to as parthenium weed. *Listronotus setosipennis* was released after tests conducted on selected native and economically important Ethiopian flora showed that only parthenium weed could sustain the weevil. A starter culture of *L. setosipennis* was provided by the Agricultural Research Council – Plant Health and Protection, South Africa (by researchers Lorraine Strathie and Dr Andrew McConnachie) as part of a project led by Virginia State University and funded by the U.S. Agency for International Development (USAID) through the IPM Innovation Lab office at Virginia Tech.

Parthenium weed causes losses of crop yields, adversely affects livestock production by invading pastures, its pollen causes allergic reactions in humans and animals, and when the plant is consumed by cows, it taints their milk and meat. Tainted milk has lower market value and is rejected by children in Ethiopia. The allelopathic properties of the plant allow it to displace native plants, thereby adversely affecting biodiversity. Parthenium weed, since its introduction into Ethiopia (believed to be during the late 1970s) has spread to all regions of the country. Roadside surveys in Ethiopia during the mid-2000s recorded occurrence of parthenium weed at altitudes from 1,000 m to 2,500 m, with most infestations at high density (>3 plants m^{-2}).

The most widely used current method of controlling parthenium weed in Ethiopia is hand-pulling, and herbicides are occasionally used to suppress it in high value crops such as teff (*Eragrostis tef*; Poaceae). To be effective, hand-weeding has to be conducted multiple times throughout the growth season as the weed continues to emerge. During the peak growing period, labour may not be readily available for hand-weeding as there are other agricultural tasks that require the attention of the farmer. In addition, many people are allergic to parthenium weed, confounding the problem of sourcing labour for hand-weeding. Chemical control of parthenium weed can be expensive for small-holder farmers and herbicides require multiple applications within a season and in subsequent seasons. Parthenium weed is ideal for biological control as it has many natural enemies in its native range and forms monocultures in the field, providing an ample food source for the selected host-specific biocontrol agents. Biological control of parthenium weed has been implemented in Australia and India, and also within Africa as Ethiopia, South Africa, Uganda and Tanzania have introduced biological control agents.

Listronotus setosipennis is one of two biocontrol agents that were introduced into Ethiopia to manage parthenium weed. Eggs of the weevil are laid in the flower or less commonly on the leaf petioles of the weed. Within five days, the larva hatches from the egg and burrows through the peduncle, before entering the stem. The larva feeds within the parthenium weed stem until it is fully developed. Feeding by four or five larvae inside a stem can kill a plant, depending on its size. After completing development, the larva exits the stem and enters the soil, where it pupates before emerging as an adult, completing its life cycle. It takes about 4 weeks for *L. setosipennis* to complete egg to adult development. During the dry season the adult survives in the soil or inside the dry, senesced parthenium weed stems, emerging after the onset of rainfall, when parthenium weed starts to grow and flower.

In Ethiopia, *L. setosipennis* has been released at multiple field sites in the central and north-eastern parts of the country. At one of the release sites, Mojo in central Ethiopia, where five hundred *L. setosipennis* adults were released on 12 July 2017 (Figure 1), the field where they were released was heavily invaded and dominated by parthenium weed, with the exception of a few shrubs. However, four years after the release of *L. setosipennis* there, the population of parthenium weed was significantly reduced and the grass has started to thrive, with few parthenium weed plants remaining (Figure 2). It took 4 years for the weevil population to build up and spread to all corners of the field. The weevil weakened or killed parthenium weed plants, facilitating the emergence and growth of the grass (Figure 2). From mid-2021, cattle were excluded from this field, to protect newly planted tree seedlings, which also aided the growth of grass. The combination of parthenium weed control by *L. setosipennis*, followed later by livestock exclusion through fencing, allowed the grass species to emerge and thrive. Grass can be harvested and fed to cattle at the end of the growing season. This strategy utilizing a combination of the weevil and livestock grazing exclusion can rehabilitate pasture lands that are heavily invaded by parthenium weed.

Figure 1. Dense infestations of *Parthenium hysterophorus* in a field in Mojo, Ethiopia at the time of release of *Listronotus setosipennis* on 7 December 2017.

Figure 2. The same field in Mojo, Ethiopia on 8 October 2021, with extensive grass cover and few *Parthenium hysterophorus* plants, following the establishment of *Listronotus setosipennis*, and more recent exclusion of livestock.

Parthenium weed in China: A brief update on new records, biological control evaluation and nationwide survey

Dr Runping Mao
Institute of Plant Protection, Wuhan Institute of Landscape Architecture, Hubei, China
E-mail: r.mao@uq.net.au

A short communication, published in 2020 reported Chengdu Customs to have found a parthenium weed population at a location in Luzhou, Sichuan Province where imported grains are inspected. The population was discovered when a survey was undertaken of exotic/invasive species at this place of inspection in July 2019. A recent contact with the corresponding author suggested this population was not eradicated at that time, and now may have established locally. There was no indication whether this population was related to either the southern population of parthenium weed in Yunnan and Guangxi Provinces or to the northern population found in Shandong Province.

A recently published list of exotic plants in Ningbo, Zhejiang Province marked parthenium weed as present in 2021. This record is *ca*. 166 km northeast of a previously known population found in Wenzhou, Zhejiang Province in 2012. The actural date of introduction is not given, nor the possible source of this population.

The stem-galling moth (*Epiblemma strenuana* Walker, 1863) was released in Laibin, Guangxi Province in 2009 to control common ragweed (*Ambrosia artemisiifolia* L.). Despite reports of *E. strenuana* on parthenium weed in 2012 (Shi *et al.* 2018), a field evaluation survey conducted from 2010 to 2013 found limited parthenium weed populations around the release site, therefore no feeding of *E. strenuana* on parthenium weed was observed. The other site where *E. strenuana* was released for the same purpose was in Hunan Province, northeast of Guangxi. No detailed records or herbarium samples of parthenium weed could be found in that Province.

Based on the strategic needs of national biosecurity, prevention and control of invasive alien species, the National Forestry and Grassland Bureau of China launched a national survey of invasive alien species in forest, grassland and wetland ecosystems in 2021. Seven typical forest, grassland and wetland ecosystems were selected as pilot sites to test and improve the technical protocols of the survey. This nationwide survey will be carried out from 2022 and completed in 2023, covering 65 species including parthenium weed. The survey of these key invasive species in China will be conducted by using a specifically developed App named Biodiversity Monitoring Data Collection System. Data will be collected and reviewed in each Province before the final report is published.

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Upcoming Conferences on Weed Science

19th EWRS Symposium 2022
Dates: 20-23 June 2022
Venue: Athens, GREECE
Website: https://www.ewrs.org/en/info/Upcoming-events/19th-EWRS-Symposium-2022-Athens-Greece

22nd Australasian Weeds Conference (22AWC)
Dates: 25-29 September 2022
Venue: Adelaide Oval, SA, AUSTRALIA
Website: https://wmssa.org.au/22awc/

8th International Weed Science Congress
Dates: 4-9 December 2022
Venue: Bangkok, THAILAND
Website: https://www.iwsc2020.com/

16th International Symposium on Biological Control of Weeds
Dates: 7–12 May 2023
Venue: Puerto Iguazú, Misiones, ARGENTINA
Website: https://isbcw-iguazu.com/

Recent Publications

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