

January 2026

Invabiome

A newsletter on Invasive species



Second edition

PROLOGUE

Welcome to the second edition of the Indian Forum for Invasion Biology (IFIB) newsletter, **INVABIOME**. As we navigate a world of rapid globalization and climate instability, the challenge of Invasive Alien Species has become one of the most pressing threats to India's ecological and economic security.

Indian Forum for Invasion Biology (IFIB)

WHO WE ARE

The Indian Forum for Invasion Biology (IFIB) is India's premier network of researchers, practitioners, and stakeholders dedicated to understanding and combating invasive alien species. We are a collaborative platform that brings together expertise from across the country to address one of the most pressing environmental challenges of our time.

Why IFIB needs to exist

Invasive alien species (IAS) pose one of the greatest threats to global biodiversity and economic stability. As globalization accelerates and climate patterns shift, emerging economies like India face unprecedented challenges from biological invasions. Despite this growing threat, many countries lack the knowledge, coordination, and awareness needed to mount an effective response. Recognizing that fragmented efforts cannot tackle this complex problem, IFIB was created to unite expertise, coordinate responses, and build the capacity needed for effective action.

Our Origin Story

The Indian Forum for Invasion Biology was born from a groundbreaking national meeting at Azim Premji University, Bhopal, on February 21-22, 2025. This historic gathering brought together 34 researchers and practitioners from diverse backgrounds, geographies, and career stages—all united by a common mission to combat invasive species in India.

The meeting concluded with an inspiring vision: to create India's first national forum dedicated to invasion biology, fostering collaboration between academia, policy makers, and practitioners while bridging the critical gap between science and real-world application.

Our Mission

We foster collaboration between academia, policy makers, and practitioners while bridging the critical gap between scientific research and real-world conservation action. Through coordinated efforts, shared resources, and collective expertise, IFIB aims to build India's capacity to prevent, detect, and manage biological invasions effectively.

The Mission and Objectives of IFIB

The IFIB was established to serve as a unified platform for scientists, policymakers, and practitioners to confront the biological invasion crisis in India. Our core missions include:

- **Bridging Knowledge Gaps:** Identifying and addressing critical data voids in IAS research, especially in under-studied areas like marine and microbial invasions.
- **Science-to-Action Linkages:** Enhancing the connection between academic research and on-the-ground implementation to make conservation efforts more relevant and effective.
- **Stakeholder Collaboration:** Bringing together diverse groups—from government officials to local communities—to foster coordinated management strategies.

- Capacity Building: Strengthening India's response capabilities through education, shared data, and public awareness of the IAS problem.

This newsletter is a direct extension of these objectives, designed to disseminate the latest findings, share localized success stories, and keep our community connected.

In This Edition: Highlights from Our Contributors

The submissions for the 2nd edition of INVABIOME reflect the multifaceted nature of biological invasions in India, spanning from urban wetlands to dry deciduous forests.

- Rethinking the "Invader" Narrative: Several contributors advocate for a shift in how we perceive and describe invasive species, viewing them as symptoms of deeper environmental issues like land-use change and weakened ecological relationships rather than solitary "villains". Some IAS have transformed certain landscapes and displaced culturally important species, yet they have become an economic lifeline for marginalized households. Because of this duality, the authors emphasize that the value of a species needs to be determined by its ecological function within a specific context rather than giving it a fixed label.
- Socio-Economic Impacts: Management strategies are increasingly focusing on the intersection of ecology and human livelihoods. One article highlights the "weeds to wealth" initiative, where tribal communities in South India have been trained to use invasive *Lantana camara* sticks for furniture crafting, generating significant income while simultaneously reducing weed density in protected forests. Conversely, the "silent takeover" of the wetlands by the mussel and the degradation of shallow fishing grounds by the invasive plants illustrate the cost of invasion to human livelihood.
- Mechanistic Insights and New Management Tools: Advancements in scientific understanding are providing more targeted management frameworks. One article demonstrates that the characterization of plant traits helps in prioritizing the eradication and spread most cost-effectively. In aquatic systems, where invaders are often cryptic and difficult to discover, researchers are looking toward innovative tools such as eDNA for early detection, acoustic deterrents, and genetic engineering techniques to manage populations more sustainably.
- Emerging Threats and Behavioural Shifts: The edition also highlights specific species causing concern across diverse Indian landscapes. In the Doon Valley, the rapid growth of Paper Mulberry is suppressing native Sal Forest regeneration and creating "ghostly" stands of dead biomass. In urban Bengaluru, the Giant African Snail is exhibiting unusual daytime activity, likely driven by intense competition for space. Furthermore, the spread of the Dengue mosquito (*Aedes aegypti*) through historical trade routes and the dominance of feral dogs at carcass sites in the Aravalli landscape illustrate the broad range of biological threats requiring urgent, coordinated attention.

The diversity of research and perspectives in this edition underscores a fundamental truth: managing biological invasions in India is as much a social and economic challenge as it is an ecological one. Successful management of biological invasion thus depends on moving beyond reactive, short-term fixes toward proactive, science-driven stewardship, and focusing our efforts on building resilient landscapes that are naturally more resistant to future threats.

I hope that the insights shared here will inspire ongoing and future research in this domain and incite collaboration across disciplines to strengthen the biosecurity infrastructure of our country against biological invasions.

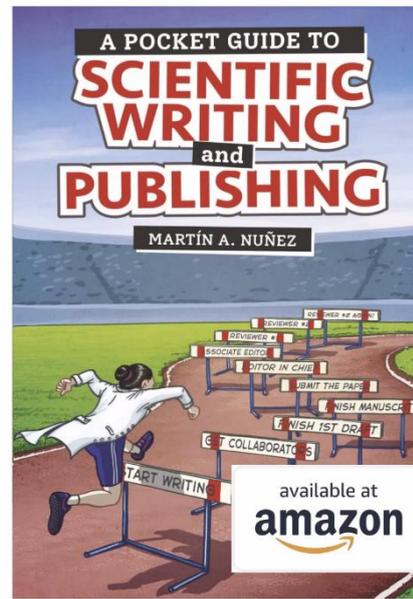
Dr. Achyut Kumar Banerjee

A Webinar on “Tree invasions as a tool to mitigate climate change: More cons than pros?”

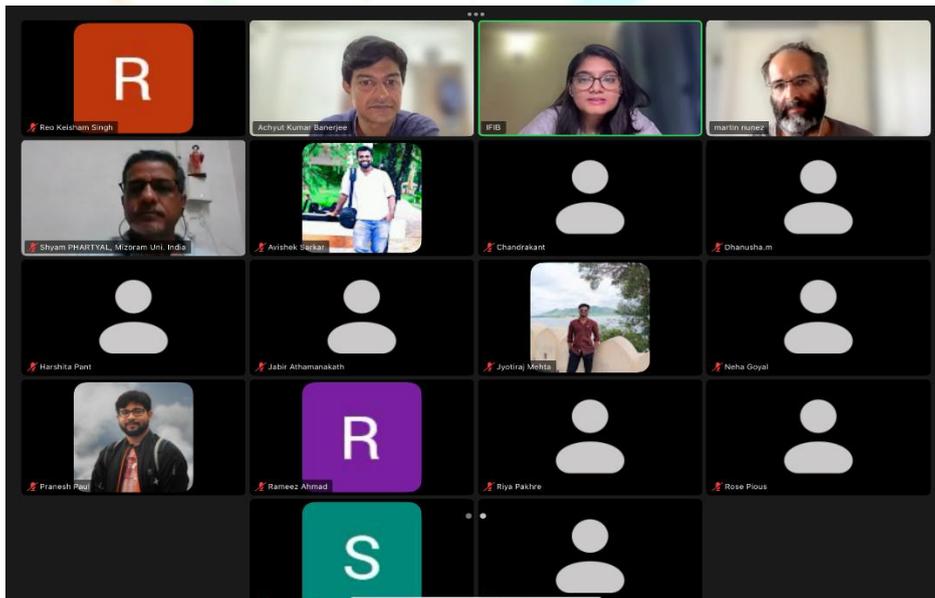
Reo Keisham Singh

The climate change debate is an ongoing debate in many platforms at the local, national and international level. The impact of climate change has influenced every field of studies. In the evening of 27th September, 2025, the IFIB invited **Prof. Martín A. Nuñez**, an associate professor in the Department of Biology and Biochemistry at the University of Houston, to discuss on the invasive trees as a tool for climate mitigation. Prof. Martín A. Nuñez’s research is primarily focused on plant chemistry, management and control of invasive species, the role of mycorrhizal fungi on plant invasion, and ecological and evolutionary theories on biological invasions. The online meet started with a discussion on the ecological, economic, and social impacts of invasive trees having a negative impact on the ecosystem. Many often missed the crucial consideration of the ecosystem disservices by the invasive species when considering any plantation measures for the benefit of carbon sequestration or even simple plantation as an ornamental plant. The discussion was largely focussed on Pine species (Lodgepole pine and Ponderosa Pine) interaction with mycorrhizal fungi. This pine species is brought for

afforestation and has naturalized and can grow up to two times in their native range. The symbiosis of mycorrhizal fungi makes the pines grow much larger and faster with the increased biomass of three times. The increase in biomass alters the soil carbon by altering soil processes and the greenhouse inoculum by the pines can be released back into the atmosphere.



He also shared a glance at his book titled “A Pocket Guide to Scientific Writing and Publishing”. The discussion concluded with a curious interaction on the ecosystem disservices that can be caused by afforestation of such invasive tree species.



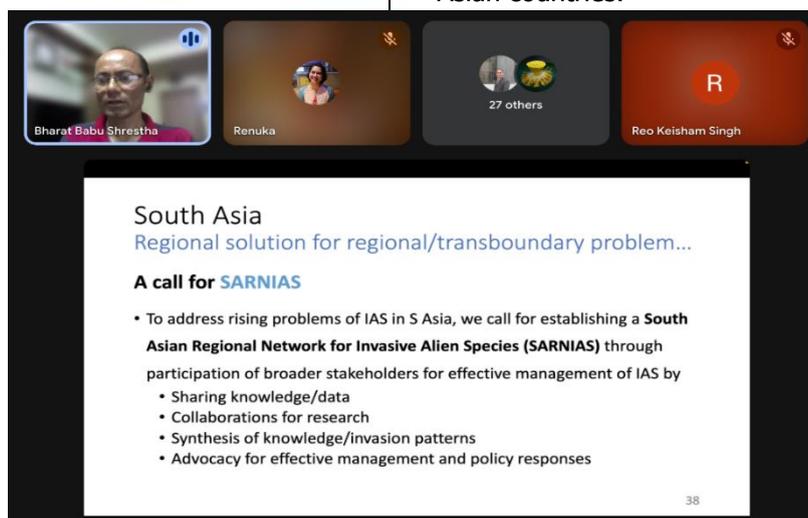
A Webinar on “Biological Invasion in the Era of Anthropocene: Challenges and prospects for managing invasive alien species in South Asia”

Reo Keisham Singh

The anthropogenic footprint is growing rapidly due to increasing human population which has crossed 8 billion. The term ‘anthropocene’ refers to the time humans started to make significant and lasting impact on the earth’s system. The biological invasion is one of the five major drivers of global environmental changes caused by anthropogenic activity across the globe. South Asian countries are densely populated and hence at high risk of Biological invasions.

Prof. Bharat Babu Shrestha from Tribhuvan University, Nepal joined the IFIB meet held online on 18th October 2025 to interact and discuss why South Asian countries are in urgent need for regional collaboration and unified policy to combat cross-border spread. Biological invasion has massive threats and South Asian countries have low national capacity for control and management of this species. Prof. Shrestha is a distinguished faculty member in the Central Department of Botany at Tribhuvan University, Nepal. He primarily works in biological invasions and climate change with a special interest towards the one of the South Asian country – Nepal. The session started with a focus on the change of planet from the exchanges of species

between different areas through the discovery of new world. The increase of invasive species has spiked from 1900s and more than 3500 species of different species are classified as invasive alien. He also emphasized, the high accumulation of established alien species in temperate region and the biotic homogenization of this species. The loss of the economy from the damage and control of these species can be accounted to USD \$423 billion. The South Asian countries are a highly connected areas through trade and travel. These regions encompassed 3 of the 35 global biodiversity hotspots (Himalaya, Indo-Burma, and Western Ghats-Sri Lanka). It was discussed that 241 invasive plant species are found in the South Asian countries. On the other hand, India has 97 invasive plant species alone as highest among the South Asian countries. The session continued discussions to the challenges in the management of these invasive species like inadequate policy responses, ineffective quarantine and biosecurity rules, low national capacities, key knowledge gaps, and lack of common and agreed standards. Furthermore, the solution was highlighted as a regional solution as moving in a transboundary approach, sharing knowledge or data, collaborations in research, synthesis of knowledge and policy responses. At the end of the session the possibility of building a collaborative platform was proposed “SARNIAS” (South Asian Regional Network for Invasive Alien Species) for effective research and management of invasive species in South Asian countries.



South Asia
Regional solution for regional/transboundary problem...

A call for SARNIAS

- To address rising problems of IAS in S Asia, we call for establishing a **South Asian Regional Network for Invasive Alien Species (SARNIAS)** through participation of broader stakeholders for effective management of IAS by
 - Sharing knowledge/data
 - Collaborations for research
 - Synthesis of knowledge/invasion patterns
 - Advocacy for effective management and policy responses

38

A Webinar on “From genes to ecosystem transformation: How genomic processes are shaping invasive species and leading to ecosystem transformation”

Harshita Pant

On December 6th, 2025, an online webinar was delivered by **Prof. Jane Molofsky** titled “From genes to ecosystem transformation: How genomic processes are shaping invasive species and leading to ecosystem transformation”, a distinguished plant ecologist and Professor of Plant Biology at the University of Vermont, USA. Prof. Molofsky earned her Ph.D. from Duke University in 1993 and brings over three decades of expertise in ecology and invasion biology. Her research focuses on the ecology and evolution of invasive plant species, particularly examining how invasive traits arise, interact with native communities, influence population dynamics, and drive eco-evolutionary feedbacks within plant communities.

In her talk, Prof. Molofsky discussed how multiple introductions of European genotypes from disparate origins can lead to continental-scale genetic variation in the native range

becoming compressed into within-population variation in the introduced range, resulting in the emergence of novel genotypes. These novel genotypes were shown to produce more tillers and greater biomass than native genotypes when grown under common environmental conditions. She further highlighted feedback mechanisms between functional traits and ecosystem transformation and explored how new traits and trait combinations arise during the invasion process. Emphasising the role of functional traits as predictors of invasiveness, she also referred to several trait databases available for invasive species research.

Concluding her talk, Prof. Molofsky noted that invasive species often succeed by occupying the edges of trait distributions, a perspective that helps reconcile the apparent conflict between environmental filtering and limiting similarity hypotheses. She also shared insights from her research work on the role of plant functional trait profiles in invasion success using data from the Republic of Korea, and summarised the webinar by underscoring that comparative analyses of functional traits between native and invasive species may help predict future biological invasions.

The screenshot shows a Zoom webinar interface. At the top, the presenter is identified as 'Jane Molofsky (Presenting)'. The main content is a slide titled 'Evolutionary Change' which contains a flowchart and a caption. The flowchart shows 'Mutations' leading to 'Multi-allelic genes', 'Keystone genes', and 'Hybridization'. 'Multi-allelic genes' leads to 'Minor to moderate phenotypic effect', which leads to 'Niche expansion' and 'Novel habitat'. 'Keystone genes' leads to 'Invasion success'. 'Hybridization' leads to 'Large phenotypic effect', which leads to 'Transgressive phenotypes' and 'Feedback alterations'. 'Invasion success' leads to 'Ecosystem transformation'. A dashed line connects 'Keystone genes' to 'Large phenotypic effect'. A caption below the diagram explains the pathways and their prevalence. The bottom of the screen shows a list of participants: 'Achyut Kumar Banerjee', 'Jane Molofsky', '28 others', and 'Reo Keisham Sin...'. The time is 18:38 and the meeting ID is wtt-tvtk-kiw.

2nd round of "The Invasion Hour"

Reo Keisham Singh

The second session of our lightning talks was a dynamic session where young researchers from India shared their experiences and insights from working in the domain of biological invasions, ranging from their field experiences to lab experiments, preliminary data collection to statistical data analysis, and from ideas to executions called Invasion Hour was organized on 1st November 2025 in online mode. The interactive session was joined by 3 researchers i) **Malvika Chaudhary** from CABI, India; ii) **Dr. Arunava Datta**, a faculty from Vidyasagar University; and iii) **Dr. Neha Goyal**, a faculty from University of Delhi. First interaction was about the CABI landscape initiatives where the Integrated Landscape Management approach is discussed in providing sustainable livelihoods and improve ecosystem goods and services like CABI digital tools for pest prioritization and supporting early preparedness and rapid responses, CABI digital library (Invasive series). In the second interaction, Dr. Arunava Datta shared his wonderful experience in Kruger National Park. He shared how the tourism facilities in the National camp can lead to introduction of non-native species and the role of effective regulations.

Lastly, Dr. Neha Goyal shared her extensive research on *Lantana camara* and its performance in heterogeneous light environments. Why determination of ploidy level is important?



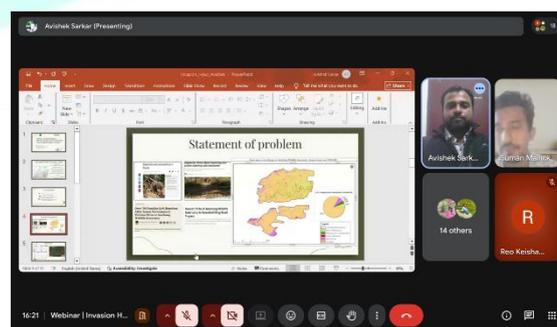
3rd Round of "The Invasion Hour"

Harshita Pant

This edition of The Invasion Hour held on **17th January, 2026** featured three early-career researchers working across diverse invasion systems. The session began with a talk by **Harshita Pant**, a research scholar from the University of Delhi, who shared insights from her fieldwork on *Ageratina adenophora* in the Himalayan region. She discussed key methodological considerations in field studies, particularly the decision-making process involved in selecting appropriate functional traits to assess plant performance.

This was followed by a presentation by **Avishek Sarkar**, a research scholar from the Forest Research Institute, Dehradun. He presented his work on the impacts of invasive plant species on phytosociological patterns within Asian elephant habitats in Assam. His talk also highlighted the complex dynamics of human-wildlife conflict in and around Amchang Wildlife Sanctuary.

The session concluded with a talk by **Dr. Suman Mallick**, Research Associate at the Wildlife Institute of India, who shared his research on the Amazon sailfin catfish, a recent invasive species in the open waters of India. He explained how mesocosm experiments were used to investigate competitive interactions between native fish species and the invasive catfish.



The audience actively engaged in the discussion, raising questions on leaf sampling methodologies and the long-term implications of human-wildlife conflict in Assam.

Reflections from EMAPI 2025: Advancing Invasion Science from the Himalaya to New Zealand

Harshita Pant,
Department of Environmental Studies,
University of Delhi, Delhi

Introduction

The 17th International Conference on Ecology and Management of Alien Plant Invasions (EMAPI 2025), held from 2nd–5th September at Lincoln University, Christchurch, New Zealand brought together a vibrant community of invasion ecologists, managers, policymakers, and early-career researchers from across the globe. As a participant and presenter, attending this conference was an enriching experience that offered intellectual stimulation, opportunities for collaboration, and a deeper appreciation of how international efforts converge to address the growing challenge of biological invasions.

A Global Meeting Ground for Invasion Biology

EMAPI is widely recognized for its interdisciplinary scope and focus on bridging research and management. This year's conference continued that legacy, featuring thematic tracks, including advances in biological control of weeds, an overview of a national programme tackling invasive conifers, cutting-edge tools for risk assessment, above- and below-ground impacts of alien plants and the role of environmental change in plant invasions. These themes collectively highlighted the multidimensional nature of invasion ecology and the need for integrated approaches that connect ecological theory, practical management, and social perspectives.

The opening day set an inspiring tone with a plenary lecture by Dr. Julie Coetzee, who presented compelling stories of successful aquatic weed biocontrol programs in Africa. Her talk emphasized how long-term commitment, scientific rigor, and community engagement form the backbone of effective management. Sessions throughout the day featured eminent

scientists such as Prof. Philip Hulme, Prof. Petr Pyšek, Prof. Jane Catford, Dr. Marc Cadotte, Prof. David Richardson, Prof. Hua Shao, and Prof. David Clements. Their work demonstrated how climate change, land-use patterns, and global connectivity are reshaping plant invasion dynamics often in unpredictable ways. Prof. Anibal Pauchard discussed two decades of the Mountain Invasion Research Network (MIREN) during the plenary session.

Insights from Wilding Pines to Freshwater Ecosystems

The second day focused strongly on the challenge of wilding conifers in New Zealand. Dr. Duan Peltzer delivered a plenary session linking ecological insights with practical management considerations, underscoring how invasive conifers threaten native ecosystems and require coordinated, landscape-level strategies. Case studies shared by Jan Dudenhoeffer and Thomas Paul showcased innovative management tactics, and the flash-talk session created a lively platform for young researchers to share their emerging contributions.

Later, Dr. Kate McAlpine presented an engaging overview of environmental weeds on conservation lands, emphasizing how management decisions must balance ecological priorities, cultural values, and resource limitations. Follow-up talks by Prof. Luke Flory and Pete Caldwell brought attention to community-led initiatives and the role of experimental research in refining management plans.

Day three broadened the lens even further with a plenary lecture by Prof. Montserrat Vilà, who presented a global synthesis of ecological impacts caused by invasive plants. Her assessment highlighted the need for standardized metrics and stronger international collaboration to fully understand and address impacts across ecosystems. Presentations by Dr. Christina Birnbaum and Dr. Ian Dickie delved into above- and below-ground mechanisms driving invasion success, adding mechanistic detail to discussions around impacts and ecosystem vulnerability.

An especially memorable session was delivered by Prof. Curtis Daehler, who drew lessons from Hawaii's unique ecological history. His talk illustrated how island ecosystems, with their high endemism and isolated evolutionary trajectories are both highly vulnerable to and deeply informative about plant invasions. Prof. Wayne Dawson's presentation on global hotspots of freshwater plant invasions further reinforced the urgency of addressing emerging aquatic threats.

Presenting My Research at EMAPI

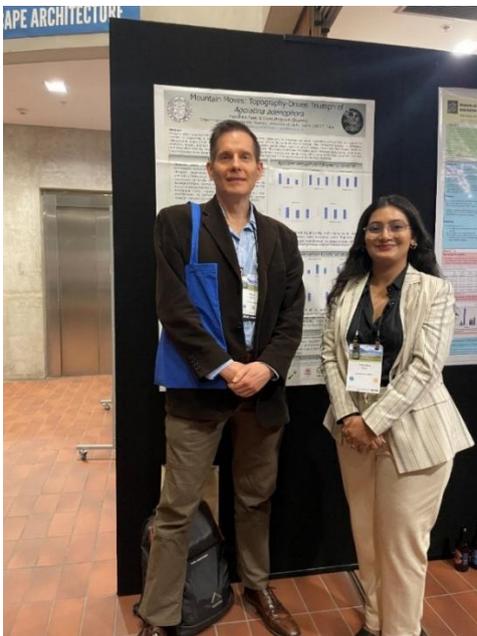


Figure 1: In discussion with Dr. Philip Hulme

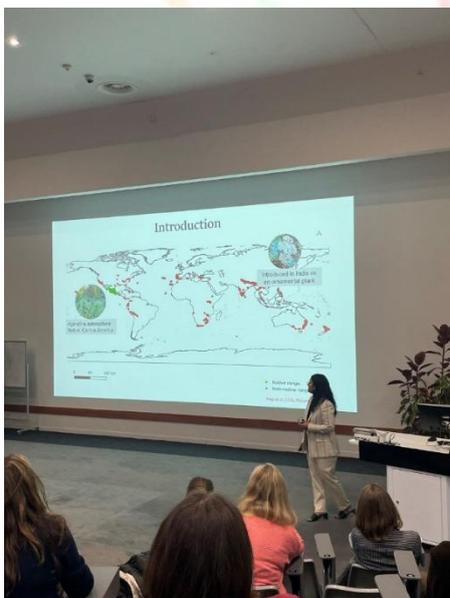


Figure 2: Presenting my research work at EMAPI 2025

I presented my work titled "Mountain Moves: Topography-Driven Triumph of *Ageratina adenophora*," which examines how topographic variation influences the functional traits and performance of this invasive species in the Himalayan region. Using a trait-based approach, my study highlights how slope type, elevation, and microenvironmental conditions shape invasion success and information that can be valuable for designing targeted management strategies in mountain ecosystems.

Sharing this research with an international audience provided an excellent opportunity to receive constructive feedback and engage in stimulating discussions.

Learning Beyond the Lecture Halls: Field Trip Experience

On 5th September, participants joined a field excursion to Lyttelton Port and Quail Island, two sites that exemplify New Zealand's proactive and highly coordinated approach to invasive species management. At Lyttelton Port, biosecurity officers demonstrated inspection protocols, monitoring systems, and early-detection strategies that help prevent introductions via maritime trade. Observing these processes first-hand highlighted the importance of strong institutional frameworks and continuous vigilance.



Figure 3: Understanding restoration strategies at Quail Island, New Zealand

The visit to Quail Island showcased ongoing restoration efforts, including native vegetation recovery and invasive plant control. The work being carried out there reflects decades of commitment and community involvement.



Figure 4: Biosecurity experts explaining stringent biosecurity protocols at Lyttleton Port, New Zealand

Seeing these practical applications of ecological science reinforced the central conference message: effective management requires both scientific evidence and long-term stewardship.

Closing Reflections

EMAPI 2025 was more than a conference, it was a platform for exchanging ideas, expanding networks, and reimagining the role of ecological research in addressing global challenges. For me, it strengthened my academic confidence, broadened my understanding of invasion processes, and allowed me to share insights from the Himalayan region, a landscape that faces increasing pressure from invasive species yet remains underrepresented in global discourse.

The experience will undoubtedly influence the direction of my research and future collaborations, and I am grateful for the support that enabled me to participate.



Global Conferences to Explore

XVII International Symposium on Biological Control of Weeds (Click for more details)	8-13 March 2026	Rotorua, New Zealand
VI International Young Researchers Conference on Invasive Species - 2026 (IYRCIS) (Click for more details)	5-6 May 2026	Online
Ecological Society of America, 111th Annual Meeting, 2026 (Click for more details)	26-31 July 2026	Salk Lake City, Utah
Neobiota 2026, the 14th International Conference on Biological Invasions (Click for more details)	7-11 Sept 2026	Brussels, Belgium

"The Deadly Cousin of The Tiger Mosquito" - An invader that roams the Indian subcontinent

Kartik Srivastava

University experimental school, Baroda

The Dengue mosquito *Aedes aegypti*, which is widely and more commonly called as the "Cousin" of the Asian Tiger mosquito *Aedes albopictus*, both being members of the same genus *Aedes* and even the same sub-genus *Stegomyia* (Powell, 2005) and both capable of causing deadly human diseases. However, with time, the *A. aegypti* has become an invasive species in the Indian subcontinent, capable of growing easily and rapidly in human habitations and often outcompeting other native mosquito species including *A. albopictus*.

A. aegypti, being non-native to the Indian subcontinent made its way to India from Africa (it's native place) through the ships carrying water barrels, cargos and colonial slave trade routes during the 18th-19th century. Once it was able to make its way to the coastal cities of India, it also spread inland.

Just like *A. albopictus*, *A. aegypti* too acts as a potential vector for several deadly human diseases like Dengue, Chikangunya, Zika and Yellow fever (outside India) but what makes *A. aegypti* invasive is that, it is more tough and resistant, unlike other species and can easily outcompete other native species (Lushasi et. al, 2024) including, *A. albopictus* (Gilotra et. al, 1967) and that's the major reason that *A. aegypti* can be more commonly found throughout the subcontinent and shows a relatively wider distribution in India, than the *A. albopictus*.

This species is extremely adaptable as well, commonly seen growing and breeding in any of the possible places in human habitations (especially in its favourable season of monsoons) including tyres, barrels, buckets, mud-pots, ditches, dustbins and even polythene sheets (Getachew et. al, 2015) with tough eggs which can easily resist dry conditions. The females of this species act as vectors of deadly Dengue, Zika and

Chikangunya viruses as it feeds upon the human blood for providing nourishment to the developing eggs. While doing so they transmit the viruses into human blood causing the disease.

Dengue, which is relatively more deadly than the latter two, alone affected approximately 14.6 million people worldwide and caused 12,000 deaths in 2024 (WHO). Moreover, such diseases are not just physically impactful to a person but mentally too and above that, financial strains are again worrisome. A study by Shephard et. al showed that the direct annual medical cost between 2006-12 in India for Dengue was 548 million US dollars.

The biggest question which arises now is how to manage this invasive species. Considering the smaller size of the species and broader range of its distribution, it's practically difficult to completely eradicate the species from the country but, its population could of course, be checked upon and controlled effectively. There have been numerous ways to tackle this problematic species like fogging of chemicals to destroy the larvae or cleaning of ponds or filling of puddles, however these approaches are either not eco-friendly or these are relatively cost-ineffective. But with the advent of bioremediation approaches, some biological agents could also be used to destroy the larvae of this silent but deadly invader. Since biological agents would be used, hence these approaches would not cause any pollution, moreover, these approaches are cost effective too. One such approach is- introduction of fishes like the mosquitofish *Gambusia holbrooki* (El-Bassal et. al, 2012), *G. affinis* or guppy fish *Poecilia reticulata* (Kay et. al, 2008) in stagnant water units or water bodies as these fish species can directly feed upon the larvae of *A. aegypti* thus, controlling its population. Also, BTI (*Bacillus thuringiensis israelensis*) which is a bacterial species capable of producing Cry toxins and that can kill the insect larvae could also be widely used, as suggested by 'National Vector Borne Disease Control Programme'. The spores of BTI can be introduced into the water tanks, containers etc. upon which the mosquito larvae

will feed and eventually die.

Personally, I believe these biological approaches are the one of the best ways out to put a check on this invasive species. Although, these approaches too might not be welcomed until there is awareness and education about *A. aegypti* and the deadly diseases being caused by the species. Hence, there's a need for collective efforts both by the government as well as citizens to plan a holistic way out to curb this invasive species and the health-problems caused by it.

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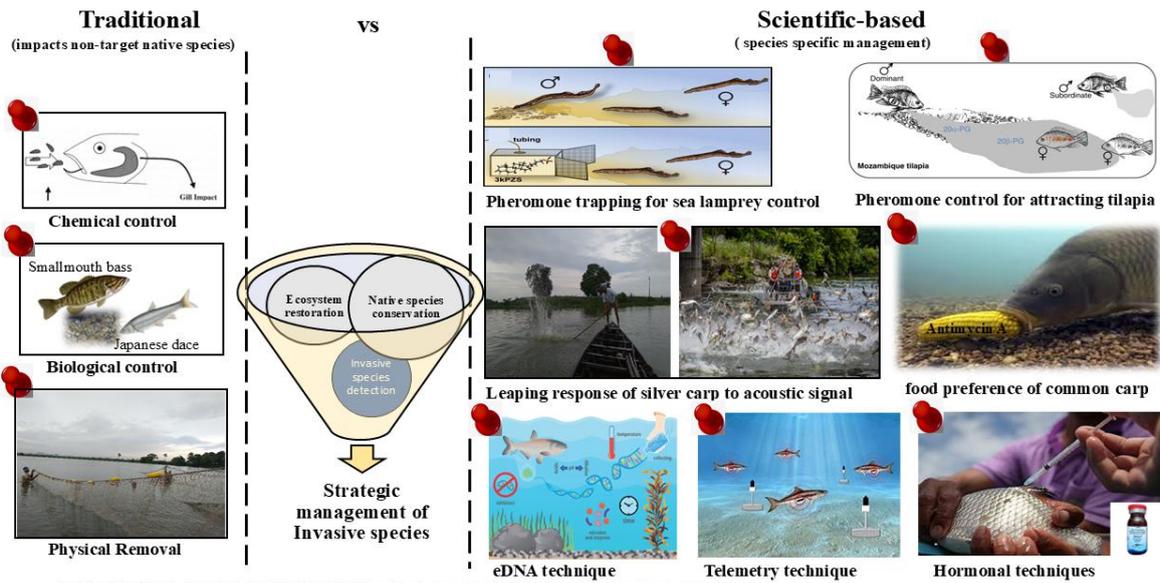
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Management of Invasive species with special emphasis on aquatic ecosystem

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Invasive species have already taken a toll on the ecosystem, both terrestrial and aquatic, through various drivers, the prominent one being human interest of trades (ornamental plants & pets), ballast water exchanges, aquaculture to decrease pressure of wild catch, accidental release or escape and biocontrol of pests (guppy or mosquito fish to control mosquito larvae). Hence, proper management is warranted to conserve the natural endemic population at the point of species invasion. Terrestrial invasions can be tackled by removal in some cases, for example lantana spp., although it proved to be inefficient due to rapid expansion. Things become difficult when it comes to the context of aquatic species, as they are cryptic and not very easy to discover. Post invasion, invasive species are subjected to rapid



‘Scientific-pathway based conservation is the way forward for management of invasive species’

expansion of its population due to absence of natural predators, extra ordinary adaptation capability, generalist feeding behavior, superior or bold, and territorial behaviors in the invaded ecosystem displacing native inhabitants from its habitat, competing for food or directly predated on the young ones of native species making it detrimental for the native population to thrive. Thus, management of invasives needs urgent attention and can be further classified into traditional and scientific knowledge-based pathways.

1) Traditional:

The traditional pathway has impacts on non-target species, including native species.

a) Physical control: It uses traditional knowledge of fisherman folk, which includes capture and removal. Invasive species are captured using nets and removed while regular fishing practices. Unfortunately, this practice is not efficient for cryptic species and captures both native as well as non-native species wasting the effort of fisherman community along with increased cost of fuel consumption, but harvest and productivity fall apart.

b) Biological control: Using natural predators- Indigenous Japanese dace (*Tribolodon hakonensis*), a fish egg predator of invasive smallmouth bass (*Micropterus dolomieu*) in

Japan (Iguchi and Yodo 2004), native European eel (*Anguilla anguilla*) effective predator of the invasive red swamp crayfish (*Procambarus clarkia*) in the Netherlands (Musseau et al. 2015), native Eurasian perch (*Perca fluviatilis*) controlling population of invasive topmouth gudgeon (*Pseudorasbora parva*) in the United Kingdom (Davies and Britton 2015). Adding a predator to ecologically balanced ecosystem, might be a cause for unstable ecosystem altering the trophic chain in few cases.

c) Chemical control- treating fish with poisons leading to mass mortality (Rayner and Creese, 2019) including non-target species.

2) Scientific knowledge-based:

A scientific knowledge-based pathway includes understanding the biology and behaviors of the species for laying down a proper management strategy for the species in its invaded ecosystem.

a) Understanding feeding preference, luring the invasive species with species-specific food attractants (Corn bait for common carp (*Cyprinus carpio L.*)) (Poole et al., 2018)

b) Understanding pheromonal communication during mating season, using synthetic pheromones to lure the invasive species

(Management of Sea lamprey (*Petromyzon marinus*)) (Hansen et al., 2016)

c) Understanding acoustic deterrent for carp removal (in case of silver carp (*Hypophthalmichthys molitrix*)) (Vetter et al., 2015)

d) Molecular techniques for early detection of invasives (Environmental DNA (eDNA) technique) (Larson et al., 2020)

e) Applying sterile-male release in fish can fertilize wild-type eggs, but does not generate viable offspring (sea lamprey (*Petromyzon marinus*) control in the Great Lakes (Twohey et al. 2003)

f) Use of telemetry to locate seasonal aggregations of the pest (common carp in lakes of Midwestern North America) (Bajer et al. 2011)

g) daughterless technologies depend on the release of fish where all of the offspring are male by destroying the X chromosome during meiosis, all sperm cells will carry the Y chromosome and generate males (feminization of common carp (Bongers et al. 1999)

h) Application of genetic engineering techniques to control hormone levels that determine sex in fish (daughterless carp strategy (Thresher et al. 2014a))

i) Application of species-specific virus to control invasive species (Cyprinid herpesvirus-3 (also known as koi herpes virus; KHV) is being considered as a biocontrol agent specific to common carp (Hedrick et al. 2000) was shown to cause large carp mortality outbreaks in Europe, Japan, and Indonesia (Haenen et al. 2004).

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A Silent Takeover: What the Charru Mussel (*Mytella strigata*) Teaches Us about India's Changing Coasts

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There are moments when an invasive species goes from being a biological curiosity to a lived reality—*Mytella strigata*, the charru mussel, has crossed that line in India (Sanpanich & Wells, 2019; Vajiram & Ravi, 2025). For years, its presence along the southeast coast felt like a distant warning (Vigyan Varta, 2024). It clung to bits of marine litter, a handful of shells here and there, almost unnoticed (Drishti IAS, 2020; Vajiram & Ravi, 2025). But today, its invasion is unfolding in one of India's most sensitive and livelihood-rich coastal systems: the Ennore–Pulicat wetlands (Namboothri et al., 2022; The News Minute, 2023; Vigyan Varta, 2024).

What strikes me most is the speed at which this species has shifted from “emerging” to “established” (Sanpanich & Wells, 2019; VLIZ, 2021). Charru mussels are talented travellers. Across the world, they have spread through ballast water, ship hulls, and drifting plastic—vehicles we unintentionally provide. Once they arrive, they waste no time. In places like Singapore, they overran shorelines and aquaculture nets so quickly that native mussels simply vanished. India now stands at a similar crossroads (National University of Singapore [NUS], 2018).

Along the Ennore–Pulicat belt, local fishermen are witnessing first-hand how drastically an invasive species can alter a landscape (The News Minute, 2023; Gender in Aquaculture and Fisheries [GAF], 2023). Several *paadu*—traditional fishing zones such as Karukkumaram, Kandachedi, and Jallikuzhi—are now overrun by dense mussel beds. Boats get stuck, nets tear under the weight of the clustered shells, and the familiar movement of the creek has changed. One fisherman described the situation simply: “It feels like the water has a new owner.”

This, to me, captures the essence of invasion ecology—it is not just about species competing underwater. It is about people, livelihoods, space, and identity. When mussels block a fishing route, that disruption is ecological, but its consequences are deeply human.

Government agencies have attempted to respond, largely through dredging operations (National Green Tribunal [NGT], 2023a, 2023b). Large stretches of the creek have been mechanically cleared in recent months, and fishermen have noticed temporary improvements in navigation. But dredging, while immediately visible, remains a short-term fix. New mussel colonies reappear quickly, and clearing only one part of the creek often pushes the problem farther downstream. It becomes a cycle of clearing, recolonization, and recurring frustration.

For me, the key concern is not whether dredging works or fails—it is that by the time

dredging becomes necessary, the invasion has already progressed far beyond the early-warning stage. With *M. strigata*, India has entered the response phase much later than ideal. And this is not an isolated case. As marine traffic increases and coastlines become more interconnected, invasions are no longer slow, natural migrations—they are rapid, human-assisted leaps.

The root of this mussel's success lies in its biology. Compared to the native *Perna viridis*, the charru mussel has a digestive system that adapts remarkably well to new food sources. Studies from the Pacific show that its gut microbiota is packed with carbohydrate-degrading bacteria, giving it a competitive edge that allows it to thrive in nutrient-rich estuaries like those in Tamil Nadu. Warm waters, sheltered lagoons, and constant food availability offer everything it needs to flourish (Sanpanich & Wells, 2019, Zuo et al., 2024).

Yet, despite the ecological threat, I find myself curious about the species' future role in Indian waters. Researchers are already exploring possibilities like using harvested mussels for animal feed or fertilizer. If done carefully, could the invasion be managed while generating value? Or will that risk creating new problems, as often happens when we try to turn invasive species into resources?

No easy answers exist. But what is clear to me is this: India must shift from reactive crisis management to proactive ecological vigilance. Early detection along shipping corridors, rapid reporting systems for fishermen, and regular monitoring of estuaries could prevent future invasions from reaching the scale seen in Ennore.

Right now, the charru mussel serves as a warning—not just about one species, but about how vulnerable our coasts have become. If India learns from this invasion and strengthens its marine biosecurity, *M. strigata* might be remembered as the invasion that changed how we protect our shores. If not, it may be the first of many such takeovers.

Either way, the story unfolding in Ennore is no longer an alert—it is a lesson. The question is whether we are willing to learn from it.

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The paradox of *Neltuma (Prosopis) juliflora*

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Very few species possess the ability to thrive under extreme harsh conditions (drought, salinity, pollution etc.) as profoundly as *Neltuma juliflora* (Mesquite). The species was introduced to the Indian subcontinent to provide ecosystem services such as greening drylands, combating soil erosion, and supplying fuelwood. At present, depending on who you ask, this thorny tree is either a resilient savior or an ecological villain. Recent research on mesquite's impacts in non-native landscapes reveals a nuanced truth: under the present ongoing and future climate instability and in

human altered systems, the idea of categorizing *Neltuma juliflora* as purely good or bad no longer make sense.

It is quite impossible not to appreciate mesquite's remarkable resilience. In dry drought regions, where agriculture fails and soil erode – mesquite thrives and survives under extreme conditions. It renders much needed ecosystem services such as firewood, carbon sequestration, pollination resources, and honey production. Also, in metal contaminated soils, Mesquite phyto-remediate the soil and enrich soil with essential nutrients. Right in a time when climate vagaries push global landscapes towards desertification, a that species anchor soil and enriches soil carbon pool can no longer be a notorious weed, but a climate warrior, sequester atmospheric carbon in its biomass / soil and fight climate change for humanity in the forefront.

Despite the benefits, invasion of Mesquite has resulted in the displacement of native plants leading biodiversity decline; which consequently affects livelihood of pastoralists. Its sharp thorn can injure animals, restrict the wildlife movement and even more its dense monocultural canopy sucks out - consume / evapotranspirates ground water potentially worsens regional water crisis.

Efforts to eradicate mesquite including physical, chemical and biological measures have largely



Neltuma juliflora invaded landscape at Tiruchirappalli, Tamil Nadu, India

failed and ineffective. This reality raises a critical management dilemma: if mesquite cannot be completely eradicated, yet cannot be allowed to expand uncontrollably, what should be done? The most practical conclusion is that management must be context specific. Mesquite must be actively eliminated from forests, riparian zones, protected habitats and landscapes where biodiversity richness is irreplaceable. In contrast, in vulnerable low biodiversity rich arid, semi-arid human dominated zones, mesquite coppices can be selectively retained to render positive ecosystem services (carbon sequestration). Controlled utilization strategies - such as converting biomass to bio-char or fuel wood might help to control the coppices expansion while delivering socio-ecological benefits.

The conflict between human needs and global system balance is perhaps the most pressing dilemma of 21st century. Mesquite may serve as a test case for adaptive management, where value of a species is largely determined by ecological functions within the context rather than by rigid labels such as "invasive" or "native".

Mesquite forces humanity to confront an important truth: global ecosystems are dynamic, largely driven by global climate. The Sahara Desert was once a green savanna with full of hippos and elephants. Today, that same landscape exists as the world's largest hot desert, reminding us that ecosystems are dynamic; species and landscapes continually evolve in response to global climate change. Although Mesquite was deliberately introduced by humans, its invasion may reflect the shift in ecosystem condition towards greater aridity. Under such dry conditions, the most adaptable species will survive the dynamic change in environment. Rather than categorizing mesquite as simply good or bad, we must focus on where it must be removed, how its invasion can be controlled, how its terrestrial biomass can be leveraged / monetized? Answers to these questions may navigate us to manage a rapidly changing planet.

Neltuma juliflora in Kutch Landscape: An Ecological Paradox

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In the arid landscape of Kutch, Gujarat, an ecological paradox unfolds. *Neltuma (Prosopis) juliflora*, the notorious invasive mesquite, has transformed over half of the region's native grasslands since its introduction in the mid-20th century. Invasive alien plant species are rapidly reshaping landscapes across the globe. These fast-spreading plants don't just crowd out native species; they disrupt entire ecological communities and alter an ecosystem function. Their impact is now recognized as a major force of human-driven environmental change, putting pressure on biodiversity, diminishing crucial ecosystem services, and even slowing down local economies that depend on healthy natural systems (Simberloff et al. 2013).



Figure 1. A picture of *Sterculia urens* (left), *Grewia tenax* (middle), and *Acacia nilotica* (extreme right) in a *Neltuma*-dominated landscape of Kutch, Gujarat. Picture Credits: MI

Neltuma has a long history of travelling far from its native lands. Of the many species introduced around the world, four- *N. glandulosa*, *N. velutina*, *N. juliflora*, and *N. pallida*- have turned into aggressive invaders (Pasiiecznik et al. 2001). *Neltuma juliflora*, which originates from Central America, northern parts of South America, and the Caribbean region (Burkart, 1976), found its way to Gujarat in the early 1960s. The Gujarat Forest Department planted it along the edges of the Banni grasslands in Kutch as a barrier to slow the advance of the

Great Rann. However, the species quickly exceeded its intended role. Its ability to withstand harsh, saline, and arid conditions, combined with rapid growth and seeds easily spread by livestock, enabled it to overtake native vegetation. Over the years, *N. juliflora* has spread across almost the entire Kutch landscape (Dixit et al. 2009).

Neltuma juliflora has now become one of the main sources of livelihood in rural Kutch, with seed pods used as livestock feed and wood used in charcoal making. The rapid spread of *Neltuma*, now occupying more than half of the region's former grasslands, has created a complicated conservation puzzle. Its dense thickets add structural cover benefits wildlife such as Indian leopard, Striped Hyaena, Caracal, Jungle cat, Desert cat, Golden Jackal, Bengal fox, Indian Crested Porcupine, Indian gazelle, Nilgai, and Wild boar, along with large reptiles such as Bengal Monitor Lizard. Even birds like the Baya weaver construct their intricate nests within *Neltuma* canopies, demonstrating adaptive plasticity in the Kutch landscape.



Figure 2. A Baya Weaver's intricately woven nest hanging from the canopy of a *Neltuma juliflora* shrub in Chadva Rakhal, Kutch. Picture Credits: MAB

But this benefit comes at a cost. *N. juliflora* has steadily displaced key native species across the landscape of Kutch, as observed during our fieldwork. The invasive shrub has outcompeted economically important species like *Vachellia nilotica* and *Senegalia senegal*, both valued for their gum arabic and fodder production. It has also displaced culturally and ecologically important shrubs like *Salvadora persica* and *S.*

oleoides, known for their traditional use as natural toothbrushes and their role in supporting livestock and maintaining soil health. Other natives, including *Grewia tenax*, *Capparis decidua*, *Cordia sinensis*, and *Euphorbia caducifolia*, have been affected as well.



Figure 3. A Bengal Fox peeks out from the dense *Neltuma juliflora* thickets in the Narayan Sarovar Chinkara Sanctuary, Kutch. Picture Credits: SAK

The ecological restoration of the Kutch landscape requires strong integration between the forest department, non-governmental organizations, and the local community. The Forest Department has begun prioritizing the revival of these native species, with special attention to restoring *Salvadora* as a sustainable alternative to *Neltuma*. The extraction of *Neltuma* is allowed for local communities for charcoal production, a livelihood resource shipped to Uttarakhand, Himachal Pradesh, and Kashmir, creating natural harvest pressure. Yet, clearing *Neltuma juliflora* from the landscape is far from straightforward, especially because the plant has become woven into the local economy. For many marginalized households in Banni, its pods, gum, and honey provide a modest but vital source of income, and its wood remains a dependable fuel resource (Sahjeevan, n.d.). However, insights gathered through Participatory Rural Appraisal in the Banni region show that local communities clearly recognize the adverse effects of the *Neltuma* invasion. Many residents associate its spread with rising drought frequency, reduced rainfall, and the loss of native grasses such as *Dichanthium annulatum* (Jinjvo), *Cenchrus ciliaris* (Dhaman),

Sporobolus fertilis (Khevai), and *Chloris barbata* (Siyarpuchha). Their observations point to the broader ecological shifts reshaping the landscape (Joshi et al. 2009).



Figure 4. A sweeping view from Kala Dungar, the highest hills in eastern Kutch, showing *Neltuma*-covered slopes stretching toward the vast floodplains of the White Rann. Picture Credits: NZ

Successful restoration activity from Guneri village in the westernmost part of Kutch has shown how targeted interventions can revive degraded land. In this initiative, *Neltuma* was cleared, and the soil was treated with manure to improve moisture retention. Over three years, the site began to recover, soil pH stabilized around 7.6, and a richer mix of grasses and herbs returned. Species such as *Aristida adscensionis*, *Indigofera linifolia*, *Indigofera cordifolia*, *Goniogyna hirta*, and *Melanocenchris jacquemontii* reappeared, signaling a gradual but meaningful ecological comeback (Gavali et al. 2025). The story of *Neltuma* in Kutch reminds us that conservation challenges are rarely black and white. This invasive species has become both an ecological threat and an economic lifeline, creating a delicate balance that demands thoughtful, community-centered solutions. As restoration efforts gain momentum across Banni, the path forward lies not in simple eradication but in fostering collaborative approaches that weave together biodiversity recovery, sustainable livelihoods, and traditional ecological knowledge. The choices made today will determine whether this ancient landscape can reclaim its native character while continuing to

sustain the communities that depend on it, transforming a paradox into a model of resilient coexistence.

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The role of Allee effects (density-dependent fitness) and strategic trait modulation in the invasion dynamics of *Hyptis suaveolens* (L.) Poit.

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The management of invasive plant species is a persistent challenge in conservation ecology. Thus, a deeper mechanistic understanding of the factors driving invasion success is crucial. While much focus has been on the impacts of large, dense populations, the dynamics of low-density founding populations are critical for predicting and preventing range expansion. Our recent research, published in *Ecological Processes*, investigates these early establishment dynamics through the lens of density-dependent fitness and phenotypic plasticity in a significant plant invader, *Hyptis suaveolens* (L.) Poit., within the invaded regions of dry deciduous forests the Vindhyan highlands of India.

The study was premised on the Allee effects concept, i.e., a positive relationship between population density and components of individual fitness of a species. Review of the literature revealed that empirical evidence for Allee effects in plant invaders, particularly across different spatial scales, is scarce. We hypothesized that *H. suaveolens* would exhibit component Allee effects at the fine (individual) scale and demographic Allee effects at the coarse (patch) scale, with its noted phenotypic plasticity modulating these effects across a density gradient.

A multi-scale methodology

To test this, we conducted a field assessment across naturally occurring monospecific patches of *H. suaveolens*. Patches were categorized into low-, medium-, and high-density populations.

Plant performance was evaluated at two distinct scales:

1. *Fine scale* (Plant Traits - PITs): Measuring individual vegetative (height, biomass, number of secondary stems) and reproductive traits (seed number and mass).

2. *Coarse scale* (Patch Traits - PaTs): Assessing population-level metrics including population density, total patch biomass, and total seed output per patch.

A Plasticity Response Index (PI) was calculated to quantify trait modulation between density classes.

Key findings: evidence for density-dependent strategies

Our results revealed a complex, density-dependent strategy facilitating the invasion success of *H. suaveolens*. At the fine scale, we observed a clear component Allee effect in vegetative growth; plant height and biomass were significantly lower in low-density populations compared to medium- and high-density ones. Conversely, reproductive output per plant was highest in high-density patches. Interestingly, low-density individuals produced more seeds than medium-density ones, which can be linked to their significantly higher production of secondary stems (a compensatory horizontal growth strategy). Furthermore, low-density plants produced larger, heavier seeds, suggesting a bet-hedging strategy favouring local establishment under sparse conditions.

At the coarse scale, the results of the demographic study demonstrated how individual-level trade-offs translate to population-level success. Total patch biomass was similarly high in both medium- and high-density patches, indicating successful resource monopolization by monospecific thickets of *H. suaveolens*. Total seed output per patch was an order of magnitude higher in high-density populations, driven by the combined effect of high plant density and sustained per-plant fecundity. This highlights the transition of *H. suaveolens* invading population from 'individual persistence' (low-density) to 'collective resource dominance' (medium-density) and



In dialogue with the invader: a moment of field study capturing the researcher with plant invader in dry deciduous forests of the Vindhyan highlands, India

finally to 'massive propagule pressure' (high-density).

Moreover, the PI analysis confirmed significant trait modulation. For instance, the shift from low-to-medium density involved high plasticity in patch biomass but low plasticity in patch seed output. The reverse was true for the medium-to-high density transition. This indicates an elastic response at the population level, where different fitness components are plastically emphasized at different density stages to overcome potential Allee effects limitations.

Implications for invasion ecology and management

This study provides robust empirical evidence for Allee effects in an invasive plant, demonstrating that density-dependent regulations are not merely a demographic bottleneck but a dynamic phase mediated by trait plasticity. The "wisdom of the crowd" metaphor effectively captures this: the invading population's strategy evolves with its increasing

density. From a management perspective, these findings offer a strategic framework:

1. **Prioritize low-density patches:** Low-density patches, while exhibiting compensatory traits, are demographically the most vulnerable to intervention due to underlying component Allee effects. Their eradication is the most cost-effective method to prevent transition to higher-density, exponentially more impactful stages.
2. **Differentiate control strategies:** Management in medium-density patches should aim to reduce biomass dominance, thereby releasing native species from light competition. In high-density patches, the goal must be to keep a check on the seed rain, preventing regional dispersal and new satellite establishment.
3. **Incorporate scale in risk assessment:** Predicting invasion spread requires models that account for how individual plant traits (fine-scale) plastically respond to density, and how these responses scale up to determine patch-level growth and dispersal (coarse-scale).

Conclusion

Invasion success of *H. suaveolens* is driven by a density-dependent modulation of its functional traits across scales. The present study calls for developing a comprehensive understanding that moves beyond a static view of invasive traits and embraces the dynamic interplay between density, fitness, and plasticity across scales. This will help in sharpening the risk assessment and refining the management scenario. This multi-scale, mechanistic approach is essential for developing targeted strategies to mitigate the impacts of this and other noxious plant invaders.

Margins Under Threat: Biological Invasion in Guwahati's Wetland Edge Ecosystems

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Wetlands in Guwahati, such as Deepor Beel, Silsako Beel, Borsola Beel, and Sorusola Beel, form a crucial undervalued ecological network that supports stormwater retention, biodiversity, and livelihoods. While the open-water zones of these wetlands receive attention, the fringe wetland zones, including marshes, seasonally flooded fields, and shallow littoral areas, often remain overlooked in conservation and management efforts (Hazarika, 2023). These zones support dense vegetation cover and provide habitat for amphibians, aquatic insects, juvenile fish, and ground-feeding birds, making them essential components of wetland resilience in an expanding urban environment (Rai, 2020).

Currently, the rise in anthropogenic disturbances due to the development of dense settlements and road connectivity networks in the fringe areas of wetlands acts as a propagule dispersal facilitator for the non-native plants. In Guwahati, the combination of *Pontederia crassipes* (water hyacinth), *Lantana camara*,

and *Chromolaena odorata* exerts considerable detrimental effects on the wetlands and their fringe areas. The successful establishment and propagation of non-native plants such as *Chromolaena odorata* and *Lantana camara*, resulting in invasion in the fringe areas, results in alteration in the vegetation compositions, which can subsequently lead to an increase in soil erosion, nutrient-enriched surface run-off, and sedimentation. Consequently, this causes shallowing of the feeder streams, drainage channels, and an increase in the growth of aquatic non-native plants like *Pontederia crassipes* in the marshes, promoting rapid mat formation, near-monoculture conditions, and a reduction in habitat diversity (Lahon et al., 2023). As the number of native plant species declines, food and shelter for small mammals, amphibians, and wetland birds are diminished (Pandey et al., 2018). Fringe degradation of the wetlands also disrupts ecological corridors connecting wetlands to adjoining landscapes. Historically, Deepor Beel maintained connectivity with the Rani-Garbhanga forest, enabling elephants and other wildlife to move between habitats. Increasing fragmentation, coupled with the dominating presence of non-native species like *Ageratum sp.*, *Ipomea carnea*, *Mikania micrantha*, *Mimosa sp.*, etc., resulted in degradation of the corridors, thereby heightening the risks of human-wildlife conflict (Nikita et al., 2024).

The presence of invasive plant species significantly impacts the livelihoods of local communities. Fringe vegetation, which provides fodder, stems, and seasonal harvesting opportunities of cultural importance, is being replaced by invasives. As these invasive species replace the native plants and water quality declines, the harvesting becomes harder and less productive. This weakens community-wetland relationships and erodes traditional ecological knowledge for example, in the fringe areas of Deepor Beel, dense mats of water hyacinth restrict fishing access and reduce the availability of native wetland plants traditionally used by local communities. (SAFE, 2016). Additionally, fishers also report decreased access to shallow fishing grounds and reduced

fish catch. This is primarily due to the restriction in mobility and degradation of vital spawning grounds by the invasive plants (Kalita, 2025). Therefore, the cumulative impact of invasive plants demonstrates an urgent need to protect these vital ecological spaces.



Photo: *Pontederia crassipes* dominating the surface of Deepor Beel, Guwahati - a clear indication of invasive species expansion and loss of open-water habitat

The Way Forward

For Guwahati's wetlands to continue supporting urban ecological security, fringe zones must be recognized as priority conservation spaces. Effective strategies may include:

- Restoration of native fringe vegetation through planting of sedges, grasses, and marsh herbs
- Regular monitoring of invasive spread and mechanical removal before dominance is established
- Maintaining open hydrological corridors by preventing drainage blockage and encroachment
- Community-based stewardship programs involving fishers and youth residents

- Urban planning regulations that legally define and protect wetland margins

Shifting conservation focus to the edges rather than only the open water will help restore habitat quality, protect biodiversity, and strengthen flood resilience for Guwahati's future. Recognizing fringe wetland zones as overlooked frontlines is essential in ensuring that the city does not lose its most valuable ecological buffers in the face of rapid environmental change.

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Living With Invaders: Rethinking Our Relationship with Invasive Alien Species

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Invasive Alien Species (IAS) are often described using strong, combative words invaders, aggressors, threats. This language shapes how we imagine biological invasions: as battles between “bad species” and “good ecosystems.” But the more I study invasion ecology, the clearer it becomes that invasions are rarely that simple. IAS are not villains acting alone; they are symptoms of deeper environmental problems created by human choices, land-use changes, and weakened ecological relationships. Understanding them requires us to look beyond removal and confront the ways we shape the ecosystems in which invasives flourish.

During my fieldwork and wildlife biology training, I have seen these patterns unfold across India. *Prosopis juliflora* thriving in degraded drylands, *Lantana camara* expanding through forest edges and canopy gaps, *Parthenium hysterophorus* dominating croplands, roadside soils, and urban patches, and in freshwater systems, species like tilapia, African catfish, and water hyacinth altering habitat structure and native species interactions. Many of these impacts are widely documented, such as *Lantana's* transformation of forest structure (Sharma et al., 2005) and water hyacinth's disruption of freshwater functioning (Villamagna & Murphy, 2010).

These patterns are not limited to human-dominated landscapes protected areas across the world are also increasingly affected by invasive species, underscoring the pervasiveness of the problem (Foxcroft et al., 2017). But the question that struck me most during fieldwork was not simply what these species do, but why they are able to establish and spread. While many invasive alien species possess biological traits such as phenotypic plasticity, rapid growth, or allelopathy that enhance their competitive ability, my

observations repeatedly pointed to environmental conditions particularly disturbance and degradation as the key factors enabling their success.

Prosopis spreads where overgrazing removes native grasses. *Lantana* thrives in disturbed forest edges created by fuelwood extraction or roads. *Parthenium* colonises ploughed soils, urban waste plots, and agricultural margins because constant soil disturbance and nutrient enrichment favour its germination and rapid growth. Water hyacinth forms thick mats where sewage and agricultural runoff overload water bodies with nitrogen and phosphorus. Even tilapia and African catfish spread rapidly when rivers are modified, native species decline, or aquaculture escapes go unmanaged.

In other words, invasive species often succeed because ecosystems are already weakened a pattern consistent with the disturbance hypothesis and the biotic resistance hypothesis, which suggest that degraded or simplified ecosystems offer fewer barriers to invasion. Degraded soils, fragmented forests, polluted water bodies, and altered hydrology create ecological windows that invaders exploit. What appears to be an invasive species problem is often also a land-use, governance, or ecological resilience problem; while species introductions are a necessary precondition for invasions, ecosystem degradation largely determines whether introduced species become invasive.

The impacts that follow are equally complex. IAS reduce native biodiversity, alter nutrient cycles, intensify fires, change hydrology, and displace vulnerable species. Yet these effects are often magnified in ecosystems already under stress. A monoculture plantation, for example, provides exactly the homogeneous conditions *Lantana* needs to spread; a poorly managed reservoir gives tilapia and African catfish unchallenged space a polluted lake gives water hyacinth unlimited nutrients.

The solution, therefore, cannot be limited to physically removing the species. One of the most important lessons I have learned from research, practitioners, and communities is that

simply uprooting or eradicating an invasive species without restoring the underlying ecosystem only creates temporary relief. *Prosopis* returns unless grazing is controlled and grasslands are restored (Mwangi & Swallow, 2005). *Lantana* re-invades unless canopy cover is restored (Sharma & Raghubanshi, 2009). *Parthenium* recovers quickly unless soil disturbance is reduced and competitive native grasses are planted (Khan et al., 2013). Water hyacinth returns unless nutrient pollution is addressed (Villamagna & Murphy, 2010).

Communities often ask, "What do we replace this with?" Their question captures the heart of invasion management. Invasive species frequently provide fuelwood, fodder, fast-growing biomass, or fisheries in resource-poor landscapes. Removing them without offering alternatives can unintentionally harm the very people conservation aims to support.

This is why the conversation must shift from simply "controlling invaders" to "building resilient ecosystems." Restoration approaches such as native species planting, hydrological repair, soil recovery, canopy closure, and community stewardship address the underlying ecological vulnerabilities that invasive species exploit, rather than merely treating the symptoms of invasion. Research consistently shows that healthy, functioning ecosystems are far more resistant to biological invasions (Catford et al., 2009).

Public awareness is equally essential. Many invasives spread through everyday human actions: ornamental plants sold in nurseries, exotic pets released into local environments, fast-growing trees planted during greening drives, or farmed fish escaping into rivers. By improving ecological literacy and encouraging community monitoring, we strengthen prevention and early detection the most effective forms of invasion management.

Perhaps the most important shift needed is emotional. When we label species as "alien" or "enemies," we overlook the ecological and social complexity behind invasions. Most IAS

thrive not because they are inherently superior, but because human activities have weakened the native systems meant to resist them. Viewing IAS as indicators of ecological imbalance encourages us to focus on restoration, better land use, and long-term ecological planning.

Biological invasions remind us that ecosystems carry the memory of past decisions plantations, dams, aquaculture choices, or urbanisation and the choices we make today will influence landscapes for decades. Managing IAS is therefore not only about protecting biodiversity; it is also an opportunity to rebuild ecological integrity with responsibility, empathy, and long-term vision. As IAS continue to spread across India and the world, the challenge is to move from reactive, short-term responses to proactive, science-driven stewardship. When we embrace ecological resilience, social understanding, and community involvement, conservation becomes not only more effective, but also more enduring.

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Biological Invasion and Management of Free-ranging Dog at Carcass Sites in Aravalli Landscape, Haryana

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Background: Scavenging vertebrates, as true ecosystem managers, deliver various services like disease control, carcass removal, nutrient recycling, and high existence values (Wenting et al., 2024). However, anthropogenic threats have caused a drastic decline in vulture populations and disrupted the hierarchy of carcass consumption. After the severe decline of vultures in India, free-ranging dog populations have increased enormously and emerged as a major invasive threat to native

wildlife (Markandya et al., 2008). Consequently, they have monopolized the ephemeral resources, such as carcasses, which are confined both spatially and temporally. These population fluctuations and their implications highlight the need for ecological insights into succession patterns and scavenging behaviours of vertebrates at carcass sites.

Methodology: We evaluated the vertebrate scavenging patterns at frequent, infrequent, and single carcass sites with varying disposal rates in the Aravalli landscape, Mahendergarh district, Haryana. At each site, camera traps in advance mode captured three images per trigger with a 30-seconds delay. Carcasses were monitored until fully consumed or visitation declined markedly, with observations confined to a 5-m radius to reduce detection bias.

Findings:

1. A total effort of 413 trap-nights at 48 ungulate carcasses yielded 5,251 independent detections of 26 vertebrate species (14 scavengers and 12 omnivores).
2. Free-ranging dogs accounted for 42%, 40%, and 72% of the total carcass visitation events at frequent, infrequent, and single-carcass sites, respectively, exhibiting the highest visitation and carcass exploitation.
3. Circular statistics in R, including rose diagrams and kernel density estimation (Ridout & Linkie, 2009), indicated that free-ranging dogs primarily scavenged during day–night showing a low temporal overlap with native scavengers: Indian golden jackal ($\Delta^{\wedge} = 0.30$), Striped hyena ($\Delta^{\wedge} = 0.19$), and Indian leopard ($\Delta^{\wedge} = 0.22$).
4. Additionally, free-ranging dog visitations declined from 58% to 37% in the presence of the Indian leopards, indicating a strong “landscape of fear effect”.
5. However, the high activity overlap occurred with rufous treepie ($\Delta^{\wedge} = 0.80$) and cattle egret ($\Delta^{\wedge} = 0.74$), likely reflecting facultative commensalism that provides indirect benefits to



Free-ranging dog visiting a carcass dumping site in Musnota, Mahendergarh, Haryana (A) and Indian leopard predated the same individual (B), demonstrating predator-mediated population regulation of free-ranging dogs. (Photo credit: SACON).

small avian scavengers when dogs retrieve buried or intact carcasses.

6. Overall, day–night scavenging intensity and pack foraging propensity enabled free-ranging dogs to dominate carcass sites and influence the foraging patterns of other vertebrates.

Management Strategies:

1. Our findings prioritize the top-down regulatory effect of the Indian leopard in mitigating the ecological impacts of free-ranging dogs.
2. Free-ranging dog sterilization programs provide an ethical approach to gradually reduce their numbers, especially in urban areas lacking the leopard-driven trophic cascade effect.
3. Free-ranging dogs, being invasive, aid in carcass removal, however diseases can spread directly from rotting carcasses, especially in the absence of obligatory and top facultative scavengers. Therefore, integrating sterilization programs with habitat restoration and

reintroduction of native scavengers can be an effective and sustainable management approach.

4. Community awareness is crucial to encourage appropriate carcass disposal and foster local participation in protecting native scavengers and their habitats, ultimately overcoming the impacts of free-ranging dogs.

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From Disciplined Sal Forest to Ghostly Destruction: The Rise of Over-Ambitious Paper Mulberry in the Doon Valley Sal Forests

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Doon Valley is an ecological hotspot located between the Shivalik Hills and the Lesser Himalayas. It is a longitudinal depression formed by tectonic movements. Enclosed by mountains on all sides, the valley's forests have evolved distinctly, allowing mixed plant communities to thrive and shape the region's unique microclimate. The valley functions as a major perennial seepage zone, ensuring a continuous water supply that feeds both the Yamuna and Ganga rivers. Historically, the region was characterized by year-round flowing streams, cool winds, clean air, sustainable agriculture, and dense old-growth forests. Previous records from the valley shows presence of diverse floral communities, including Swamp forests, Grasslands, Cane brakes, Wetlands, Mix Sal forests, etc. Locals have shared with us stories that these forests have served the Mughal rulers; Valuable timber of Sal was supplied to Delhi for various purposes. Historically, during 1646–1687, Shri Guru Ram Rai, eldest son of the Seventh Sikh Guru, Shri Guru Har Rai, Shree Guru Har Rai, established his 'Dera' in the valley, his valuable contribution shaped the cultural and historical identity of the valley, and hence got the name 'Dehradun'

Monotonous Sal Forests of Doon Valley

In 1816, when the British gained control of Doon Valley, they quickly recognized the value of its rich timber resources. After studying the valley's forests, they realized that Sal was a dominating and highly important species. Its straight growth, minimal branching, and dense wood made it especially valuable, easy to process. The most common uses of this timber were in Railway sleepers, construction purpose, shipbuilding and military use. During the early

18s, the timber exploitation was uncontrolled. Contractors felled Sal indiscriminately and large forest patches were cleared to supply growing British cantonments in Dehradun and Mussoorie. But Sal regenerations were not that easy a task, and it was recognised during 1878 when forest school had been set up in Dehradun, which was later renamed as FRI (Forest Research Institute). The school aims to study Sal regeneration, coppicing techniques, and yield control. Late 19s was the time when increasing demands and an expanding railway network forces urgent need of continuous supply of Sal, which resulted in monoculture Sal stands, replacing mixed forests.

Introduction of Paper mulberry in India and the Doon Valley as well

Saharanpur, a district in Uttar Pradesh located about 130 km from Dehradun, became the first introduction point for *Broussonetia papyrifera* in India. The species was brought there in 1880 to enhance paper production and support rapid silvicultural practices. Over time, it began to be planted widely as an avenue tree in urban and semi-urban areas. By 1973, the species had naturalized in the sub-Himalayan landscapes, where its aggressive growth and prolific reproduction combined with the absence of natural predators revealed its invasive potential. It was soon officially recognized as an invasive species in India.

Broussonetia papyrifera, originally native to East Asia, particularly China, Japan, Taiwan, and Korea are a dioecious species, with male and female flowers borne on separate trees. It has a short lifespan but an exceptionally rapid growth rate. In the Doon Valley, a mature Sal tree reaching around 90 meters may be 100–150 years old, whereas paper mulberry can attain a comparable height within just a few years, though with only 20–30% of the Sal tree's biomass. Its wood is weak, porous, low in density, and holds no commercial value; even termites do not prefer to feed on it. The extensive urban planting of paper mulberry in earlier decades for shade, ornamentation, and landscaping enabled the species to escape into the natural and semi-natural environments of

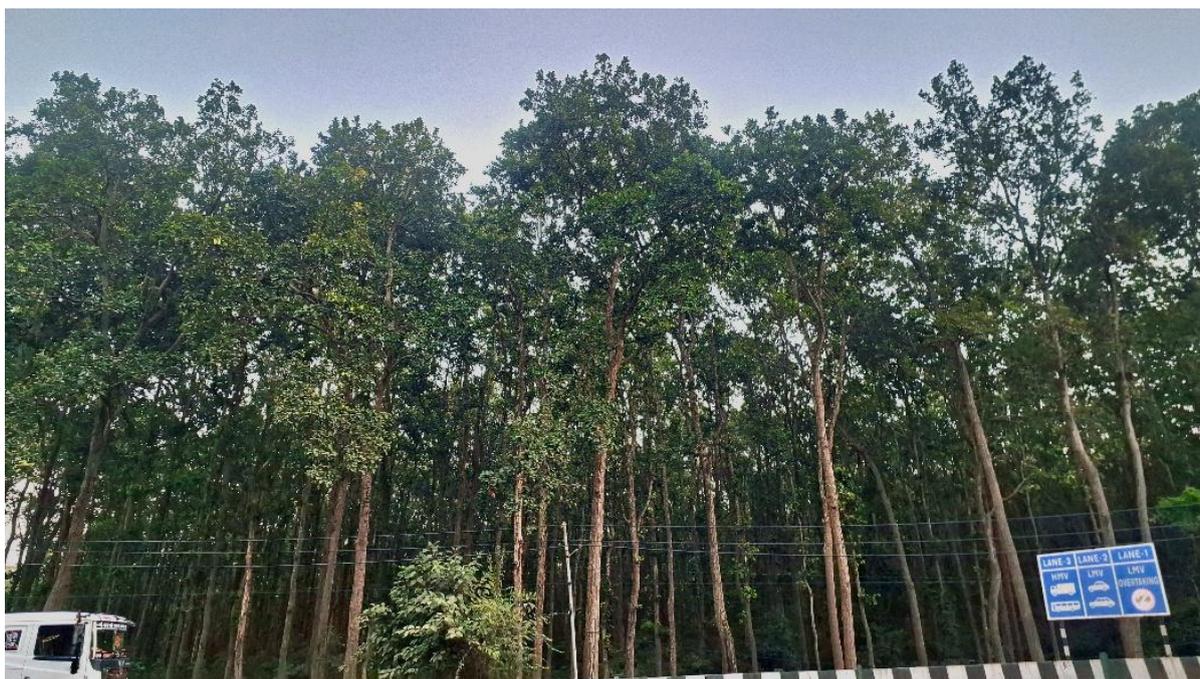


Fig. A view of Monotonous Sal forests of Doon Valley

the Doon Valley. Today, it has spread far beyond gardens and institutional premises, colonizing diverse habitats such as roadside margins, village peripheries, urban fringes, degraded scrublands, floodplains, and long-abandoned wastelands.

Paper mulberry: A target-oriented species

This species has adopted highly strategic mechanisms to spread and persist for long periods. In North India, the native yet invasive Rhesus macaque plays an important role in its expansion. During late winter and summer, the bright red, fleshy fruits of the paper mulberry become one of the macaques' most preferred food sources. At the peak of the fruiting season, their diet relies almost entirely on these fruits. The seeds pass unharmed through the macaques' digestive system and are excreted in their feces. A single stool can contain hundreds of viable seeds, each capable of germinating quickly, thereby enabling rapid and widespread colonization. The species primarily targets ruderal and polluted sites, forest fringes, canopy gaps within Sal forests, and other open spaces. These areas also support substantial populations of rhesus macaques, which transport the seeds wherever they travel,

further accelerating the plant's spread across the landscape.

Adding to this, Paper Mulberry exhibits a strong tolerance to drought, shade, variable soil textures, nutrient-poor substrates, and repeated disturbances, conditions under which many native species, especially Sal (*Shorea robusta*), struggle to regenerate. Once established, the species forms thick, tall, and impenetrable thickets that block sunlight, increase competition for soil moisture, and suppress the natural understorey.

Threats to Valleys forests

Once established, individuals of this species begin competing with local biodiversity. Their rapid growth suppresses native vegetation and eventually challenges even the tall Sal trees. During the monsoon season, strong pre-rain winds often cause these weakened tall trees to topple. As they fall, they bring down other trees, branches, lianas, and climbing shrubs with them, causing significant disturbance to the surrounding canopy. Now these disturbed areas/patches need ample time to undergo secondary succession, but within that time, 2-3 generations of paper mulberry have already completed their life cycle. All around the fringe forests and forests near human habitation

around valley, multiple tall death paper mulberry trees are seen standing giving ghostly appearance to the forest, even this standing dead biomass is fatal if fallen on someone passing by.

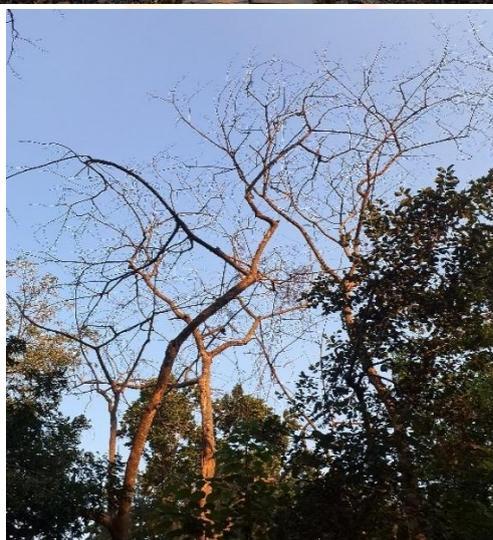
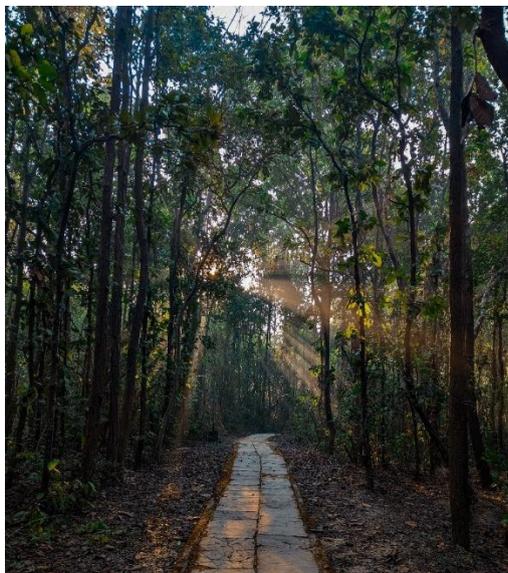


Fig. From Disciplined Sal Forest to Dead Ghostly appearance due to dead trees of Paper mulberry

Management to Control invasion

Complete eradication of this species from the forests of the Doon Valley is extremely challenging; however, gradual and consistent management efforts can keep its spread under control. An urgent priority is to manage the reproduction and population of rhesus macaques, which serve as the primary dispersers of this species. Systematic removal of all standing individuals is recommended, though the process is labour-intensive and

time-consuming. Nevertheless, carrying it out at least once or twice a year during the initial years, especially before the flowering season, is essential. Experimental approaches such as removing male trees have been attempted, but identifying male and female individuals outside the flowering period is difficult. Moreover, because the species is wind-pollinated, eliminating male trees is not an effective strategy, as pollen from distant males can still fertilize female flowers.

During our field surveys, we recorded around 13 species of fig trees in the valley. Heavily disturbed areas such as forest fringes and canopy gaps should be prioritized for plantation efforts. Along with sal, multiple native fig species should be planted to promote more stable vegetation recovery in these zones. Fig trees can help establish a resilient canopy and also play a significant role in controlling soil erosion. Such plantation drives will also help create heterogeneous, disease-free forest communities.

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Place based weeds to wealth approach: A case study on effective control and management of invasive *Lantana camara* from South India

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Abstract

The development of inclusive management strategies and outreach is necessary to deal with invasive alien species like *Lantana camara* (hereafter referred to as *Lantana*) in dry tropical forests. Numerous attempts have been made both in India and elsewhere to control the spread of *Lantana* using physical, chemical, biological, and integrated methods, which have

yielded little success. Our study evaluates time-tested, localized, inclusive, and cost-effective weeds to wealth (WTW) approach and compares it with conventional control methods. We used economic viability, environmental security, and sustainability indicators to assess the effectiveness of the method. We used long-term monitoring forest survey data and qualitative data from periodical community interviews for evaluation and comparison.

In the past two decades, Ashoka Trust for Research in Ecology and the Environment (ATREE) has trained 300 people under the WTW initiative. Facilitated from 20 years (2004 to 2024) on Lantana crafting and established decentralized Lantana craft centres (LCCs) in Malai Mahadeshwara (MM) Hills Wildlife Sanctuary. The tribal artisans (from Soliga and Beda Gampana) are ingeniously utilizing the invasive weed *Lantana*. The indigenous communities involved in conservation practices with place-based control and management tools, i.e., bush thinning techniques (BTT), are being used effectively. Diversified 158 different *lantana* craft products, which are cheaper than cane and equally sturdy, and are selling in local as well as urban markets. This initiative showcases the localized, inclusive approach that generated income (more than Rs 4.10 crore), created employment, and reduced (40%) *Lantana* density in about 28-thousand-hectare forests by removing a hundred tons of *Lantana* sticks every year.

It is proved proven that making use of *Lantana* by involving the local community would be a win-win initiative rather than the physical removal process adapted adopted by the forest department. This initiative resulted in the improvement of the social and economic status of families which are working the Lantana craft centre. Also, periodical harvesting of *Lantana* in the forest area increased native plant species regeneration. This initiative addresses the issues with controlling invasive species, biodiversity conservation, and enhancing the livelihoods of forest depended-dependent people. Socioeconomic profile analysis of the households and swat analysis of the problem

were used. The Interventions, skill development, awareness building, and interlinking tools are used to convert invasive *Lantana* into utility products which that meet the livelihoods of local people in the study area.

This long-term study revealed that the use of the invasive *Lantana* as a long-term effective management tool (Bush thinning technique) for *Lantana* in the forest, and also opportunity to generate livelihoods for local communities. Long-term monitoring and research showed that a significant reduction in the density of *Lantana* and increased regeneration of native plant species in harvested sites. However, more inclusive policy and regulatory roles to ease accessibility and ownership to the local community in control and management of invasive species is an urgent need for solving the Lantana problem in protected areas.

Responses:

The Weeds to Wealth (WTW) initiative (Lantana Craft Centres-LCCs) are designed to control and manage *Lantana camara* invasion in forest areas by building local skills that enable forest-dependent communities to address the problem through a community-led, decentralized, and place-based approach.

Skills serve as a local tool that equips people to respond as and when required, while simultaneously creating local employment and providing incentives that support the initiative's long-term sustainability in the affected region. This initiative supports livelihood diversification and is integrated with existing livelihood practices such as agriculture, forestry-related work, and wage labour. The program emphasizes skill development, collective ownership, and diversified income opportunities so that benefits extend beyond a single resource or activity.

In addition, the initiative incorporates adaptive management and regular monitoring to ensure that *Lantana* removal and use remain ecologically driven rather than demand-driven. This prevents the creation of a feedback loop in which continued economic benefits incentivize the maintenance or spread of *Lantana*.

When Night Creatures Step into the Sun: Unusual Daytime Activity of the Giant African Snail

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The Giant African snail, *Lissachatina fulica*, is a very well-known invasive alien species that is found on every continent except Antarctica (Vogler & Beltramino, 2022). In India, they're widespread and often cause tremendous economic damage in gardens and agricultural fields. Due to the extent of damage they cause, their ecology and management practices are well studied. They are generalist plant feeders, known to feed on over 500 species of plants (Raut & Barker, 2002). They're nocturnal and spend the day hidden beneath fallen leaves or buried in soil (Sakthivel et al., 2019). They're active during the monsoons and aestivate for the rest of the year.

Many organisms are active only during certain parts of the day or night, depending on resource availability, predation risk, and abiotic factors such as light, temperature, humidity, precipitation, and wind (Halle, 2000). Although these daily activity patterns are usually stable, sometimes species show natural shifts in when they are active. These shifts reflect how organisms balance evolutionary adaptations with changing local pressures, often helping

them navigate a trade-off between feeding and avoiding predators or avoiding direct competition for resources. As a result, some species may become active at unusual times even under less favourable conditions (Levy et al., 2018; Tambling et al., 2015).

As a part of my Master's dissertation, due to the significance of *Lissachatina fulica* in a green campus, I decided to do an Ecological Risk Assessment of the snail's presence in the Bangalore University campus, Bangalore. During the pilot study, the snails were observed foraging even during the day under clear skies. This was surprising since they are known to be nocturnal. I followed up by studying their activity on clear and non-rainy days.

During the study, I conducted transects around the campus and recorded their behaviour at various points of the day (8 am to 6 pm). The snails were observed foraging voraciously and moving about actively. A pair of snails was also seen copulating, another activity that normally happens only during the night.

The main abiotic factors that affect *Lissachatina fulica*'s activity level; temperature, humidity, and precipitation (Bhattacharyya et al. 2014), have been favourable during the day at the study site even in the past, and have not changed. Therefore, these factors are unlikely to explain the snails' unusual change in behaviour. The biotic factors such as prey or



African Snail infestation in a backyard in September 2023 (Mallathahalli, Bengaluru-56). The observer mentioned that their backyard garden was completely damaged by the snails, with no surviving vegetation. Photo source: Anonymous submission to an unpublished Citizen science survey

predator density and interspecific competition are also unlikely explanations, as the snails are herbivores with constant food availability, have no known predators in the area, and typically outcompete native snail species (Miranda & Pecora, 2017). Therefore, the most probable cause of the observed behaviour is intraspecific competition for space or resources, which is common in Bengaluru where *L. fulica* often occurs at very high densities.

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We are opening our invite for the Third edition of INVABIOME

We invite short articles, essays, and announcements related to biological invasions, invasive species management, and broader issues in invasion ecology. Contributions from researchers, practitioners, students, and policy experts are welcome. Further guidelines are available on our website ([click here](#))

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