The Case of Exploding *Lantana* and the Lessons it Can Teach Us

Ankila J Hiremath

Invasive alien species are a growing conservation problem, worldwide. There are over 200 invasive plants in India, of which *Lantana camara* is one of the best known. This article looks at a brief history of *Lantana*'s arrival and spread across the Indian subcontinent and the lessons that conservation biologists can learn from it.

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Living in an Age of Ecological Explosions

In 1958, the British zoologist, Charles Elton, published a book based on a series of radio broadcasts [1]. In the book, he talked about what he called 'ecological explosions,' referring to the tremendous increase in the numbers of some organisms. Unlike the more commonly understood meaning of the term 'explosion,' Elton qualified that ecological explosions happened gradually (and were not accompanied by a loud noise). Yet, they could be equally devastating in their impacts, whether by affecting human health, or bringing about ecological transformations, or even causing species extinctions.

What Elton was worried about while talking about ecological explosions was the mixing of species from different biogeographical realms – whether accidentally, or purposefully. Biogeographical realms are large regions of the Earth that roughly correspond to the continents. These realms are separated from each other by geographical barriers, e.g., oceans or high mountains. Thus, species within a biogeographical realm have a shared evolutionary history quite distinct from species in other realms, and this contributes to the overall diversity of life on Earth. The mixing of species between biogeographical realms has happened in the geological past, but is relatively rare, since it requires the breaking down of

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geographical barriers between different realms, allowing for the large-scale movement of species. One such example is the rise of the Panamanian land bridge connecting the South and North American continents about 3 million years ago, which led to one of the greatest known faunal exchanges. Such mixing of biotas has also been assisted by human migrations over the historical past. For instance, most of humanity's food supply comes from a handful of species (e.g., wheat, rice, corn, etc.) that people carried from one part of the world to another as they colonized new lands. Elton's book drew attention to the rapidity with which human-mediated mixing of species was starting to occur, thanks to our unprecedented, and ever-growing, trade and travel. More importantly, it drew attention to the ecological consequences – mostly negative – of such mixing.

This phenomenon of ecological explosions that Elton referred to is now better known as 'biological invasion'. Not all species that are introduced are able to establish in their new environments; and not all that do establish are harmful. However, some proportion of introduced species are known to spread uncontrollably in their introduced environments and do untold damage. These species that are known to 'explode' in their introduced environments are known as invasive alien species; 'invasive' refers to their ability to spread uncontrollably, and 'alien' refers to their distant origins.

Ecology of Invasions

It was not until several decades after Elton's book was first published that it caught the attention of the ecological and conservation community. Today, more than half a century later, biological invasions are recognized as one of the principal threats to the conservation of biological diversity, along with other human-caused elements of global transformation, such as land-use and land-cover change, increasing nitrogen deposition, and global warming [2]. Apart from their impacts on native biodiversity, invasive species also alter nutrient and water cycles, change disturbance regimes, have adverse impacts on agriculture and forestry, affect

the provisioning of ecosystem services, and have negative impacts on human health.

What enables some species to become invasive? The success of invasive alien species has been attributed to a number of factors. One factor is the absence of natural enemies of these species in their introduced environments, which would otherwise keep their populations in check. This is called the 'enemy release hypothesis'. A related explanation is the 'evolution of increased competitive ability'. This suggests that in the absence of natural enemies, invasive species can evolve to deploy resources towards growing larger, enabling them to be more competitive, since they need not allocate those resources to defend themselves. Yet another explanation is the 'novel weapons hypothesis'. This refers to the presence of allelopathic chemicals by which invasive species inhibit neighbours in their introduced environments; the same chemicals typically have no adverse impact on co-evolved neighbours in the species' native environments.

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Apart from the ecological characteristics of invasive species themselves, certain ecosystems may be more vulnerable to invasions than others. For example, species-poor biotas, such as on isolated oceanic islands, are thought to yield more readily to species invasions. One explanation given is that these less diverse systems may have 'empty niches'[1] that can be readily occupied by newcomers. The relative isolation of island ecosystems makes their biota evolutionarily distinct, with a high degree of endemism; in addition, the absence of certain functional groups (e.g., predators or pathogens) makes the biota of these isolated islands more vulnerable to the impacts of introduced invasive species. In fact, a number of species extinctions on oceanic islands have been directly attributed to the arrival of alien species. A well-known example is the extinction of a large proportion of Hawaii's endemic birds, which has been linked to the deliberate introduction of domestic birds bearing avian malaria, and the accidental arrival of the mosquito vector of the disease.

[1] A species' niche can be thought of as the space occupied by that species in a community.

Another factor that might make ecosystems more vulnerable to invasion is disturbance. More disturbed systems may be more

susceptible to invasion. Disturbance frees up resources and creates opportunities for colonization, which invasive species – many of which are weedy[2] – may be better able to exploit than native species. More recently, some researchers have suggested that a change in the disturbance regime, rather than the disturbance itself, could also facilitate invasions. The reasoning, in this case, is that the species in a given ecosystem may be adapted to a certain disturbance regime, but may be less able to respond to a change in the disturbance, creating the opportunity for invasive species to colonize following the disturbance.

[2] Weedy species typically are fast growing and produce large numbers of well-dispersed seeds; both these characteristics enable them to take advantage of disturbed habitats.

Invasive Species in India

How many alien invasive species are there in India? Despite the ecological importance of invasive species and the conservation concerns associated with them, we do not yet have a very good idea of their numbers. While this may seem surprising at first, it is important to understand that invasion is a gradual process, involving the overcoming of multiple barriers [3]. Thus, it is not always easy to label a species as invasive at the outset.

The first barrier that a species must overcome is geographical. Most introduced species are aided in overcoming this barrier due to their transport by people. Introductions can be deliberate, e.g., species that are introduced for economic reasons, whether for use in forestry, agriculture, or horticulture, or for use in the nursery or pet trade. Introductions can also be accidental, with species arriving as stowaways in cargo, or as contaminants with deliberately introduced species.

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Once a species arrives in a new environment, it must first overcome environmental or climatic barriers to its survival. Not all introduced species are likely to survive in their new environments. Typically, species coming from similar environmental conditions in their native ranges are more likely to survive in their introduced range. At this stage, they are considered as 'casuals,' surviving only as cultivated species.

The next barrier a species encounters is reproductive. Some species

may thrive in cultivation, but may not be able to reproduce naturally and form self-sustaining populations, e.g., due to the lack of the right pollinators, or dispersers. If they are able to overcome these reproductive limitations, for instance, by forming new biotic alliances, then they can reproduce without human assistance. At this stage, they become 'naturalised' species. Some naturalised species may remain that way, maintaining self-sustaining populations, but not becoming widespread. Those that are able to overcome barriers to dispersal and spread into new environments, becoming both abundant and widespread, are the species that are considered 'invasive.'

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One of the most comprehensive efforts to try and categorise introduced plants in India based on the stages of invasion (from casual to naturalised, to invasive) recognises 225 invasive species out of the total number of introduced or alien species in the country [4]. It also goes further, identifying 57 casual or newly introduced species, 257 naturalised species, and 134 species that are naturalised and likely to become invasive in the future.

Lantana Camara – A 'Page 3 Invasive Species'

Some years ago, while talking about invasive species, the late ecologist, Rauf Ali, lamented the fact that we now know quite a lot about some invasive species, but next to nothing about most of the invasive species in India. Those species that we know well, he termed – 'page 3 invasive species' (see *Figure* 1), and of those, *Lantana camara* (hereafter, *Lantana*) is perhaps foremost. Others on that list would include Congress grass (*Parthenium hysterophorus*), mile-a-minute weed (*Mikania micrantha*), water hyacinth (*Eichhornia crassipes*), eupatorium (*Chromolaena odorata*), and mesquite (*Prosopis juliflora*).

In the work that my colleagues and I have done in the forests of Biligiri Rangaswamy Temple Tiger Reserve (BRT), Karnataka, we found that *Lantana* – already widespread across the country – is still spreading and affecting forests and the people who depend on them. Over a 10-year period, from 1997–2007, *Lantana* went

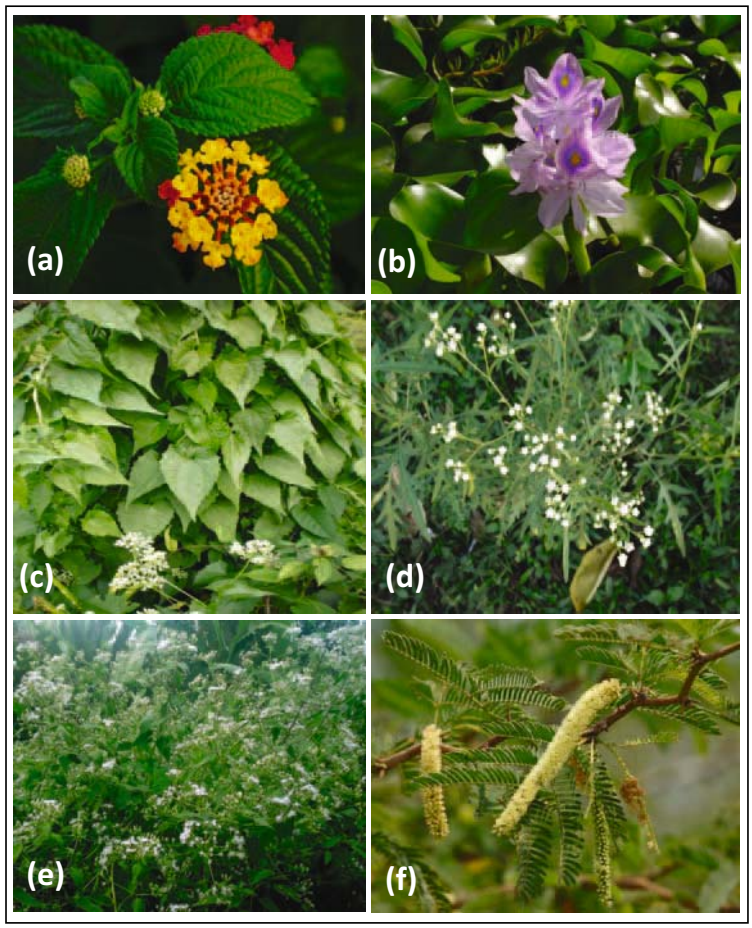

Figure 1. **(a)** *Lantana*, **(b)** Water hyacinth, **(c)** Mile-a-minute weed, **(d)** Congress grass, **(e)** Eupatorium, and **(f)** Mesquite or 'Vilayati keekar'.

from being present in about 40% of plots across the 540 km^2 BRT landscape, to being found in about 80% of plots [5]. Even more dramatic, however, is that from initially constituting only 4% of total woody stems (> 1 cm diameter at breast height or 'DBH,' a standard measure that ecologists use), by 2007, it constituted 30% of all woody stems recorded. This increase in the abundance of *Lantana* appeared to be at the expense of native stems, since there was no increase in the total number of stems recorded.

One possible explanation for this reduction in native stems may be that the presence of *Lantana* adds to the fuel load in the for-

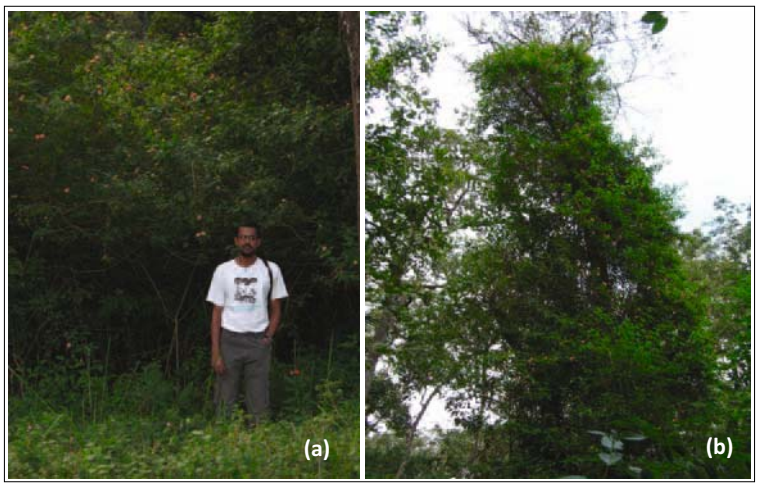

Figure 2. **(a)** *Lantana* has invaded the understory of many dry and moist deciduous forests and savannas across the country. It can form tall dense thickets, that dramatically alter vegetation structure. (Bharath Sundaram, the researcher in the foreground, is 1.84 m tall; the *Lantana* towers over him.) (Photo: A J Hiremath) **(b)** The normally shrubby *Lantana* can also clamber up tree trunks, forming 'ladder fuels' that allow fires, when they occur, to get up into the canopy. (Photo: B Sundaram)

est. *Lantana* forms a dense understory, and also clambers into tree crowns, changing the structure of the forest (see *Figure* 2). Thus, fires, when they occur (as they do during the dry season), are much more intense and severe than they would otherwise be, resulting in the mortality of adult trees [6].

Lantana has also been observed to negatively affect seedling regeneration of native species. Other researchers in BRT, studying amla (which collectively refers to *Phyllanthus emblica* and *P. indofischeri*), an important non-timber forest product for the Soliga adivasis who collect the fruit, found that *Lantana* affects the regeneration of amla seedlings, both directly and indirectly. *Lantana* affects amla directly because it grows rapidly, outcompeting young amla individuals. But it also affects regeneration indirectly, because the presence of abundant unpalatable *Lantana* in the landscape appears to increase grazing and browsing pressure on the more palatable seedlings of amla [7]. The end result is a reduction in amla regeneration, impacting the livelihoods of communities who depend on the collection of amla as a source of income.

Apart from changing forest structure and composition, there is also some evidence to suggest that *Lantana* might have unex-

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pected trophic impacts and also affect plant-animal interactions. An increase in unpalatable *Lantana*, for instance, could lead to forage scarcity for herbivores, and in turn affect populations of predators like the tiger [8]. Further, given that *Lantana* fruits prolifically, and these fruits are very attractive to frugivores, the presence of *Lantana* has been correlated with changes in bird community composition [9], and with the disruption of native plant-frugivore interactions.

Lessons *Lantana* Can Teach Us

Lantana in India has an interesting history. In the 17th and 18th centuries, European 'plant hunters' were exploring the world, bringing back species that seemed potentially useful, whether as crop plants or as garden ornamentals. *Lantana* was one such species, which was brought back by them from Latin America and the Caribbean and grown in botanical gardens across Europe. It was from there that it was introduced to India. Botanical records suggest that several closely related *Lantana* species were brought to India in the early 19th century [10]. Once in India, *Lantana* was introduced to botanical gardens across the country, as well as to colonial cantonment towns, where it was widely grown both as an ornamental and a hedge plant.

Historical accounts suggest that already by the late 19th century, *Lantana* had escaped from cultivation and started becoming locally widespread. Multiple issues of the *Indian Forester* – the journal of the Indian Forest Service – in the period between the latter half of the 19th century and the early part of the 20th century, carry articles on *Lantana*. Variously, they talk about how rapidly *Lantana* was starting to spread, its impacts on agriculture and fallows, its suppression of valuable forestry trees, and foresters' efforts to control it. The common theme running through all these articles is of *Lantana* as a problem species. Yet, *Lantana* continued to be planted as a hedge plant in gardens and around crop fields till well into the second half of the 20th century.

In hindsight, it is easy to wonder, if there had been a systematic monitoring programme in place, whether the slow 'ecological explosion' of *Lantana* might have been detected, and thus prevented. At the time, however, even the concept of alien invasive species did not exist, and *Lantana* continued to steadily spread across the country, both on its own, and aided by horticulturists and gardeners. Today, *Lantana* is perhaps the most widespread invasive species in India, occurring in diverse environments – from mountain slopes in the Himalayas, all the way to the forests in South India. There have been some efforts to control it, especially in protected areas, but there are only a few successful examples of this [11]. Some researchers are of the view that *Lantana* cannot be controlled or eradicated, and it is better for us to find ways of adaptively managing it, for example, by finding uses for it that could also help to mitigate its ecological and livelihood impacts [12] [13].

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But are there lessons that the story of *Lantana* could teach us *vis-à-vis* other invasive alien species in India? Recall that we still know very little about most invasive species reported for India. Also, recall, that biological invasions are a gradual process, not an event. Thus, it is more than likely that a number of species are still in the process of spreading. These species could, therefore, potentially be controlled before they become as widespread as *Lantana* is today. Although we missed the opportunity to do this in the case of *Lantana*, there is still time to do so for most other invasive species in the country. If the distributions of these species are mapped and monitored, we could start to determine: (a) which are the species that are spreading most rapidly and thus of the greatest concern; and (b) which are the habitats that are most vulnerable to invasion and most in need of management. In addition to these applied ecological questions, such information could also help us address more fundamental ecological questions pertaining to species invasions, for example, (a) what are the ecological traits (e.g., size, growth rate, types of fruit, etc.) associated with invasive species; and (b) what are the drivers of invasive species spread.

In 2010, countries that are signatories to the International Convention on Biological Diversity (CBD) – India amongst them – agreed to a set of goals related to the conservation of biodiversity, to be met by 2020 [14]. One of these 'Aichi Biodiversity Targets,' as they are known, pertains to invasive species, and it states, "By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment."

With barely 2 years remaining, we are still far from meeting our commitments to the Aichi Target on invasive species. This, then, is an exciting time to be an invasion biologist. There is much work yet to be done!

Suggested Reading

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