

Invasive alien species and biodiversity in India*

Alien species are non-native or exotic organisms that occur outside their natural adapted ranges and dispersal potential. Many alien species support our farming and forestry systems in a big way. However, some of the alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade and outcompete native species. International Union for Conservation of Nature and Natural Resources (IUCN) defines Alien Invasive Species as an alien species which becomes established in natural or semi-natural ecosystems or habitat, an agent of change, and threatens native biological diversity. These invasives are widely distributed in all kinds of ecosystems throughout the world, and include all categories of living organisms. Nevertheless, plants, mammals and insects comprise the most common types of invasive alien species in terrestrial environments.

The threat to biodiversity due to invasive alien species is considered second only to that of habitat destruction. Invasive species cause loss of biodiversity including species extinctions, and changes in hydrology and ecosystem function. Differences between native and exotic plant species in their requirements and modes of resource acquisition and consumption may cause a change in soil structure, its profile, decomposition, nutrient content of soil, moisture availability, etc. Invasive species are thus a serious hindrance to conservation and sustainable use of biodiversity, with significant undesirable impacts on the goods and services provided by ecosystems. Biological invasions now operate on a global scale and will undergo rapid increase in this century due to interaction with other changes such as increasing globalization of markets, rise in global trade, travel and tourism. For effective management of invasive species, knowledge about their ecology, morphology, phenology, reproductive biology, physiology and phytochemistry is essential.

A national workshop sponsored by the Ministry of Environment and Forests, Govt.

of India was organized in the Department of Botany, Banaras Hindu University during 18–20 August 2004 to discuss various aspects relating to alien invasive species and biodiversity in India. The workshop focussed on themes related with the ecology of alien invasive species such as: biology of invasive species, reasons behind invasiveness, prediction of invasive potential of non-native species, susceptibility of ecosystems to invasions, impact of invasion on native plant species and biodiversity, possibility of enhancing the capacity of ecosystems to resist or recover from alien species invasion, possible control measures, and development of a reporting system for alien invasive species. About 60 participants from all over the country attended the workshop.

Ecology of invasion requires information on the rate and mechanism of transport and movement of organism, on characteristics allowing a species to become successful invader and also on the properties of the ecosystems that make them susceptible to the invaders (V. Khanna, Zoological Survey of India). Probable traits favouring invasiveness in terrestrial plants include high tolerance against environmental extremes and greater adaptability in wide range of environmental conditions; high water, light and nutrient use efficiencies; zero or very short dormancy period, high productivity; and high reproductive potential. Emerging mechanisms of plant invasion such as enemy release hypothesis and novel weapon hypothesis (allelopathy) was part of deliberations. Inderjit (University of Delhi) discussed the novel weapon hypothesis and concluded that a single theory does not account for the success of invaders in naturalized areas.

About 40% of the species in the Indian flora are alien, of which 25% are invasive (Kavita Gupta; National Bureau of Plant Genetic Resources). R. R. Rao and R. Murugan (Central Institute of Medicinal and Aromatic Plants) discussed the richness of Indian flora and presented a list of major adventive weeds which included Asteraceae weeds such as *Parthenium hysterophorus*, *Eupatorium adenophorum*, *Eupatorium odoratum*, *Mikania micrantha*, *Ageratum conyzoides*, *Galinsoga parviflora*, etc. A list of invasive alien species of Chattisgarh was presented by K. K. Khanna and K. P. Singh (Botanical Survey of India).

Parthenium hysterophorus L., which is an exotic species from Tropical America that has naturalized most of India because of its strong invasive potential, attracted several presentations. This weed was first reported in India in 1951 from Maharashtra. The weed is an aggressive colonizer of degraded areas with poor ground cover and exposed soil such as fallow wastelands, roadsides and overgrazed pastures. It does not usually become established in undisturbed vegetation or in vigorous pastures, and there is a marked inverse relationship between existing plant cover and native weed density. *Parthenium hysterophorus* is considered as a noxious weed because of its prolific seed production and fast-spreading ability, allelopathic effect on other plants, strong competitiveness with crops and health hazard to humans as well as animals. The weed is highly allergenic and causes respiratory problems, dermatitis and asthma. However, except for allelopathic aspect and crop-weed interaction, almost no study is available on the impact of this weed on the ecosystem processes. A presentation by A. S. Raghubanshi *et al.* (Banaras Hindu University) demonstrated the effect of *P. hysterophorus* on soil nutrient pools and processes in agroecosystems. It was also emphasized that time and season of sampling also has strong influence on the observed results. The study concluded that in order to assess impact of invasive species, long-term studies are needed as adverse effects take time to appear.

K. V. Sankaran and M. A. Sreenivasan (Kerala Forest Research Institute) reported that *Mikania micrantha*, a perennial fast growing weed of Neotropical origin, has become a major menace in natural forests, plantations, agricultural systems in northeast and southwest India. The presentation elaborated negative impact of the weed which includes crop yield reduction, loss of native biodiversity and prevention of forest regeneration. Data were presented indicating that out of surveyed localities, about 61% showed various levels of infestation which was mainly localized in moist deciduous forests, teak plantations, and all categories and disturbed forests. Control options for the species were also discussed.

Three presentations focussed on *Lantana camara*, one of the ten worst weeds of the world, which is a native of tropical

*Based on a workshop in the Department of Botany, Banaras Hindu University during 18–20 August 2004 to discuss various aspects relating to alien invasive species and biodiversity in India.

and subtropical America. The species was introduced in India as an ornamental shrub during AD 1809–1810. It is now found all over the Indian sub-continent, stretching from the submontane regions of the outer Himalaya to southernmost part of India. The plant is spreading fast due to the human disturbances such as cultivation, road construction and forest fragmentation and degradation. G. P. Sharma *et al.* (Banaras Hindu University) discussed important attributes of lantana making it invasive which included fitness homeostatis, phenotypic plasticity, benefits from destructive foraging activities, widespread geographical range, vegetative reproduction capabilities, fire resistance, better competitive ability and allelopathy. S. P. Singh *et al.* (Kumaun University) presented their work on lantana in the Himalaya which shows that the species does not colonize a disturbed site in one go. Low allocation of biomass to roots, and low wood density enable it to rapidly establish aboveground plant cover. High nutrient extraction efficiency contributes to its colonization on the eroded sites with shallow soils. A study presented by N. A. Arvind *et al.* (Ashoka Trust for Research in Ecology and the Environment) showed that there was no significant difference in the diversity of trees, shrubs and herbs along the gradient of lantana density, except for herb species richness in the moist deciduous forests of Karnataka, India. The study also indicated marked differences in the way individual species responded to the presence of lantana.

Ageratum conyzoides L. is an annual weed native to South America that has invaded and now naturalized several parts of southern Asia including India. The invasive potential of weed is attributed to its fast growth, production of large number of small-sized wind and water-disseminated seeds and vegetative proliferation through stolons. The weed has become a problem in agroecosystems (R. P. Singh and R. K. Singh, Banaras Hindu University).

Species of parasitic dodders (*Cuscuta* spp.) are becoming a serious problem in agroecosystems of south India and are being seen increasingly on many plants, including rice, throughout the country (P. N. Rao, JNT University).

In the marine environment, ships are considered as the major vectors for the transfer of invasive species through their attachment and ballast water. However, little information exists from Indian marine ecosystems regarding the presence and the impact of alien invasive species (P. C.

Pandey, National Centre for Antarctic and Ocean Research). Many freshwater species such as *Eichornia crassipes*, *Salvinia molesta*, *Ipoemia carnea*, etc. have become a nuisance for aquatic ecosystems (K. K. Khanna, Botanical Survey of India). Of these, *E. crassipes*, introduced from Brazil during AD 1914–1916, is of most nuisance as it causes hindrance in navigation, chokes irrigation systems and reduces aesthetic value of water bodies (R. P. Singh and R. K. Singh, Banaras Hindu University). Presentations of R. M. Kathiresan (Annamalai University) dealt with long-term changes in invasive weed populations of flooded rice fields. Many freshwater and marine algae including species of *Microcystis*, *Caulerpa*, *Cladophora*, etc. cause extensive damage to the ecosystems and affect aquatic biodiversity adversely (A. S. Ahluwalia, Punjab University).

Workshop participants felt that little information exists regarding invasive fauna and microbes in India. Need of creating specialist groups in this regard was emphasized so that better information could be compiled. The only fauna discussed in the workshop was mosquito, several species of which are invasive and are spreading fast throughout the world. The biology of mosquito invasion was presented by V. P. Sharma (New Delhi) who stressed the fact that several species of mosquitoes are spreading in new localities within a region and in different countries where they were previously absent. These have also provided opportunity for the invasion of new diseases in various countries.

Mapping and monitoring of invasive plants was discussed in two presentations which proposed to use remote sensing and simulation models. The satellite spectral and spatial resolutions available so far do not facilitate the clear identification and mapping of alien species in their foster habitats. This could be attributed to the lack of distinct spectral behaviour of the alien species and background contrast on one hand and their highly dispersed nature of distribution on the other (S. P. S. Kushwaha, Indian Institute of Remote Sensing). The problem is more acute in the case of species growing as understorey vegetation. The aerospace sensing, however, can be cost-effective and an efficient tool to assess and monitor the relatively homogenous species patches distributed over large areas. Many alien invasives benefit from the reduced competition that follows habitat degradation. As a direct relationship has been demonstrated between canopy opening

due to disturbance and density of species such as *L. camara*, *Chromolaena odorata*, *Mikania micrantha*, etc. remote sensing has the potential to identify areas where invasive species may be present or have the potential to invade. The use of technique in identifying areas in the Siwaliks occupied by *L. camara* was demonstrated. M. Irfan Ullah and S. Davande (Ashoka Trust for Research in Ecology and the Environment) presented effectiveness of GARP (Genetic Algorithm for Rule-set Prediction) based modelling in predicting the invasion of *Prosopis juliflora* in the deserts of Kachch. GARP is a niche modelling tool that creates ecological model for species based on the environmental conditions where the species would be able to maintain populations. The model performed with reasonable accuracy and was able to predict invasion of *Prosopis juliflora* with dependable precision. Such models combined with remote sensing may be valuable tools for prediction and monitoring of invasive species.

Many of the invasive species can be used for economic benefits. Participants emphasized that economic valuation of most of the invasive species is due and should be done on priority basis. In this context, M. N. V. Prasad (University of Hyderabad) discussed the use of metalliferous invasive species to cleanup metal-contaminated ecosystems. The knowledge of how metalliferous invasive plants can specifically accumulate or exclude essential elements, bioavailability of metals, rhizospheric processes as well as translocation and processing and storage in the plant parts is essential for proper utilization of these plants.

A presentation by Kavita Gupta discussed various regulatory issues in the light of international agreements such as the Convention on Biological Diversity (CBD), the Agreement on Sanitary and Phytosanitary (SPS) Measures of the World Trade Organization (WTO), the International Plant Protection Convention (IPPC) for setting the International Standard for Phytosanitary Measures (ISPMs).

A set of recommendations made at the workshop, to provide a basis for initiation of a national debate, maybe obtained from the author.

A. S. Raghubanshi*, L. C. Rai, J. P. Gaur and J. S. Singh, Department of Botany, Banaras Hindu University, Varanasi 221 005, India. *For correspondence. e-mail: asr@bhu.ac.in