

Modern approaches

for the detection and prediction of invasive pests

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The accelerated pace of commercial and social globalization has created opportunities for the movement of species to new areas of the world. As arthropods are dispersed beyond their native ranges, they escape population-regulating predators, parasitoids and pathogens and encounter naïve host plants and animals. In absence of these regulating factors, they find opportunity in almost logarithmic fashion. In the past, we have examples of many successful invasion which have caused havoc on environment. With the advancement of technology in the current scenario, we need to imply these technologies in the field of invasion science. With regards to invasion of a species, early detection of the pest is the most lauded approach to address invasive alien species. For the early detection, technologies such as x-ray technique, acoustics, volatile chemical profile, genetic approaches and geographic information system (GIS) can be incorporated.

Keywords: Invasive alien species, Modern approach, Quarantine

INVASIVE alien species (IAS) are the animals, plants or other organisms that are introduced into the places outside of their natural range, negatively impacting the native biodiversity, ecosystem services and human well-being. The accelerating pace of globalisation and climate change are the two major causes of alien species being introduced in a new environment. Alien species travel along with the global movement of goods and passengers. Changing climate makes the new environment favourable for the alien species to colonise and become invasive. The prevailing winds and cyclones may even push flying insect species beyond the transcontinental boundaries.

India represents a highly diverse weather and climatic condition that supports the establishment of various introduced alien species. Instead of a structured quarantine system, there has been around 22 successful recorded invasions till date, which ultimately questions the functioning of quarantine

system in India. These invasive species have greatly impacted Indian agriculture by threatening human health, jeopardizing food security, endangering valued species, economic losses, and disrupting ecosystem functions. To prevent further invasion, we need to upgrade quarantine stations with newer technologies such as raising public awareness and investing more money in research and development.

Causes

Climate change may facilitate the spread and establishment of alien species and create new opportunity for them to become invasive species. As the climate is warming up, many IAS have the capacity to spread quickly to higher latitudes and elevations. Hence, it is the need of the hour to incorporate IAS into climate change policies. Extreme weather conditions including hurricanes, floods and droughts can spread IAS to new places and reduce the ecosystem ability to

keep off incursions. A flying insect may find it easy to take longer flight on the prevailing wind and with storms. It has been known that *Spodoptera frugiperda* can cover 1000 km in a single flight if the wind is supporting its movement. Globalisation is another factor that is facilitating insect hitchhikers to pave their way into another region. It has been noted that timescales for half of the initial invasive species took 106 years, but other recent half introductions took only 21 years (Table 1). This reflects that somehow globalisation has facilitated the introduction of species in India.

Process of invasion

For millions of years, geographic barriers such as oceans and mountains separated the evolving insect population. But the recent advancement in the transport system has increased the pace of globalisation and so, is the process of alien species invasion. Fortunately, not all the alien species are invasive. It has been estimated

Table 1. Chronicle events in the introduction of invasive pests in India

Common name	Scientific name	Year of introduction
Woolly apple aphid	<i>Eriosoma lanigerum</i>	1989
San jose scale	<i>Quadraspidiotus perniciosus</i>	1911
Lantana bug	<i>Orthezia insignis</i>	1915
Cottony cushion scale	<i>Icerya purchasi</i>	1921
Potato tuber moth	<i>Phthorimaea operculella</i>	1937
Diamond back moth	<i>Plutella xylostella</i>	1941
Pine woolly aphid	<i>Pineus pini</i>	1970
Subabul psyllid	<i>Heteropsylla cubana</i>	1988
Serpentine leaf miner	<i>Liriomyza trifolii</i>	1990
Coffee berry borer	<i>Hypothenemus hampei</i>	1990
Spiralling whitefly	<i>Aleurodicus disperses</i>	1995
Silver leaf whitefly	<i>Bemisia argentifolii</i>	1999
Papaya mealybug	<i>Paracoccus marginatus</i>	2001
Erythrina gall wasp	<i>Quadrastichus erythrinae</i>	2005
Lotus lily midge	<i>Stenochironomus nelumbus</i>	2005
Blue gum chalcid	<i>Leptocybe invasa</i>	2006
Tomato pin worm	<i>Tuta absoluta</i>	2014
Invasive chilli thrips	<i>Pterochloroides persicae</i>	2015
Rugose spiralling whitefly	<i>Aleurodicus rugioperculatus</i>	2016
Fall army worm	<i>Spodoptera frugiperda</i>	2018
Cassava mealybug	<i>Phenococcus manihoti</i>	2020
Woolly whitefly	<i>Aleurothrixus floccosus</i>	2020

that there is one success in every thousand attempts of invasion. Considering the immense amount of damage done by the IAS, it can be said that it is a low probability high consequence event.

The process of biological invasion is categorised into three distinct phases, i.e. arrival, establishment and spread. In the arrival phase, the individuals are transported to new areas outside of their native range. Here, they are devoid of their natural enemies. After finding the favourable environment and naive plant species, they enter second phase of establishment. In this phase, they multiply and grow. In the third phase of invasion, they spread to a new area and get established in the new habitat.

Management of IAS

We are mostly driven by the consequences and not by the innovation. The prophylactic measures are usually ignored and when the problem becomes severe then in panicked state, we mostly

go for insecticide spray which has a negative impact on health and environment. In this manner, prediction and prevention remains the most lauded approach to address alien invasive species.

X-ray scanning for the detection of hidden infestation: Sometimes, the hidden infestation of insects is difficult to detect, as the internal damage is not evident from outside. Many countries have adopted zero-tolerance regulations for the presence of insect infestation. In 2014, the countries of the European Union banned the import of many commodities such as, vegetables and fruits from India. In many countries, zero tolerance regulations for the presence of insect infestation in fruits imposes high strains on the food industries by making their entire shipment unmarketable just for a few infested fruits. Thus, it has become important to detect such infestation in the very early stage.

X-rays can detect the hollow space or any density change in fruits or grains created by the pest.

Some of the fruit flies have a long ovipositor, the eggs are inserted deeply into the fruits and vegetables. The puncture site is very minute and is not visible with naked eyes. The eggs hatch and the larvae feed on the internal content of the fruit. In such cases, a non-invasive method is used to detect the presence of the invasion. Automation in this process of detection and rejection of the infested produce by using artificial intelligence significantly reduces time and money.

Genetic approach for the of IAS:

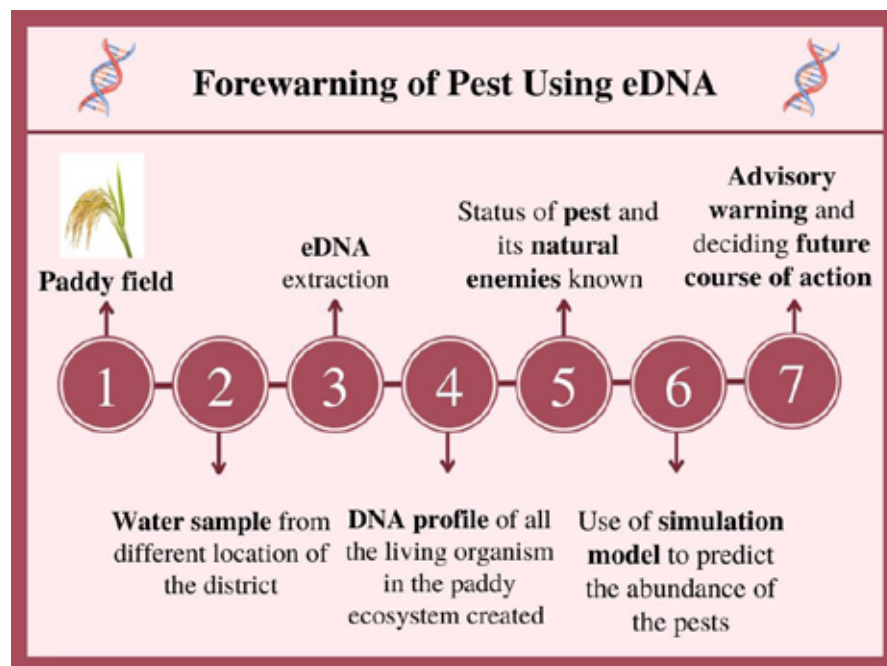
Rapid confirmation of alien species is very important in the effective management of alien species. Along with the help of traditional taxonomists, the genomic approach is best suited for rapid identification. With the help of the genetic approach, various strains, biotypes or haplotypes could be easily distinguished within a species. An accurate knowledge of originating country and targeted approach could be taken for the search of natural enemy which have coevolved with the pest. A wide range of genes such as, mitochondrial COI, 16s RNA, 18s RNA, elongation factor 1- α gene etc can accurately differentiate the biotypes or haplotype of the species.

eDNA for the surveillance of invasive species: Early detection of alien species followed by the rapid responses has resulted in successful eradication of many invasive species which are known to cause ecological or economic damage to humans. The environmental DNA (eDNA) detection technique is a promising technology that involves high-resolution processing techniques to detect or trace amounts of DNA. Environmental DNA consists of freely available DNA or biological material containing DNA that has been shed or dropped by organisms as they move through the environment (e.g. skin flakes, hair, feathers, scales, setae, exuviae (molted exoskeletons) or even fecal matter).

A successful demonstration for how the eDNA approach could be used to detect invasive species comes from North America. The brown marmorated stink bug

(BMSB, *Halyomorpha halys*) which is native to South-East Asia, invaded to North-America in 1998 and spread to different parts of the country. It has been reported that eDNA approach could be more sensitive than conventional pheromone and black light traps in the detection of the BMSB. The eDNA is collected from the surface of the fruit and if the BMSB visits the host plant, then the eDNA is deposited and it can be detected. Also, the eDNA approach has revolutionized the agricultural pest surveillance, e.g. water sampling from the paddy field can tell all the species present in the farm and species composition of the farm can be used to predict the type of pests and the management practices to be taken.

Electronic nose: Electronic nose (e-nose) is the device designed to sense a very low concentration of volatile compounds emanating from the living organism. Plants release volatile compounds in response to an infestation with a pest. The sensors of the e-noses are made of synthetic materials such as metal-oxide-semiconductor, conducting polymers, polymer composites, mass spectrometers, etc. In invasion science, it could be used for the detection of hidden pests in food grain consignment or to detect a pest. The Emerald ash borer (EAB), introduced to the United States in the early 1990s became invasive and the production of ash trees became challenging for the government. The damage symptoms were visible only when the survival of tree was



Proposal of schematic diagram on forewarning of pest in paddy ecosystem using eDNA

questionable. Then, USDA (United States Department of Agriculture) developed an e-nose which can detect EAB whose larvae tunnel is under sapwood and identify them before the symptoms appear, preventing tree death and damage.

Use of acoustics for the detection of hidden infestation: The hidden infestations of wood boring insects are not visible externally. The chewing by the wood-boring insect makes a characteristic sound which could be heard by the human ear, but many a times these sounds are not audible and a very sensitive device is needed to hear. By using acoustic devices, the early infestation of the insects could be detected easily by non-invasive method.

Taking help from GIS, GPS and AI: Risk assessment or predicting the likelihood, that an environment will be invaded by a non-native species, is considered to be the first step in mitigating the impacts of invasive species. Geographical Information Systems (GIS) and Global Positioning System (GPS) are used to pin point a location on earth and perform spatial analysis. Using an artificial intelligence (AI) system, it is possible to create potential distribution maps of an invasive species. Various models are emerging for the prediction of potential threat of invading species. The species environmental matching (SEM) model is one such example which predicts the spread of the Eucalyptus gall wasp in China.

Success story

Many innovations come from farmers and one such method is the use of stethoscope for the detection of borer pest in the fruit and plantation trees. Mr Chakradhar Pradhan of Bargarh district in Orissa used stethoscope to detect incidence of borers in his lemon orchard. His novel approach for the detection of hidden pest incidence could be applied to most perennial fruit trees such as coconut, arecanut, different species of palm, and different temperate fruit trees such as apples, pear, peaches and plums which are prone to different shoot and root borer insects. Also, use of acoustics is applied for the early detection of invasive pests such as Asian longhorn beetle and Emerald ash borer in the USA. In quarantine stations, the use of acoustics may prevent the entry of wood boring pests.



Chakradhar Pradhan, who innovated the early detection of borer pests in trees using a stethoscope



Electronic nose for the detection of Emerald ash borer
Source: United States Department of Agriculture

universities, agriculture departments etc. with advanced technologies to avoid crises as those created in the recent past. The timely review of available technologies and the incorporation of these modern technologies into pest management brings additional benefits to sustainable agriculture. In India, quarantine centers should be fully equipped with such technologies to create barriers between indigenous flora and fauna and alien species. Once these alien species break the quarantine barrier, the result can be catastrophic for food production and the environment. Hence, the article describes the few technologies that have been already adopted or are at the stage of development to be recruited in the science of invasion in the near future.

SUMMARY

At this moment, we are most vulnerable to the threat of alien

species due to globalization and therefore need to strengthen quarantine stations, agricultural

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HANDBOOK OF FISHERIES AND AQUACULTURE



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In 2006, the Indian Council of Agricultural Research, brought out the First Edition of 'Handbook of Fisheries and Aquaculture'. The present revised edition comprises 42 updated and six new chapters, viz. Fish physiology; Aquaculture engineering, Fisheries development in India; Fisheries cooperatives; Demand and supply of fish; and Climate change – impact and mitigation. The Handbook would be of great value to students, researchers, planners, farmers, young entrepreneurs and all stakeholders in fisheries and aquaculture.

TECHNICAL SPECIFICATIONS

Size : Royal Octavo (16 cm × 24 cm) • No. of pages : i-x + 1116 • Price : ₹ 1500 • Postage : ₹ 100
ISBN No. : 978-81-7164-106-2

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