Globalisation – a game of consequences

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Introduction

Broadly, globalisation is to "make worldwide in scope or application" but the term became popular in relation to the opening of international financial markets and business activities in the 1980-90s. Globalisation began with Man's first emigrations from Africa and the subsequent development and spread of agriculture, trade and urbanisation. The first significant problem to emerge as a consequence of early globalisation was the black death/plague caused by the bacterium *Yersinia pestis,* an enzootic of ground rodents and their fleas in central Asia. This was probably carried along the silk route and spread rapidly in densely populated cites of Europe, in effect 'human monocultures', killing an estimated 50% of the European population in the 14th century. Since then, other diseases of man, livestock and crops have continued to spread mostly through the agency of human activity linked to increasing globalisation.

Crop globalisation

Plants evolved in geographically separate centres of origin and/or diversity as part of natural ecosystems in which organisms live in a dynamic balance so that production and consumption between components of the system are evened out. Agriculture has selected out crop plants from the system and increased their productivity by reducing competition from other components of the ecosystem. The greatest gains in productivity have tended to be made when the selected crops are grown outside their centres of evolution where crops are free from the competitive pressure of their coevolved pests and pathogens. Examples are coffee from Africa to S. America and Asia, cocoa from S. America to Africa, rubber from S. America to Asia, potato from the Andes now global, sugarcane and banana both from Asia/Pacific now across the tropics.

A consequence of this is that they then become vulnerable to different biotic constraints due to:

- Loss of genetic diversity and associated protective biome
- Exposure to 'new encounter' pests and pathogens
- 'Catch up' of coevolved problems or 're-encounter' with ancestral problems.
- Altered agro-environmental conditions

Another consequence is that the improved productivity of crops in these new areas disadvantages producers in their native lands who still have to bear the cost of controlling the detrimental elements of the co-evolved biome.

The process of agricultural development itself, fostered by global trade and population expansion, has also created conditions that exacerbate directly or indirectly the impact of pests and diseases. Monocultures, continuous cropping and lack of genetic variability all favour disease epidemics and pest outbreaks, while soil degradation predisposes crops to soil borne diseases both through water/nutrient stress and reduced ecosystem stability.

Globalisation over the past 150 years has meant that coevolved pest and diseases have been catching up with their plant hosts, often with disastrous socio-economic consequences. The natural barriers which once separated the world's floras and faunas no longer exist and invasive alien species pose a potent and burgeoning threat to both natural and agricultural ecosystems.

Disrupted ecosystems

Conditions favouring crop species when they were grown outside their centres of evolution also apply to other species many of which become invasive and disrupt the ecosystems of their new ranges. The Global Invasive Species Programme (GISP) was founded in 1997 and aims are to assess and combat the threat of invasive species which can come from any taxonomic group and whose impacts cost at least US$ 1.4 trillion annually. The GISP websites list innumerable examples of invasive species from all taxonomic groups - mammals, birds, amphibians, fish, crustaceans, insects, plants, fungi, bacteria and viruses causing damage to man, animals, native ecosystems, waterways, forestry and agriculture.

Methods of spread

The mechanisms involved in the spread of alien invasive species including pests and pathogens are varied. Some have spread through natural means of dispersal, but much intercontinental spread has been by through the normal processes of travel and trade. Others, especially weed species, have been imported initially as ornamentals and have become rampant when escaped into the wider environment e.g. water hyacinth, Japanese knot weed. Some have been imported as crop plants or animals that have subsequently become invasive e.g. *Leucaena*, camels in Australia and a few as biocontrol agents that have become pests themselves e.g. the cane toad in Australian. Seed is another major route through which alien invasive species especially pests and diseases are spread - e.g. potato blight, karnal bunt of wheat. The threat of alien invasives also includes bioterrorism where harmful organisms may be deliberately spread.

Some Examples

Potato - potato blight is the prime example of the consequence of a 'catch up' pathogen (*Phytophthora infestans*) causing havoc. When first imported and grown in temperate regions of both the USA and Europe this coevolved pathogen was left behind and the potato flourished, but blight eventually caught up with devastating results especially in Ireland. One indirect consequence of this episode was the repeal of the Corn Laws, thus facilitating greater trade expansion. More recently, the A2 mating type of the pathogen was imported from Mexico into Europe and as a consequence the pathogen can now produce oospores giving it greater genetic variability and aiding inter-seasonal survival.

Coffee – coffee rust (*Hemileia vastatrix*) is a further example of a 'catch up' pathogen causing problems. When coffee was transported from Africa to Asia and S America it left behind the coevolved rust pathogen. The disease reached Asia in the late 1800s, probably via the transport of coffee material across the Indian Ocean, where it caused considerable damage and was largely responsible for the demise of coffee growing in Ceylon and its replacement by tea, and as a reputed consequence, made the British into a tea drinking nation. Rust eventually reached Brazil in the 1970s, probably through unintended passive human transport and has since spread to all major coffee producing countries. Similarly the coffee berry borer (*Hypothenemus hampei*) spread from Africa to Brazil in the 1920s and is now found throughout South and Central America. Coffee berry disease (*Colletotricum kahawae*) is an interesting example of a 're-encounter' disease. The tetraploid *Coffea arabica* has its centre of diversity (but not of origin) on the Ethiopian plateau. When it was introduced to W. Kenya (and probably Cameroon as well) it came into contact with its wild diploid *Coffea* progenitors and their associated coevolved microflora one member of which was the coffee berry disease pathogen to which *C. arabica* had no resistance. The disease flared up and spread throughout the new coffee plantations in Kenya and eventually other coffee producing countries in Africa causing considerable damage to the industry in Kenya in the 1960s until control measures were developed. The disease remains restricted to Africa.

Cocoa provides typical examples of 'new encounter' pathogens. When the crop, which has its centre of origin in the upper Amazon, was grown in W Africa it encountered both the virulent *Phytophthora megakarya* causing severe black pod disease, and the virus which causes swollen shoot disease both of which are part of the native microflora of W. Africa forests. When grown in Papua New Guinea it encountered yet another native microorganism (*Oncobasidium theobromae*) to which it was susceptible, causing vascular steak dieback.

Cassava - two forms of a 'new encounter' virus causing Africa cassava mosaic from west and east Africa combined in the northern Uganda region to produce a virulent form that caused considerable damage to this major staple crop.

Cashews - large areas in S. Tanzania were planted to cashews on old groundnut scheme lands in the 1960s-70s. When powdery mildew disease arrived, it caused major problems in the dense cashew orchards which flowered during the cool humid season most suited to mildew development on susceptible cashew inflorescences.

One can add to this list many examples from other crops, trees and whole ecosystems that have been ravaged by invasive or new pest species.

Management options

Prevention

International plant quarantine regulations aim to prevent the entry of exotic pest organisms into most countries and are co-ordinated under the FAO Plant Protection Convention. However, lists of quarantine pests can only include those that are known threats, and problems occur due to unclear taxonomic identity or because they are sub-specific taxa (e.g. races or mating types), because they are not economic pests in their native habitat, or because they have changed from a minor to a major pest status through genetic adaptation, through agricultural change, or through climatic change that increases epidemiological competence.

The efficacy of plant-health regulations is also dependent on sampling and detection procedures that can never provide a complete safeguard. The above limitations, coupled with the sheer volume of the movement of commodities and people associated with globalisation, suggests that the threats to biosecurity posed by the movement of exotic organisms seems likely to increase.

Eradication

Eradication of new or invasive pest species is only feasible where the area affected is limited and well defined, suitable methods of eradication are available and the costs entailed can be met. Eradication has had some success with animal and human diseases including worldwide eradication programmes e.g. rinderpest and smallpox, but success against plant diseases and weeds has rarely been achieved.

Control

Genetic resistance is the preferred method to control diseases. Sources of resistance can often be found in the centres of diversity of crop species and used in breeding programmes to develop disease resistant cultivars, but such resistance may not prove durable especially in the long term. Integrated management practices incorporating cultural, chemical and genetic resistance have been mostly developed for control of exotic pests and diseases.

Biological control

Introduction of natural enemies often found in the centre of diversity of invasive species has been very successful against a number of major weed species. The mile-a-minute weed *Mikania micrantha,* causing significant damage to forest and tea plantations in Asia, is being brought under control with a rust *Puccinia spegazzinii* brought from its centre of origin in Mexico. Water Hyacinth *Eichornia crassipes* is now largely controlled by weevils *Neochetina spp.* collected from its natural habitat in S America. However, potential biocontrol agents firstly need to be found then cultured and rigorously assessed for efficacy and specificity; otherwise the consequences of introduction can make them into pests themselves.

Endophytes

There is now compelling evidence that fungal endophytes are important components of plants in natural ecosystems and that these help their hosts to overcome both abiotic and biotic stresses. On-going work is showing that plant species moved outside of their centres of origin or diversity are impoverished in their coevolved endophytic mycobiota, and they may be highly vulnerable to attack by ‘catch up’ coevolved pests and diseases. The use of endophytes may therefore provide another line of defence against exotic pest species in the future