SUSTAINABLE DEVELOPMENT GOAL 15

LIFE ON LAND

CONTRIBUTIONS OF EMBRAPA

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Technical Editors

Embrapa

Brazilian Agricultural Research Corporation
Ministry of Agriculture, Livestock and Food Supply

Sustainable Development Goal 15

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Chapter 8

Alien species: economical use, control and impact reduction

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Introduction

This chapter deals with the contributions of the Brazilian Agricultural Research Corporation (Embrapa) to reach target 15.8 of the Sustainable Development Goals 15 (United Nations, 2018): By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.

Alien species are those outside of their natural origen zone. Alien species become invasive when they threaten the biological diversity and environmental balance. Alien species with potential to cause damages and economic losses are considered a "quarantine pest," in accordance with the International Standards for Phytosanitary Measure (ISPM) No. 5 of the International Plant Protection Convention (IPPC) of the Food and Agriculture Organization of the United Nations (FAO).

Species' introduction mechanisms may be deliberate or accidental. Intentional introductions are always with the main purpose of obtaining economic gain, both from profiting from the cultivation and sale of these organisms and from biologically controlling pest species that threaten environmental balance or agricultural production. Therefore, due to its economic importance, alien species are largely used, and its escape is a problem to be avoided with good practices identified in research studies and technical follow-ups, with monitoring and

correction if intervention is necessary. Non-intentional introductions can occur by several means, such as by packaging materials and merchandise display made of wood, propagation materials as seeds and seedlings, agricultural machines and implements, means of transportation (airplane cargo compartment, containers, trucks), water discharge from ship ballasts. Even deforestation and degradation of green areas provide opportunities for invasions, and climate changes may as well foster or force the migration of species that try to survive.

Besides pressures of predation and competition exerted on native species, invasive alien species may also cause changes to the environment, resulting in losses of agricultural and forest production, soils and pastures, and dissemination of parasites and pathogens whose vectors are alien organisms. Invasive species are therefore one of the most important environmental challenges in the world. It is not always possible to combat them; generally, complex and expensive proceedings without guaranteed results are necessary. To reduce the impact of alien organisms on the environment, management strategies are used aiming to create mechanisms of environmental resistance.

Control and impact reduction

Dispersion assessments of introduced alien species are important both for monitoring the environmental quality and for elaborating control measures and impact mitigation. These assessments can be combined with germplasm, gamete, and tissue databases, which are important for the preservation of information on genetic diversity.

At Embrapa, research studies are performed to seek conservation, characterization, and documentation of native and alien species with potential for use in agriculture. Environmental and economic losses due to the presence of alien species already happened in Brazil in planted *Pinus* and *Eucalyptus* forests. In 1988, forest heritage of *Pinus* spp. was put at risk by the introduction of sirex woodwasp (*Sirex noctilio*), which caused the death of 60% of the trees. However, Embrapa coordinated an integrated pest management program (IPM) applied to sirex woodwasp involving the monitoring and biological control associated to silviculture control, which reduced the occurrence of trees attacked by the pest, with significant economic returns to foresters.

In the same way, an IPM program for controlling giant conifer aphids (*Cinara pinivora* and *Cinara atlantica*) introduced in Brazil in 1996 and 1998 was developed

with emphasis on biological control. The balance of pest population was restored, and they are now completely under control. In 2008, bronze bug (*Thaumastocoris peregrinus*) and eucalyptus gall wasp (*Leptocybe invasa*) (Wilcken, 2008; Wilcken; Berti Filho, 2008; Wilcken et al., 2010) were introduced. Damages caused by the attack of *T. peregrinus* led to reductions of 14% in volume increase, 5% in diameter increase, and 3% in height increase of eucalyptus trees. The estimated average potential loss caused by *T. peregrinus'* outbreak was R$ 1,400/ha (Junqueira, 2016). Biological control is the main strategy to manage *T. peregrinus* in commercial eucalyptus crops. In Brazil, this program started in 2009, through a cooperation project between the Forestry Science and Research Institute (Ipef), the São Paulo State University (Unesp, Botucatu campus) and Embrapa, which developed the methodology for mass creation and studied bioecological parameters using egg parasitoids (*Cleruchoides noackae*) from Australia. Companies associated with Ipef's Program of Forest Protection (Protef) have made releases in fields.

Biological control is widely used to combat pests and, for this reason, it is the subject of research studies developed by the Company in its Units, such as Embrapa Temperate Agriculture (*Anastrepha fraterculus; Fopius arisanus*), Embrapa Western Agriculture (*Helicoverpa armigera*), Embrapa Environment (*Ipomoea* spp.), Embrapa Genetic Resources (*Harlequin succinea*) and Embrapa Soybean.

In cargo transportation using vessels, water from the environment is collected in the vessel's ballast tanks. This proceeding is used to compensate the weight lost by the unloading of cargos, and makes it possible to control the vessel's draft and stability. Both water collection and discharge proceedings occur mainly in harbor areas, where small invertebrates, plants, seaweeds, eggs and larvae of several animals, cysts, spores or other types of resistant cells, besides bacteria and viruses, that is, many small organisms, may be and pass through this system, so as to be transferred between geographical areas.

Because of the comprehensiveness and intensity of international maritime traffic, ballast water is considered one of the main vectors of interoceanic and transoceanic movement of coastal species. Vessels that transport the largest volumes of ballast waters are tankers and bulk carriers, which are responsible for around 85% of Brazil's harbor exchange (both import and export). Several factors determine the future of organisms introduced in a new environment through ballast water, such as the diversity and local environmental parameters (water temperature, nutrients, and local pollution). Therefore, it is practically impossible to forecast which will be the next species to be introduced or when and where this

will occur. On a daily basis, over 3 thousand species of organisms are transported in ballast water through the world.

The golden mussel (*Limnoperna fortunei*), a species from Southeast Asia, probably came to South America in ballast water of vessels that sail commerce routes between Asian countries and Argentina. In 1991, this mollusk reached the Río de la Plata Estuary, in Argentina, where it thrived and from where it spread to the Paraguay, Paraná, and Uruguay rivers and their respective affluents. In 2015, the area of occurrence of the golden mussel in South America was mapped with the collaboration of Embrapa Pantanal, which studies the species since 1998 in the Paraguay River Basin, within the scope of the Fundo Setorial de Recursos Hídricos (Sectoral Fund for Water Resources) (CT-Hidro), led by Instituto de Estudos do Mar Almirante Paulo Moreira (IEAPM). It detected that the sectors most challenged by the species are electric power (due to their encrustation in the power plants' refrigeration system), tank-net system fishing (Figure 1) and water collection. A new program for restraining the species is being drafted by MMA and Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Ibama) with the collaboration of Embrapa Pantanal.

Quarantine processes are necessary for the introduction, cultivation, establishment, and control of alien species and their pests. In this sense, the Company performs extensive work by means of research studies carried out by Embrapa Genetic Resources & Biotechnology (plant germplasm quarantine), Embrapa Forestry (monitoring and control of alien pests in pine and eucalyptus), Embrapa Environment (alien pests in eucalyptus forests), Embrapa Amapá (carambola fruit fly, *Bactrocera carambolae*), Embrapa Roraima (ching bug, *Blissus* sp.), Embrapa Agrobiology (alien parasitoid in commercial orchards, *Diachasmimorpha longicaudata*), Embrapa Grape & Wine (fruit fly, *Anastrepha fraterculus*), Embrapa Southern Livestock (*Eragrostis plana*), Embrapa Wheat (genetic variation and virulence of *Magnaporthe oryzae*), among others. Embrapa Swine & Poultry and Embrapa Pantanal have jointly worked for structuring and implementing systems for population management and epidemiological surveillance of feral swine.

It is worth emphasizing that necessary governmental actions to face issues related to the introduction of alien pests sometimes divert budget resources that could be applied in health, education, research, etc. Thus, prevention (performed through a system of legal measures combined with strong inspection, surveillance and alternatives for quarantine treatments) will strengthen Brazilian forest and agricultural defense, avoiding economic, environmental, and social losses.

Photo: Márcia Divina Oliveira

Figure 1. Cleaning of a tank-net with golden mussel (*Limnoperna fortunei*) encrustation in the Canoas Reservoir, Paranapanema, São Paulo.

Economical use of introduced species

In order to benefit from the economical use of alien species with reduced environmental impacts, Embrapa and partners have been working in research studies and technical guidances for the application of good practices in agricultural systems, making income generation and sustainable regional development possible.

Although river basins may act as physical barriers and limit the occurrence and spread of aquatic organisms, anthropogenic and environmental events frequently promote the exchange of species among biomes. Many species of fish were introduced in reservoirs, lakes, and rivers as a way of strenghthening the fishing potential and the production of animal protein for human food. In other

cases, alien species were created in confined artificial environments, but failures in management allowed their escape to neighboring natural environments.

Another mechanism of introduction is the facilitation through physical change in the environment, as recently occurred after the construction of the Itaipu dam, which eliminated a natural barrier of dispersion of aquatic organisms: Guairá Falls (located in the Brazilian state of Paraná). Consequently, 33 species of fish went up the Paraná River Basin beyond the pre-existing natural barrier (Júlio Júnior et al., 2009; Vitule et al., 2012).

In *Pantanal*, two examples of introductions due to operational failures in crop systems are the successful establishment of peacock bass (*Cichla piquiti*) (Resende et al., 2008), a fish originary of the Amazon, and tambacu, a cross-breeding between the tambaqui female (*Colossoma macropomum*) with the pacu male (*Piaractus mesopotamicus*). Besides these fishes, since 2013, the presence of *Gymnotus sylvius* has been regionally noticed over the Upper Paraguay Basin; until 1999, this species had not been found beyond the Miranda River Basin. Embrapa Pantanal studies reported that such species did not cause impacts on the places where it was captured, the aquatic community did not change its structure or environment to integrate it, and it is among the most fished for the commercialization of baits. This is a successful example of the economical use of alien species (Sousa et al., 2017).

Initiatives connecting economical use and reduction of the impact of alien species presence in the environment result in economic, social, and environmental benefits, and they have been developed by Embrapa in several Brazilian geographic regions.

The Western honey bee (*Apis mellifera*) is a polyhybrid originated from the random naturally occurring cross-breeding of sub-species *Apis mellifera scutellata*, of African origin, and *Apis mellifera* and *Apis mellifera ligustica*, of European origin, which were brought to Brazil after 1956 with the purpose of establishing beekeeping as an income and development source in the Country. Despite displaying a marked defensive behavior as compared to that of European sub-species, the Western honey bee is more tolerant to pests and diseases, and it has been the most effective for obtaining honey products (honey, propolis, pollen, wax, etc.), which fosters the development of beekeeping in most regions of Brazil.

Embrapa Pantanal and its partners have been conducting research studies to adapt the production system of these bees to the region's conditions, to monitor the effects of their presence in the ecosystem and to promote honey production

as a sustainable income source for inhabitants of rural settlements, riversides, traditional communities and other farmers in general, thus fostering regional development and fighting poverty (Figure 2).

Sodom apple (*Calotropis procera*) and *Leucaena leucocephala* are alien species originary of Africa and Central America, respectively. In Brazil, they frequently occur in the Corumbá region, MS. These species were studied by Embrapa Pantanal with the participation of small farmers, who used them as hay to supplement animal fodder in the dry season (Figure 3), with the aim of achieving sustainable milk cattle production in rural settlements in the region (Lisita et al., 2009). Under the same perspective (regional development promotion), Embrapa Mid-North has performed research studies aiming at the introduction and evaluation of alien plants in irrigated areas of the state of Piauí.

Because of the importance of livestock for Brazil, alien pastures have been increasingly used due to their efficiency to feed cattle. For example, this happens in the Midwestern region of the country, where, since the 1970s, in *Pantanal*,

Photo: Vanderlei Doniseti Acassio dos Reis

Figure 2. Collection of Western honey bees' honey in a production system adapted to the regional conditions of *Pantanal* in the state of Mato Grosso do Sul.

Photo: Frederico Olivieri Lisita

Figure 3. Production of Sodom apple hay (*Calotropis procera*) in Taquaral settlement, in Corumbá, MS.

the most used species are *Panicum maximum* (Guinea grass and green panic grass), *Cynodon nlemfuensis* (Bermuda grass), *Paspalum notatum* (Bahia grass), *Panicum repens* (Torpedo grass), *Digitaria decumbens* (Pangola grass), *Pennisetum purpureum* (elephant grass), *Saccharum officinarum* (sugarcane), *Cynodon dactylon* (Bahama grass), *Hyparrhenia rufa* (Jaragua grass), *Paspalum plicatulum* (brown-seed paspalum), *Andropogon gayanus* and, more recently, brachiaria (*Urochloa decumbens*, *Urochloa humidicola*, and *Urochloa brizantha*). Over the last 10 years, the use of species of the *Urochloa* gender (Santos et al., 2005) was intensified.

To minimize the risks of environmental impacts caused by the presence of these alien grasses without affecting livestock production (which is crucial for economy and food production regionally and nationally), Embrapa Pantanal and Embrapa Beef Cattle perform research studies aiming at their rational use by following good practices. Besides, the outcomes of their georeferencing monitoring analyzed by Embrapa Agricultural Informatics show that only 12% of the *Pantanal* biome has been modified since the 1970s.

Final considerations

Facing the challenges for productivity increase in food production without environmental and social losses, since its creation in 1972, Embrapa has been performing research studies to find paths and solutions for Brazilian agriculture to achieve sustainability and the highest technological standards. The development of research projects for mitigating impacts related to the effects of introducing alien species and to its economical use in all national territory is part of this scenario. The examples presented in this chapter show the continuous and improving work of several teams distributed in Embrapa Units in varied regions.

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