BACKGROUNDER

ISC Invasive Species Council AUSTRALIA

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The invasion risks of introducing new genetic variants of exotic plants and animals

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Currently, most of the focus in assessments of proposed imports of plants and animals into Australia is at a species level. This means that once a species is a permitted import, new genetic material (new subspecies, cultivars, biotypes) can usually be introduced into the environment without assessment.

Many species permitted import into Australia are already serious weeds or pests (they are permitted because they were already established in Australia when the current system of risk assessment was implemented). It has been assumed that permitting different variants of a species that is already a weed or pest can't do much more harm. But recent evidence shows that introducing new genetic material can facilitate invasion and create a much worse problem. This justifies requiring assessment of the risks of importing new genetic material – as occurred, for example, with the proposed importation of savannah cats.

There are two broad categories of risks associated with the import of new genetic material – risks arising directly from new variants and risks associated with interbreeding of different genetic variants. Wilson and colleagues (2009) summarized the risks as (i) increasing the chance of introducing a preadapted genotype, (ii) increasing the chance of establishment with outcrossed species, (iii) increasing genetic variation for particular adaptive features and (iv) increasing the likelihood of adaptive evolution [for example, to climate change].

1. New genetic variants of a species permitted import can have different features that increase invasability and/or potential environmental impacts

The environment minister refused the importation of savannah cats because it is likely they would escape into the wild and increase predation pressure on native species. There are similar risks with importing new strains of other weeds and pests. If Boer goats and Kalahari goats, imported from South Africa to produce more drought-hardy goat breeds, escape into the wild, they are likely to increase the degradation pressure of feral goats.

As one example of the invasability difference between two genetic variants of the same species, Delatte and colleagues (2009) found that the invasive biotype B of whitefly (Bemisia tabaci) had an increased rate of reproduction (and associated traits such as short developmental times and high fecundity) and competitive advantages, such as large adult and offspring sizes, over the non-invasive biotype Ms.

Plant breeders in Australia and overseas are developing new varieties of already weedy species to increase tolerance of drought, frost, salinity and other environmental constraints that could facilitate weed expansion, as could varieties with greater fertility or other competitive advantages. A kikuyu grass (Pennisetum clandestinum) breeding program, for example, is aiming to produce varieties that exhibit shade and drought tolerance and resistance to disease.[1] Kikuyu is an environmental weed, one of the exotic perennial grasses listed as a key threatening process in NSW[2], and a threat to at least 16 threatened species in NSW (Coutts-Smith & Downey 2006). But because kikuyu is not declared noxious anywhere in Australia, any new variant can be bred domestically or imported without a risk assessment. New cultivars of the pasture grasses and environmental weeds cocksfoot (Dactylis glomerata) and tall fescue (Festuca arundinacea) are being bred for lower rainfall areas (400-700 mm), with tolerance to drought and persistence in acid and/or low fertility soils, and suitable for sowing across up to 20 million ha (Crosbie 2007). Again, there is no requirement for their weed risk to be assessed.

2. Interbreeding of different genetic variants can stimulate invasiveness and result in novel genotypes with much greater impacts on the environment

Research in recent years has found that hybridization is a catalyst for invasive evolution of plants and other organisms. There is documented evidence for at least 35 cases in which hybridization preceded invasions of introduced plants (Schierenbeck & Ellstrand 2009).

According to Lavergne and Molofsky (2007), the importation of new genetic material of an existing introduced species can result in:

1 See www.agcsa.com.au/static/atm_articles/html/9_4_3b.html. "Promising selections" include "aggressive forms suitable for pasture production."

2 See listing at http://www.environment.nsw.gov.au/determinations/ExoticPerennialGrassesKTPListing.htm.

(i) hybrid vigor - recombination of genetic variants can produce a cultivar more invasive than the parent forms,

(ii) an increase in genetic variance and subsequent natural selection of invasive ability, and

(iii) an increase in phenotypic plasticity, which may promote invasion by allowing growth in a variety of environmental conditions (Lavergne and Molofsky 2008).

In an example of the first risk, Culley and Hardiman (2008) found that naturalised specimens of Pyrus calleryana, a Chinese tree species commonly planted as an ornamental in residential and commercial areas in the US, were a cross between genetically distinct cultivars from different parts of China. In Australia, pampas Grass (Cortaderia selloana) was not a major weed for decades because all the plants in gardens were female. When a new colour variant was imported – a hermaphrodite – the plants began setting seed and pampas grass became a serious environmental weed.

Hybridization between species can also occur. For example, the Invasive Species Council is concerned that a sterile cultivar of Distichlis spicata (a serious weed overseas), known as NyPa Forage™, which is permitted into Australia, could hybridise with an Australian distichlis (D. distichophylla) to produce a weedy cross.

The introduction of multiple genetic variants of plants can provide them with the genetic potential to become super-invasive.[3] Lavergne and Molofsky (2007), for example, found that multiple introductions of the serious invasive wetland weed canary reed grass (Phalaris arundinacea) into the US had resulted in genetic reshuffling and recombination within the introduced populations to give rise to novel genotypes that were highly invasive. There was higher genetic diversity (and heritable phenotypic variation) in its invasive US range than in its native European range.[4] They concluded that "multiply introduced invasive species are particularly predisposed to exhibit high rates of phenotypic evolution after their introduction, and may be very successful in adapting to predicted climate change in future decades."

In simple terms, the importation of new genetic material bestows invasive or potentially invasive species with more evolutionary potential to flourish under existing or changing conditions. It can turn weeds into 'super-invaders'. Many of Australia's serious weeds are hybrids – lantana (Lantana camara), blackberry (Rubus fruticosus), mesquite (Prosopis spp.) and spartina (Spartina anglica) among them.

Policy implications

Even if no control of particular existing variants of invasive species is undertaken,[5] there is scientific justification in banning the import of new genetic variants of these species because of the additional environmental risks associated with new genetic material. There is also justification in limiting imports of some taxa to particular subspecies or variants, requiring that other genetic variants be assessed.

Risk assessments of taxa lower than species level already occurs for some proposed imports. For example, two subspecies of the legume Bituminaria bituminosa have recently been granted approval for import, but the species itself is not permitted and other subspecies would probably not pass a weed risk assessment.

Recommendation: Require that new genetic variants of permitted imports undergo risk assessment, taking into account (a) features of the new variant that may increase invasion risk and harm to the environment and (b) the potential for hybridization and genetic recombination to increase invasion risks.

References

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3 According to University of Adelaide's Chair in Plant Conservation Biology, Andrew Lowe, "in most cases super weeds become a problem after multiple introductions from different sources. By combining this genetic variation, new genetic mutations can arise that can give the alien species the potential to adapt and turn super-invasive." (Media release, May 2009).

4 Wilson et al. (2009) note that "natural dispersal pathways tend to introduce limited genetic variation from restricted sources over very large timescales, whereas human-mediated pathways tend to introduce larger proportions of genetic variation from more diverse sources over extremely short periods of geological time."

5 Under World Trade Organisation rules (the Sanitary and Phytosanitary Agreement) there are restrictions on what plants and animals can be banned from import. Weed taxa can only be banned if they are being "officially controlled". Unless a weed is being controlled (and only a small proportion in Australia are controlled), only new variants could be banned, if there was scientific justification for it.

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