Are the Aliens Taking Over? Invasive Species and Their Increasing Impact on Biodiversity

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The evidence to date is undeniable. Not only are the total numbers of alien species established in Europe increasing but, for many taxa, the rate at which they have become successfully introduced is higher now than at any time in the past (Hulme et al. 2009). Alien species may impact on the populations of specific native species through hybridisation, by facilitating the spread of pathogens or parasites, via grazing or predation or via competition for resources. As the examples in the forthcoming sections of this chapter illustrate, once established within Europe's borders, the progressive spread across the continent of invasive species such as giant hogweed *Heracleum mantegazzianum*, the Asian ladybug *Harmonia axyridis*, and the horse chestnut leafminer *Camararia ohridella* appears inevitable and unhindered by current management response. But while we may have quantified numbers and distributions, what do we know of their impacts? Alien species may impact on specific native species through hybridisation, by facilitating the spread of pathogens or parasites, via grazing, predation or competition. Furthermore, when dominant, they can change nutrient and water cycling of ecosystems, and even disturbance regimes such as increasing soil disturbance, sedimentation, or fire risk. Existing knowledge of impacts in Europe is much less than on other continents. For example, from a total of 10,317 species alien in Europe the ecological and economic impacts are only documented for 1,094 and 1,347 species, respectively (Vilà et al. 2010). Thus the number and impact of harmful invasive alien species in Europe is chronically underestimated, especially for species that do not damage agriculture or human health.

Hybridisation between alien and native species is a potentially serious threat to biodiversity. Hybridization may result in an infertile hybrid and this may lead to the decline of native species populations when hybrids represent the majority of offspring produced. Alternatively, the hybrids may be fertile and interbreed amongst themselves as well as the parental stock but generally perform less well than the native. Such "genetic pollution" threatens the integrity of native species and where this involves the spread of maladaptive genes, lower hybrid performance could lead to progressive native population declines. A further possibility is that the hybrid may exhibit new traits that enable it to occupy ecosystems from which either parent was previously absent or it may perform more vigorously in presently occupied ecosystems. While examples of each of these threats are known from Europe (Table **1**), a complete assessment is currently constrained by limited taxonomic knowledge, especially for invertebrates.

The success of many alien species in new regions has been attributed to the escape from parasites and pathogens prevalent in their native ranges. Yet, there are many cases where an alien species arrives with its parasites/pathogens and the latter have detrimental impacts on native species. In some cases, the parasite or pathogen has a marked impact on native populations without unduly affecting the alien host. Dramatic examples in Europe include the transmission of parapox virus between alien grey and native red squirrels and plague fungus in North-American signal crayfish that has spread to native European crayfish. In these examples, the pathogen is believed to have facilitated the establishment and spread of the alien host because the alien host is resistant to its pathogen whereas the European relatives are susceptible and die (Table **2**). There are also examples where the introduction of an alien host has assisted the establishment of a parasite/pathogen but subsequently the latter has spread more widely via free-living stages (e.g., eel swim-bladder nematode *Angullicola crassus*) or several alternate native hosts (sudden oak death fungus *Phytophthera* spp.). Often the impact of parasites and pathogens is most marked in commercial populations of hosts where densities are high. The wider impact on wild populations is more difficult to assess but can occur over a large spatial scale and long time period as illustrated by the decline of elms (*Ulmus procera*) in the UK following the introduction and spread of Dutch elm disease (*Ophiostoma ulmi*).

Where an alien predator has become successfully established it will more than likely subsist on a diet of native prey. The American mink (*Mustela vison*) is held partially responsible for the decline in water vole populations (*Arvicola terrestris*) in the UK. The muskrat (*Ondatra zibethicus*) preys, amongst other things, upon native freshwater mussels and can often lead to local population extinctions. The introduction of an alien amphipod (*Gmelinoides fasciatus*) from Lake Baikal into eastern European lakes resulted in the extinction of native amphipods. The predatory New Zealand flatworm (*Arthurdendyus triangulatus*) is suspected of causing declines

Table 1. Selected examples for hybrids between alien and native species in Europe and the consequence of hybrid offspring (adapted from Hulme 2007).

Taxon	Organism	Alien species	Native species	Consequence
Plants	Cordgrass	*Spartina alterniflora*	*Spartina maritima*	Allotetraploid hybrid is an aggressive invader of mudflats
Birds	Duck	*Oxyura jamaicensis*	*Oxyura leucocephala*	Hybridisation threatens genetic integrity of endemic native
Mammals	Mink	*Neovison vison*	*Mustella lutreola*	Infertile hybrid offspring reduce population growth rate of native

Table 2. Selected examples of pathogens and parasites transmitted to native hosts following the introduction of specific alien species into Europe (adapted from Hulme 2007).

Taxon	Alien host	Native host	Alien parasite/pathogen
Plants	*Rhododendron ponticum*	*Quercus petraea*	Sudden oak death fungus
Crustacea	*Pacifastacus leniusculus*	*Austropotamobius pallipes*	Crayfish plague fungus
Insects	*Apis cerana*	*Apis mellifera*	Varroa mite
Fish	*Anguilla japonica*	*Anguilla anguilla*	Swim-bladder nematode
Mammals	*Sciurus carolinensis*	*Sciurus vulgaris*	Parapox virus

Table 3. Selected examples of the impacts of alien vertebrates on native fauna of European island territories (adapted from Hulme 2007).

Island	Territory	Region	Alien predator	Native prey
South Uist	UK	North Atlantic	American Mink	Arctic Tern
Madeira	Portugal	North Atlantic	Brown Rat	Trocaz Pigeon
La Gomera	Spain	North Atlantic	Feral Cat	Giant Lizard
Swedish Isles	Sweden	Baltic	American Mink	Eider Duck
Bornholm	Denmark	Baltic	Brown Rat	Black-headed Gull
Baltic Islands	Finland	Baltic	American Mink	Black Guillemot
San Stephano	Italy	Mediterranean	Feral Cat	San Stephano Lizard
Corsica	France	Mediterranean	Black Rat	Cory's Shearwater
Capraia	Italy	Mediterranean	Feral Cat	Balearic Shearwater

and local extinctions of earthworms in western Scotland. The most marked predatory impacts are often found on islands where small populations of relatively naïve prey such as small endemic bird populations are exposed to food-limited alien predators. In many cases the alien culprits are feral cats (*Felis catus*) and rats (*Rattus* spp.) and the victims are the flightless chicks of nesting seabirds or reptiles many of them endemic to specific islands (Table **3**).

Evidence of alien herbivores impacts on specific native plant species populations is largely drawn from the agriculture and forestry sector where introduced pests cause significant damage to crops and plantations. Outside of managed ecosystems, it is generalist vertebrate herbivores that have a reputation of negative impacts on biodiversity, especially on islands. Feral goats (*Capra hircus*) and to a lesser extent sheep and cattle have established populations on many islands as a result of deliberate introductions or escapes from domestic livestock. Rabbits (*Oryctolagus cuniculus*) continue to pose problems in the Canary Islands and in the British Isles where by grazing they threaten unique plant communities and modify the landscape.

For plant communities there are many examples of alien plants outcompeting native plants by reducing seedling establishment, by shading or by decreasing plant growth by reducing soil nutrients and water availability. Anecdotal reports often suggest that alien animals can also compete and displace native animals. The larger, more aggressive Canadian beaver (*Castor canadensis*) is believed to outcompete and replace the European beaver (*C. fiber*) in northern Europe. Mandarin ducks (*Aix galericulata*) are assumed to compete with the native goldeneye (*Bucephala clangula*) since both species nest in tree holes close to rivers and such sites are in limited supply.

In many cases, the impact of alien species is to replace or reduce the abundance of ecologically equivalent native species and there are rarely wider ecological implications. However, in selected cases alien species may act as ecosystem engineers or keystone species leading to significant alterations in invaded ecosystems. Alien species that act as ecosystem engineers have the potential to transform ecosystems by altering underlying biogeochemical, hydrological and/or geomorphological processes. Wholesale ecosystem changes occur following colonisation of coastal sand dunes by nitrogen fixing mimosas (*Acacia* spp.) that includes augmentation of soil nutrients, stabilisation of dunes and replacement of native plant species. Riparian habitats are prone to the impacts of alien burrowing animals such as the Chinese mitten crab (*Eriocheir sinensis*) and coypu (*Myocastor coypu*) that destabilise riverbanks and increase soil erosion as well as flood events. Dense populations of the freshwater Asiatic clam (*Corbicula fluminea*) may affect the structure of planktonic communities and thus shift primary production to benthic communities. Alien species may also have such a wide impact on the resident fauna and flora through competitive and trophic interactions that they are classed as keystone species. One of the most pronounced shifts in ecosystems has been as a result of the recent invasion of the American comb jelly (*Mnemiopsis leidyi*) to the Black and Caspian Seas. This predatory ctenophore has led to significant declines in zooplankton abundance that subsequently reduced pelagic fish populations. In Spain, the Argentine ant (*Linepithema humile*) displaces not only native invertebrates but also vertebrates and even impacts on plants through disruption of myrmecochorous seed dispersal mutualisms.

But what are the most widespread species causing impacts? Vertebrates and terrestrial invertebrates cause impacts across the widest number of regions in Europe (Vilà et al. 2010). For example, the muskrat (*Ondatra zibethicus*) and the raccoon dog (*Nyctereutes procyonoides*) are known to cause impacts in more than 50 European regions. Several insects such as the thrips *Frankliniella occidentalis* and *Heliotrips haemorrhoidalis* are also documented to cause impacts on crops in more than 30 regions. The most widespread aquatic organisms with impact are crustaceans such as the Chinese mitten crab (*Eriocheir sinensis*, 20 regions) and molluscs, for example the zebra mussel (*Dreissena polymorpha*, 20) and the Pacific oyster (*Crassostrea gigas*, 18). In contrast, alien terrestrial plants with known impacts are rarely widespread, often documented in only one region. Since many of these alien plants are widespread in Europe (Lambdon et al. 2008), this finding illustrates that the perception of impacts can be quite localised. Tree of heaven (*Ailanthus altissima*), black locust (*Robinia pseudoacacia*) and Japanese knotweed (*Fallopia japonica*) are the plant species with the most widespread impacts.

In summary, many invaders cause multiple impacts over a large area in Europe. The overall impact of invaders depends upon their area of distribution, local abundance and per capita effect, but these three components are difficult to quantify. Quantifying such impacts should be a priority in Europe and an essential component of risk assessment.

References

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