1 Biological Invasions: why it Matters

Wolfgang Nentwig

The dispersal of organisms is a natural process, important for the distribution of life on earth. It is also important for the appearance and expression of biodiversity, strengthening the multiple forms and functions of diversity in living organisms. We, too, profit from this process and its dynamics, and are even dependent on it. On a longer time scale, dispersal is one of the drivers of evolution, responsible for life itself.

Dispersal is limited by multiple barriers, among which geographical barriers are the most evident. However, human dispersal has overcome all biogeographical barriers, and humans now inhabit all parts of the world. Our activities are on a global scale, and we have been working intensively for centuries to connect all parts of the world ever closer together. In human history, roads were the first expression of these interconnections, as well as shipping. Today, we can reach any spot on earth by plane within 24 h, and vessels transport cargo around the globe within a few weeks. In addition, new connections between water drainage systems, lakes and oceans have been constructed.

Man did not conquer the world alone. He was always accompanied by his domesticated animals, crop plants, pets, pathogens and parasites. In addition to this, we gather and transport ornamental plants and animals or parts of these. Already our ancestors collected feathers and fur, shells and seeds for multiple purposes. Wilson called this search or even love for all types of life expressions "biophilia" (Wilson 1984). From a philosophical point of view, one could state that we obviously need to surround ourselves with nature because we are part of it. From a more ecological (and also medical) point of view, one could state that we need our natural surrounding because it enables our survival, personally and as a species.

The dark side of this entourage of many species which always surrounds us is the spread of exactly these species to every spot where we stay and to which we move. Consequently, we distribute hundreds and thousands of species intentionally and unintentionally worldwide. Bringing a given species into a new habitat is not neutral to the environment because it interacts with resident species or abiotic parameters or energy and matter fluxes.

Ecological Studies, Vol. 193
W. Nentwig (Ed.)
Biological Invasions

Usually, the result of an additional species is neither an enrichment of the ecosystem nor any amelioration whatsoever. The acclimatisation societies (which I would call pseudoscientific, rather than scientific), founded in the second half of the 19th century to "vaccinate", professionally and on a large scale, new world colonies with European species in order to "ameliorate" their "inferior" species richness, made a fatal error. It is meanwhile widely known, at least to the scientific community, that alien species are among the major dangers to the well-functioning of our environment.

The consequences of introducing alien species can be manifold: though the majority of these species has no (or no visible) immediate negative effect, some do exhibit ecological impacts directly or after a short time of adapting to the new environment. The more obvious cases are invasive aliens competing with native species, dominating their new environment or even replacing native residents. Quite often, this is done with the complicity of newly introduced pathogens or parasites to which the alien species is adapted but to which a close resident relative is not. Thus, alien species regularly lead to a loss of biodiversity and to a homogenization of the invaded habitat. Secondary damage may be chemical pollution and erosion. Alien species consume and contaminate water, thereby reducing its quantity and quality. Many alien species themselves are pathogens or parasites which threaten the indigenous species community. Weeds and animal pests are of high importance to humans because they impede on agriculture. Human pathogens such as bacteria and viruses attack humans directly and may cost millions of lives. On a global scale, this ever-increasing mixture of species originating from all over the world and being spread everywhere results in one gigantic muddle, initiating a homogenization of world ecosystems towards a least-common denominator.

One of the earliest invasions of a dangerous microorganism led to "the plague" or Black Death which, in medieval times, reached Europe from East Asia and killed about one third of the European population. Caused by the pathogen *Yersinia pestis*, with fleas, mice and rats as vectors, this disease has been spreading all over the world until recently. The potato blight *Phytophthora infestans*, a fungal pathogen of the potato, was introduced in 1840 from North America into Europe, causing mass famine in many countries the following years. Most severely affected was the Irish population, which was reduced to half its size not only by starvation as such but also by an associated mass emigration (Nentwig 2005).

To date, the most serious disease to have attacked mankind has been the pandemic influenza which spread from North America via Europe to all parts of the world at the end of the First World War. Recent estimates indicate that, over the period 1918–1920, about one third of the world population had been infected and 100 million people lost their lives – up to 20 % victims. The most recent pandemic is AIDS. Since the 1960s, the human immunodeficiency virus has spread from West or Central Africa via North America to the rest of the

world. So far, more than 40 million people have been infected, some 5 million people are newly infected each year and 3–4 million, mostly in sub-Saharan Africa, have died. Though HIV has as yet infected only 1 % of the world population, it has the potential of becoming a very serious threat to mankind (Nentwig 2005).

Meanwhile, the economic costs associated with alien species are known for some countries, some species, some time periods as well as for some processes. There are increasingly good data which facilitate some generalizations and extrapolations. Such data (albeit incomplete) already indicate the various economic damages associated with invasive alien species in several nations of the world to amount to about 5 % of the world GNP. Including the countries, species and processes still unaccounted for, this value would certainly be much higher (cf. Chap. 18).

Fifty years ago, the British ecologist Charles Elton published his *Ecology of invasions by animals and plants*, already then clearly stating that our world's new mix of native and alien species has unfavourable and dangerous aspects: "The whole matter goes far wider than any technological discussion of pest control, though many of the examples are taken from applied ecology. The real thing is that we are living in a period of the world's history when the mingling of thousands of kinds of organisms from different parts of the world is setting up terrific dislocations in nature. We are seeing huge changes in the natural population balance of the world" (Elton 1958). Elton was among the first to realize the typical pattern of a biological invasion which he also called biological explosion. He asked pertinent questions: why and how are species dispersed by human activities? What is the negative impact of species in a new environment? How can this be prevented? Elton is rightly considered as one of the founders not only of ecology but also of the so-called invasion biology.

The discovery of America by Columbus in 1492 is usually set as the zero point of our definition of biological invasions. This is arguably rather an arbitrary date but it indeed marks the start of a new era of fast global population movements and trade. Thus, it does not really matter that already the Romans – and other earlier cultures, too – had imported new species into their empire. Rather, it was approximately 500 years ago when the main process began which today is called globalization, and its basic principles have not changed in the last centuries. The speed, however, is accelerating from year to year.

A new development of the last few decades concerns the self-conception of globalization, and the ease with which global trade proceeds. Global regulatory concepts such as the General Agreement on Tariffs and Trade GATT and its successor, the World Trade Organization WTO, are intended to facilitate exchange between all nations. These treaties reduce tariffs, export subsidies, protective measures, any kind of import limits, and quotas. On a worldwide basis, the goal is to eliminate all obstructions for free trade, which is seen as a basic right for people, nations, industries and trading companies.

In principle, this trend is certainly positive and could promote growth in less-developed countries. So far, however, the main profit has gone to industrialized countries. A very important side-effect of the new WTO-world is that the controls of goods involving alien species can be easily denounced as trade obstruction. It could become more difficult to set up stricter quarantine measures or large-scale controls for pests. It may also become less easy to strengthen the prohibition of trade dealing with potentially invasive alien species classified as ornamentals or pets. Strong efforts will be necessary to prevent the development of the WTO-world from turning fully in the direction initiated by early capitalistic societies. Especially politicians but also decision-makers at all hierarchical levels, including opinion-makers such as journalists, need intensive furthering of education with respect to the need of preventing the spread of alien species.

Even a WTO-world is not free of regulations and of responsibility for its own activities. Since the problem of invasive alien species is primarily economic, it is open for economic solutions (Perrings et al. 2002). One promising solution could be for each trading partner to contract an obligatory insurance covering any hazards of alien species caused by international trade. Such education – to take responsibility for one's activities – needs to be strengthened.

There is increasing concern that strong lobbies may prevent necessary countermeasures to biological invasions. Indeed, urgently needed import and general trade restrictions are becoming ever less enforceable in a WTO-world. Restrictions to trade with ornamental plants will fail on the front set up by gardeners and plant lovers. It is difficult to convince public opinion about the need for eradication programs for squirrels, parakeets, racoons and other charismatic vertebrates. Such beautiful birds and appealing mammals generate much public sympathy, and this despite their alien status, and even some scientists defend exotic species and debate about the purpose of eradication measures, smartly taking advantage of the psychological and sociological impact of such species. The public obviously needs continuing education to convince the majority of the negative aspects of even cuddly aliens!

It is an oft-cited argument that, in case-by-case studies, the negative effect of each and every alien species has to be proven. This "innocent until proven guilty" approach is justified in human jurisdiction but fatal in dealing with alien species because it immediately leads to uncontrolled introductions of the worst pest species. When ecological damage is detected, it is always too late since, once released, an organism can not simply be removed. Certainly, alien species have to be treated differently – to be on the safe side, a general zero-tolerance attitude is the far better position to take. This argumentation additionally shows that our society needs much more information on the ecological hazards of alien species.

Raising public awareness is always a tricky balance between panic and lethargy. Both extremes are usually counterproductive but, indirectly, they have proved useful in the past. When Rachel Carson published her *Silent*

Table 1.1 Numbers of alien species per continent. These values are minimum numbers, empty fields indicating gaps in our knowledge (data combined after Pimentel 2002; DAISIE 2006; other sources)

	Plants	Vertebrates	Invertebrates	Microorganisms
Africa	8,750[a]	83 fish 24 herp[a] 16 mammals[a] 8 birds[a]		
North America	5,000	145 fish 53 herp[b] 20 mammals[b] 97 birds[b]	4,500 arthropods[b] 11 earthworms[b] 91 molluscs[b] 100 aquatic species[b]	20,000[b]
South America	11,605[c]	76 fish[c] 25 mammals[c] 3 birds[c]	25 nematodes[c]	500 fungi[c] 100 viruses[c]
Asia	18,000[d]	300 fish[d] 30 mammals[d] 4 birds[d]	1,100 arthropods[d]	
Australia	3,020	180 fish 20 herp 20 mammals 70 birds	1,000 terrestrial species 250 aquatic species	188
Europe	3,691	140 fish 40 herp 90 mammals 51 birds	1,350 insects 210 arachnids 65 annelids 135 other "worms" 155 crustaceans 201 molluscs 17 cnidarians	
Oceania	2,000[e]	112 fish	2,200[e]	

[a]South Africa, [b]USA, [c]Brazil, [d]India, [e]New Zealand

spring in 1962, she wanted to achieve a more responsible and carefully managed use of environmental chemicals, especially pesticides. Her book caused much concern as well as overreactions but also led to the beginning of the modern environmental conservation movement. Today's use of environmental chemicals has become much more restricted. In another notable example in 1972 when Meadows and colleagues brought out *Limits to growth*, the book suffered from a poor database and insufficient computer software for predictions. Consequently, the critics "tore it to pieces" but, today, the main message of this key work is considered accurate and is generally accepted: the resources of the earth are finite and, thus, are inevitably subject to natural lim-

its. The modern movement of sustainability roots in the ideas of Meadows and co-workers.

Elton (1958) characterized the introduction of alien species as "one of the great convulsions of the world's flora and fauna". Astonishingly, the hazards provoked by alien species did not cause that much concern among scientists, nor did it attract public awareness as much as would have been expected. However, the ultimate reason for the loss of more than 5 % of the world GNP, one main reason for the loss of biodiversity, for millions of human deaths, and for the loss of more than 20 % of the world's food production cannot be ignored.

The simple question as to how many alien species we have worldwide has no precise answer. Per continent or larger geographic area, some estimates indicate up to 10,000 alien plant species, up to 300 alien vertebrates, more than 5,000 alien invertebrates and many 1,000s of alien microorganisms (Table 1.1). Giving a more precise answer is not yet possible. This alarming knowledge gap is indicative of our whole predicament in this field, and clearly points to our urgent need for more activities at all levels to stem against the increasing flood of alien species. This is why biological invasions do matter!

Acknowledgements. My thanks for valuable comments and support on the concept of this book or on individual chapters go to Sven Bacher, Cecily Klingler and Rita Schneider. Also, I gratefully acknowledge the considerable support by the European Union of my studies on invasive alien species within FP 5 (Giant Alien EVK2-CT-2001-00128) and within FP 6 through the projects ALARM (GOCE-CT-2003-506675) and DAISIE (SSPI-CT-2003-511202). Special thanks go to Gerhard Heldmaier (University of Marburg) and to Andrea Schlitzberger (Springer-Verlag, Heidelberg).

References

Carson R (1962) Silent spring. Houghton Mifflin, Boston

DAISIE (2006) Delivering alien invasive inventories for Europe. EU project 6th FP. www.europe-aliens.org

Elton CS (1958) The ecology of invasions by animals and plants. Methuen, London

Meadows DH, Meadows DL, Randers J, Behrens WW III (1972) The limits to growth. University Books, New York

Nentwig W (2005) Humanökologie. Springer, Berlin Heidelberg New York

Perrings C, Williamson M, Barbier EB, Delfino D, Dalmazzone S, Shogren J, Simmons P, Watkinson A (2002) Biological invasion risks and the public good: an economic perspective. Conserv Ecol 6(1):1

Pimentel D (2002) Biological invasions. CRC Press, Boca Raton

Wilson EO (1984) Biophilia. Harvard University Press, Cambridge

http://www.springer.com/978-3-540-77375-7

Biological Invasions
Nentwig, W. (Ed.)
2007, XXV, 446 p., Softcover
ISBN: 978-3-540-77375-7