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Neozoa and Neophytes - Friend or Foe?

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Neozoa and Neophytes - Friend or Foe?

Abstract

An increasing number of foreign animals, plants, but also bacteria, fungi, and viruses reach us very year. Several taxa have been imported to Europe on purpose because they are used as pet animals or in horticulture, agriculture or forestry. In several instances, these newcomers have escaped to the wild. Other alien species reach us hidden in soil, water, food or in aeroplanes or ships (ballast water). Because of increasing global trade, such events will become even more common in the future. A recent demonstration on how fast these global transport networks function can be seen in the rapid spread of Sars-CoV2, the virus causing the recent Corona pandemia. Most of the newcomers cannot establish populations with us and disappear. Others are more successful and survive. Some of them are welcomed additions to the local fauna and flora. However many others, especially the invasive species, can be detrimental to the environment and biodiversity. Especially on islands, introductions of dogs, cats, rats, mice or snakes even caused the extinction of the local endemic fauna. In ecology and nature conservation, we should have a close look on each alien species; if they are clearly detrimental, we should try to eliminate them as early as possible. However, species which do not harm local flora or fauna should be regarded as interesting additions, because native biodiversity is in decline in most regions of the world.

Anahtar Kelimeler: Biodiversity, invasive species, local fauna-flora.

Neozoa ve Neophytes - Dost mu Düşman mı?

Özet

Her yıl artan sayıda yabancı hayvan, bitki ve hatta bakteri, mantar ve virus bizlere ulaşmaktadır. Birkaç takson, evcil hayvan olarak veya bahçecilik, tarım veya ormancılıkta kullanıldıkları için bilerek Avrupa'ya ithal edilmiştir. Bazı durumlarda bu hayvanlar yaban ortamına kaçtılar. Diğer yabancı türler, toprakta, suda, yiyeceklerde veya uçaklarda veya gemilerde (balast suyu) gizlenerek bize ulaşmaktadır. Artan küresel ticaret nedeniyle, bu tür olaylar gelecekte daha da yaygınlaşacaktır. Bu küresel ulaşım ağlarının ne kadar hızlı çalıştığına dair yakın tarihli bir gösteri, son Corona pandemisine neden olan virüs olan Sars-CoV2'nin hızla yayılmasında görülebilir. Yeni gelenlerin çoğu bizimle nüfus oluşturamaz ve ortadan kaybolur. Diğerleri ise daha başarılıdır ve hayatta kalırlar. Bunların bazıları yerel fauna ve floraya yapılan eklemeleri memnuniyetle karşılar. Ancak diğerleri, özellikle istilacı türler, çevreye ve biyolojik çeşitliliğe zarar verebilir. Özellikle adalarda, köpeklerin, kedilerin, sıçanların, farelerin veya yılanların girişleri, yerel endemik faunanın yok olmasına bile neden olmuştur. Ekoloji ve doğa korumada, her bir yabancı türe yakından bakmalıyız; açıkça zararlıysa, onları mümkün olduğunca erken ortadan kaldırmaya çalışmalıyız. Bununla birlikte, yerel flora veya faunaya zarar vermeyen türler, ilginç eklemeler olarak kabul edilmelidir, çünkü dünyanın çoğu bölgesinde doğal biyolojik çeşitlilik azalmaktadır.

Keywords: Biyoçeşitlilik, istilacı türler, lokal fauna-flora.

1. INTRODUCTION

As is well known that we live in a world that is subject to constant change. The classical philosophers already discussed this. For Heraclitus of Ephesus (ca. 520 - 480 BC), becoming and passing are characteristics of our world. He created the famous saying "panta rhei -

everything flows". "No man ever steps in the same river twice" summarises this philosophy in a nutshell.

Wherever we look, we see becoming and changes, be it in the formation of our universe, our world and its creatures, our environment and climate, in our own lives, but also in our social and political structures. Nevertheless, we believe that stability and balance govern our lives and our world. We would like to keep the current situation of our world in a status quo, e.g. through nature or climate protection, although on closer analysis we have to realise that our nature, biodiversity and our climate have never been static, but have always been subject to change, which we humans can actually hardly control (Reichholf 2007a).

1.1. Variability and change in biodiversity

The composition of the animal and plant world (biodiversity) depends very much on the existing habitats and the ecological niches they contain. The habitats are in turn dependent on the climate. In addition, the past (historical distribution) determines the current biodiversity in a given habitat.

Currently, the possible impact of the postulated climate change on the development of the animal and plant world is being discussed in science, but especially intensively in the media (Reichholf 2007a). The polar bear on a melting ice floe is often taken as a warning sign, although polar bears are not endangered and have increased in numbers. However, we must not forget that most organisms are not static robots but flexible organisms that can adapt to a changing environment or migrate to areas that are more suitable. Fauna and flora have an astonishing capacity for resistance (resilience) and recovery. During the last ice age 20000 years ago, there was a dry period in Africa and South America, during which the rainforests shrank to small remnant areas and most regions in the Northern hemisphere were covered with ice. Only with the onset of the post-glacial warming period did large parts of the tropics become wet again and the rainforests reached the maximum extent of the modern era within less than 10,000 years. The northern hemisphere were recolonized by plant and animals species, which had retracted to refugia in the Mediterranean region and the Near East (Parau, Wink 2021). All species living today have survived a change of glacial and warm periods several times in the last two million years. Optimists therefore assume that most animal and plant species are plastic and flexible enough to survive the current climate change.

Experts agree that human interventions in nature are more decisive than climate change for the proposed global extinction of species and loss of biodiversity (genetic diversity, diversity of species and ecosystems). These interventions include environmental destruction, resource consumption, clearing of rainforests, intensification of agriculture, land consumption by settlements and industrial plant or mines, environmental toxins, direct stalking and hunting, all of which are directly or indirectly related to the growth of the world's human population. Measures to generate alternative energy, through dam construction, wind energy or biogas plants are also already showing negative impacts on wildlife, especially birds, bats and insects. In the media, alien and especially invasive species are often claimed to be responsible for the decline of biodiversity. We will discuss this assumption in this article.

Since humans colonised all continents of the earth within the last 100000 years (Diamond 2005; Storch et al. 2013), we have consciously or unconsciously carried animals, plants and

microorganisms with us and released them into the new habitats where they did not exist before. Human were and are excellent dispersal agents. When the introduced species are able to establish themselves, we speak of neozoa in the case of animals and neophytes in the case of plants (Nentwig 2011). In our modern world, characterised by international trade, global transport and traffic routes, the rates of import of alien organisms have increased greatly. An impressive demonstration for the speed and size of the current transport networks is the fast distribution of Sars-CoV2, the virus causing the Corona pandemia.

Introduction may be unintentional, as in the case of pathogenic germs (bacteria, fungi, viruses) or arthropod pests. They can come to us as hidden passengers in water (ballast water in ships), soil (agricultural and horticultural plants) and food imports (Table 1). Some of the newcomers can survive with us and establish new populations, whereas the majority probably disappears. Since we humans love plants and animals and like to keep them in our care, there has been intensive trade across national and continental borders for centuries. In many cases, such imported species have escaped from human care and now live with us as new citizens.

Table 1. Origin and fate of foreign species
I= intentional; E = Escape; P = Establishment of local populations in the wild; INV = invasive species

Sources of foreign species	**Organisms**	**Mechanism of release**	**Purpose**	**Consequences**
Pets	Water fowl, parrots, cats, dogs	E, I	Pet animals	P, INV
Captive animals (zoos)	Waterfowl, parrots, Nandu, Racoon	E, I	Exhibition	P, INV
Hunting industry	Game birds (pheasant, partridge, turkey, ducks, deer)	I	Hunting	P
Fishery industry	Many commercial fishes, crabs and arthropods; other invertebrates for feeding	I	Aquaculture, commercial and private fishing	P, INV
Pest management	Cats, snakes, ferrets	I	Elimination of problem species	P, INV
Fur industry	Racoon, mink, muskrat, nutria	E	Fur production	P, INV
Blind passengers on ships (ballast water) or airplanes	Rats, Mice, insects, spiders, scorpions, parasites, marine organisms, bacteria, fungi, viruses	E	Accidental transport	P, INV
Blind passengers	Soil organisms, arthropods, snails, slugs and other	E	Accidental transport	P, INV

(plants, food)	invertebrates, bacteria, fungi, viruses			
Horticulture	Foreign trees, shrubs and flowering plants	E, I	Exhibition	P, INV
Bee pasture	Foreign flowering plants (*Phacelia*, Californian poppy)	I	Supply of nectar rich plants for insects	P, INV
Forestry	Foreign trees (firs, pines, oaks, Black Locust)	I	Wood production	P, INV

1.2. Alien species

Alien species can only survive in a new surrounding if they find adequate food all year round, room for reproduction and if they are not wiped out by predators or *Homo sapiens*. Of the many aliens, which arrive with us, only very few succeeded in establishing themselves in the wild. Many of the earlier successful newcomers are now so well established in the local fauna or flora that only few of us recognise them as immigrants. Prominent alien species of the native fauna and flora are listed in Table 2.

Table 2: Examples of successful neophytes and neozoa in Europe (from Nentwig 2011; Starke-Ottich et al., 2015). Relevant databases for neozoa and neophytes are GISD (Global Invasive Species Database) and DAISIE (European Invasive Alien Species).

Class	**Species (Family)**		**Origin**
Neophytes			
	Common Ragwort (*Ambrosia artemisiifolia*; Asteraceae)		North America
	Himalayan Balsam (*Impatiens glandulifera*; Balsaminaceae)		Central Asia (Himalaya)
	Peruvian Daisy (*Galinsoga quadriradiata*; *G. parviflora*; Asteraceae)		South America
	Tree of Heaven (*Ailanthus altissima*; Simaroubaceae)		East Asia
	Oregon Grape (*Mahonia aquifolium*; Berberidaceae)		North America
	Japanese Knotweed (*Reynoutria japonica*; syn. *Fallopia japonica*; Polygonaceae)		East Asia
	Canadian Goldenrod (*Solidago canadensis*; Asteraceae)		North America
	Tall Willowherb (*Epiobium brachycarpum*; Onagraceae)		North America
	Evening Primrose (*Oenothera biennis*; Onagraceae)		North America
	Giant Hogweed (*Heracleum mantegazzianum*; Apiaceae)		Caucasus

	Black Locust (Robinia pseudacacia; Fabaceae)		North America
	South African Ragwort (*Senecio inaequidens*; Asteraceae)		Southern Africa
	Jerusalem Artichoke (*Helianthus tuberosus;* Asteraceae)		North America
	Black Cherry (*Prunus serotina*; Rosaceae)		North America
	Large-leaved Lupine (*Lupinus polyphyllus*; Fabaceae)		North America
	Pontic Rhododendron (*Rhododendron ponticum*, Ericaceae)		SW Asia
Neozoa			
Invertebrates	Tiger mosquito (*Stegomya albopictus*; syn. *Aedes albopictus;* Culicidae)		Asia
	Spiralling Whitefly (*Aleurodicus dispersus*; Hemiptera)		America
	Silverleaf Whitefly (*Bemisia tabaci*; Hemiptera)		America
	Spotted-wing Drosophila (*Drosophila suzukii*; Diptera)		SE Asia
	Corn Rootworm (*Diabrotica virgifera*; Chrysomelidae)		America
	Horse-Chestnut Leaf Miner (*Cameraria ohridella*; Lepidoptera)		North America
	Box Tree Caterpillar (*Cydalima perspectalis*; Lepidoptera)		SE Asia
	Asian Ladybeetle (*Harmonia axyridis*; Coccinellidae)		Southeast Asia
	Colorado Potato Beetle (*Leptinotarsa decemlineata*; Chrysomelidae)		South America
	Palm Weevil (*Rhynchophorus ferrugineus;* Curculionidae)		Tropical Asia
	Argentine Ant (*Linepithema humile*; Formicidae)		South America
	Pharaoh Ant (*Monomorium pharaonis*; Formicidae)		Asia
	Pacific Oyster (*Crassostrea gigas*; Ostreoidae)		Sea of Japan
	Chinese Mitten Crab (*Eriocheir sinensis*; Varunidae)		China
	Louisiana Crawfish (*Procambarus clarkii*; Cambaridae)		America
	Varroa Mite (*Varroa destructor*; Varroidae)		Asia
Vertebrates			
	Pond Slider (*Trachemys scripta;* Emydidae)		America
	Goldfish (*Carassius auratus*; Cyprinidae)		East Asia

	Rose-ringed parakeet (*Psittacula krameri;* Psittacidae)		Asia
	Monk Parakeet (*Myiopsitta monachus*; Psittacidae)		South America
	Canada Goose (*Branta canadensis*; Anatidae)		North America
	Egyptian Goose (*Alopochen aegyptiacus*; Anatidae)		Africa
	Ruddy Duck (*Oxyura jamaicensis*; Anatidae)		America
	House Crow (Corvus splendens)		Asia
	American Mink (*Neogale vison*; Mustelidae)		North America
	Muskrat (*Ondatra zibethicus*; Cricetidae)		North America
	Nutria (*Myocastor coypus*; Echimyidae)		South America
	Common Racoon Dog (*Nyctereutes procyonoides*; Canidae)		Asia
	Grey Squirrel (*Sciurus carolinensis*; Sciuridae)		North America
	Common Raccoon (*Procyon lotor;* Procyonidae)		North America

1.2. Neozoa and neophytes - friend or foe?

In recent decades, an increasing number of neozoa have been found in the wild, which have most likely escaped from captivity or are descended from escapees. Among birds, most neozoa are waterfowl, which are also most commonly kept in zoos and by private keepers. Some captive escapees have succeeded in reproducing in the wild and establishing semi-tame or wild populations. For Europe, alien birds include: Nandu, Black Swan, Swan Goose, Snow Goose, Bar-headed Goose, Canada Goose, Ruddy Shelduck, Egyptian Goose, Red-breasted Goose, Mandarin Duck, Wood Duck, Ruddy Duck, Monk Parakeet, Alexandrine Parakeet and Rose-ringed Parakeet (Figure 1).

Figure 1. Examples of alien and successfully introduced birds in Europe. (a) Bar-headed Goose (b) Nandu, (c) Black Swan, (d) Swan Goose, (e) Snow Goose, (f) Canada Goose, (g) Ruddy Shelduck, (h) Egyptian Goose, (i) Red-breasted Goose, (j) Mandarin Duck, (k) Wood Duck, (l) Rose-ringed Parakeet and (m) Ruddy Duck. (all Photos M. Wink)

As most goose species are closely related, hybridisation readily occurs between semi-tame geese, with some hybrids apparently being fertile. Hybrids of Canada, Barnacle, Bar-headed, Grey-legged, Swan and Egyptian Geese are known. Such hybrids are not without problems and should actually be removed before they pass on their mixed genetic material. So far, nature conservation and environmental protection have not issued any directives to this effect. Apparently, however, natural hybridisation also occurred earlier in the evolution of geese (Ottenburgs et al. 2017).

A currently discussed topic concerns the hybridisation of ruddy ducks (Figure 2), of which the White-headed duck (*Oxyura leucocephala*) is native to Spain and other regions of the Mediterranean area. The American Ruddy duck (*Oxyura jamaicensis*) escaped from zoos in Great Britain and has thus established itself as a newcomer. The British Ruddy Duck population comprised over 6000 individuals until a few years ago. These Ruddy Ducks are increasingly spreading and have already met on the native White-headed Ducks in Spain. Although they are clearly separate allopatric species, apparently no mating barriers exists and hybridisation with fertile offspring occurred. These hybrids also interbreed with the European White-headed Ducks, so that the White-headed Duck is in danger of becoming extinct as a genetically distinct species (a phenomenon termed “genetic swamping”). In the UK, Ruddy Ducks have now been systematically shot, so that the population there now only comprises between 50 and 100 individuals.

Figure 2. (a) The European White-headed duck and the (b) American Ruddy Duck can hybridize (Photos M. Vences)

Bird breeders have produced a number of artificial hybrids that can pose a problem if they are fertile and escape into the wild. This applies, for example, to hybrids between Peregrine Falcons and Saker Falcons or hybrids between Gyr and Saker Falcons (Wink 2011). A current overview of various hybrids of birds can be found at www.avianhybrids.wordpress.com.

1.3. Invasive species

However, not all conservationists agree on whether alien species (sometimes defamed as "aliens") are an enrichment or a threat to native flora and fauna (Review in Goodenough 2010).

There is agreement among most scientists that neozoa and neophytes tend to have negative impacts on small islands, often harbouring unique endemic species. Several endemic species have become extinct on small isolated islands (Hawaii, oceanic islands, New Zealand) after dogs, rats, cats or snakes were released or escaped from boats. On some of the oceanic island, where no natural predator originally occurred, several birds had become flightless. They became easy prey for introduced cats or ferrets. Island ecosystems are often fragile, so new species quickly upset the balance.

Some animals have been deliberately introduced to control a pest species without considering the consequences. Cats that were released on some islands to kill the rats that threatened the endemic bird species, quickly took a greater liking to those very bird species than to the rats, and thus became a nuisance themselves. In order to protect the bird life of islands, programmes are underway in many places, e.g. in the Galapagos Islands, to eliminate rats and goats again.

A number of mammals, which had been introduced for fur production, such as Mink and Racoon (Fig. 3), have escaped and deliberately set free in Europe. As predators, these species cause harm among European reptiles, amphibian, birds and mammals. Most scientists agree, that these taxa are invasive and that they have a negative balance.

Figure 3. Examples of introduced mammals. (a) Grey Squirrel, (b) Nutria (both M. Wink), (c) Racoon and Racoon dog (Wikimedia Commons)

There are several insect species, which have become transported to Europe hidden in soil, horticultural or food plants, which cause harm to local plants (Fig. 4). Examples include: The Colorado Potato Beetle (*Leptinotarsa decemlineata*) from North America, which has become a pest in the old World, where potatoes are cultivated. Or the Box Tree caterpillar (*Cydalima perspectalis*) from Asia, which apparently come to Europe with plants from China. The caterpillars feed on Box plants (*Buxus sempervirens*), although they produce highly toxic steroidal alkaloids. Apparently, the caterpillar can tolerate the toxins and they have wiped out many box plants in gardens in in nature. The caterpillars become toxic themselves and are thus not eaten by predators, such as titmice. Another example is the Palm weevil (*Rhynchophorus ferrugineus*) from Asia, which lives on palms. At present, many palms around the Mediterranean basin have suffered and many of them have been killed. A thread for humans in Europe are introduced vector arthropods (such as mosquitos or ticks) which can transmit viral and bacterial pathogens (West Nile virus, Usutu virus, Dengue, Rickettsia) and parasites (Malaria).

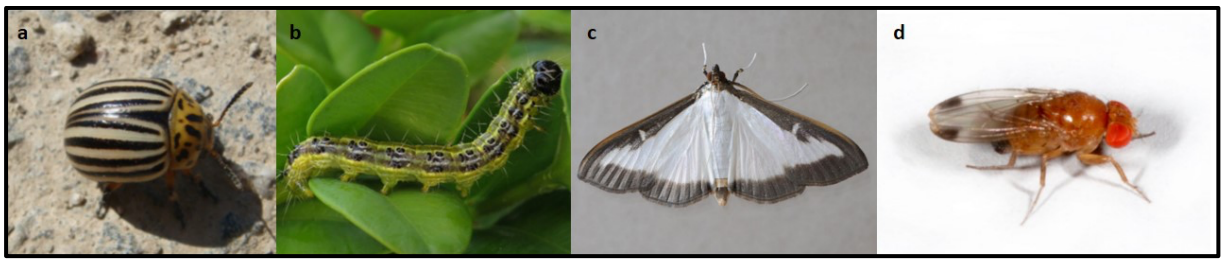

Figure 4. Examples of introduced insect pests. (a) Potato beetle (M. Wink), Box Tree Caterpillar ((b) adult, (c) larva; Wikimedia Commons), (d) Spotted-wing Drosophila

In the plant kingdom, there are several examples of invasive species (Fig. 5) that displace native species because they proliferate and overgrow entire habitats (Table 2). If you would like to study the topic of neozoa and neophytes in more detail, please refer to the following books: Reichholf (2007), Nentwig (2011), Starke-Ottich et al. (2015) and Pearce (2015).

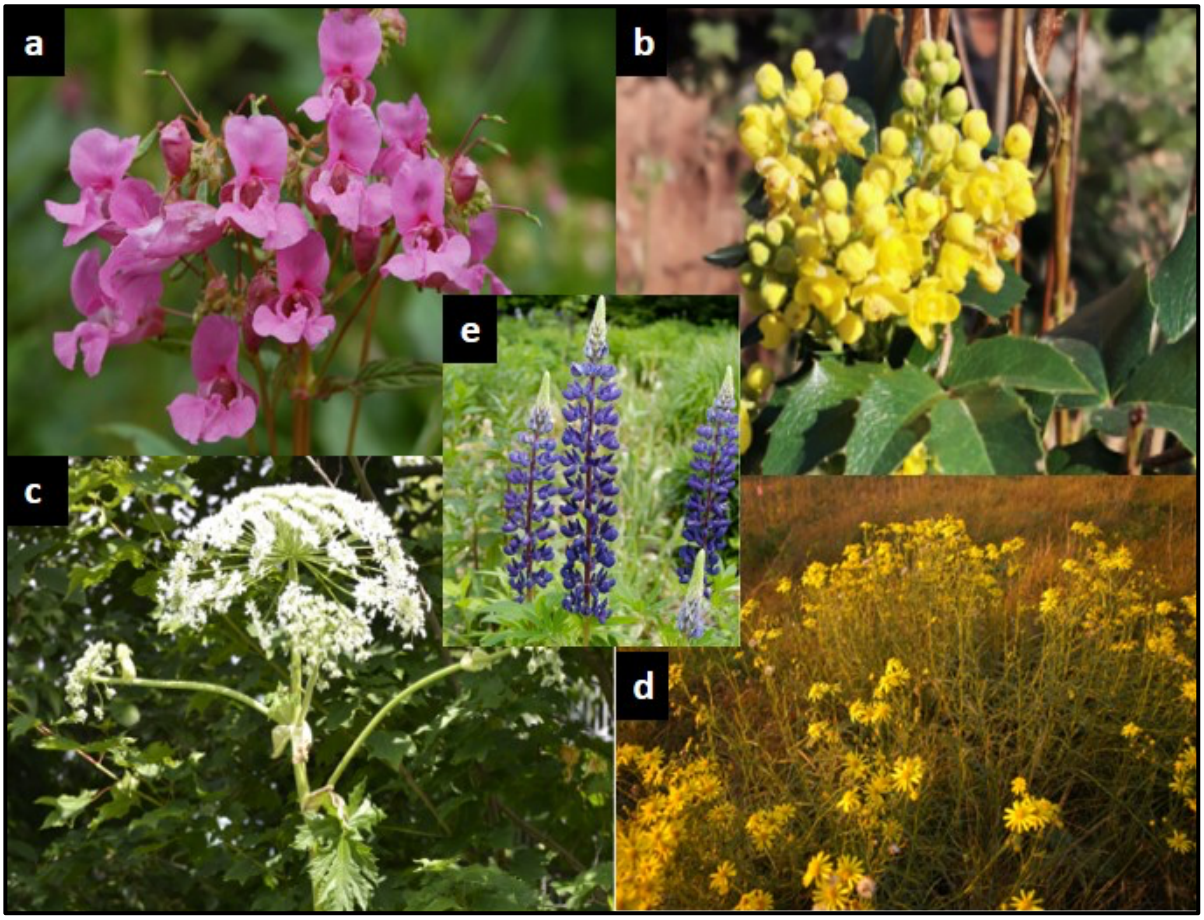

Figure 5. Examples of introduced invasive plants. (a) Himalayan Balsam, (b) Oregon Grape, (c) Giant Hogweed, (d) South-African ragwort, (e) Large leaved Lupine (photos: M. Wink)

When newcomers proliferate and negatively influences its new environment, they are often given the attribute "invasive". Characteristics of invasive species include fast growth, rapid reproduction, high dispersal ability, phenotypic plasticity, ecological competence, generalist

life style or associations with humans. In the EU and some other countries, the discussion has been ongoing for years as to whether invasive organisms are harmful to biodiversity causing ecological, environmental or economic damage and whether they should be eliminated on a large scale. However, it should be noted that many of our native animal and plant species also behave like invasive species; think of nettles or blackberries. Whether it really makes sense to eradicate all species that have negative characteristics from our point of view requires a case-by-case analysis and a thorough assessment of potential benefits and harms. Overall, we should not forget that *Homo sapiens* is the most invasive species on earth, which has exterminated several species, has destroyed many natural habitats, and will continue to do so.

For the EU, a list of 23 animal species and 14 plant species that are considered invasive aliens and whose spread should be controlled has been drawn up (Commission Implementing Regulation (EU) 2016/1141 of 13 July 2016). Three bird species are on this list: House Crow, Ruddy Duck and Sacred Ibis.

1.4. Positive aspects- friends

Many neozoa and neophytes are now partly an enrichment of local fauna or flora, as formerly native species have disappeared due to industrialised agriculture and habitat losses (construction measures of all kinds). For example, exotic waterfowl finds adequate food with us as they are herbivores and grass is abundant almost everywhere. Thus, a competition with endemic species is quite unlikely. In addition, predation and hunting pressure is usually low in parks and urbanized areas (Reichholf 2007b). As a consequence, several water fowl species have become established in Europe during the last 50 years. They include Bar-headed Goose, Swan Goose, Snow Goose, Barnacle Goose, Canada Goose, Black Swan, Egyptian Goose, Muscovy Duck, Mandarin Duck, and Ruddy Duck. In addition, also feral populations of European waterfowl species have joined the club, including Graylag Goose, Pink-footed Goose, Ruddy Shelduck, and Mallard. These waterfowl species usually do not damage existing wild populations in parks and urban environments, as these do not exists and food is abundant. These waterfowl species are often loved by visitors, especially parents with children. Other people complain that the waterfowl leave behind smelly faeces. If we would kill all the alien waterbirds, our parks would be empty. Thus better than having no birds at all, is having a diversity of alien waterfowl even if they leave things behind.

Another example is the Rose-ringed Parakeet, which was introduced to Europe more than 60 years ago, and now wild populations comprise more than 100000 pairs in Europe and Turkey (Parau et al. 2016). With regard to the species naturalised in our country, it is sometimes argued that cavity-nesting alien species, for example the Rose-ringed Parakeet, would displace other cavity-nesting species. Originally from India or Central Africa, the Rose-ringed parakeets have been resident in the parks of the cities of Bonn, Cologne, Düsseldorf, Mainz, Mannheim and Heidelberg for almost three decades and have now reached a population size of over 11 000 birds in Germany. There are similarly large populations in Belgium and Italy; only the UK has around three times as many collared parakeets (Pârâu et al. 2016). We made our own assessment of the situation and mapped all available tree hollows in parks in the Heidelberg region where the Rose-ringed Parakeet breeds in about 2000 pairs. This study showed that there are far more cavities than there is a need for. The starlings, which might be displaced by the parakeets, had sufficient breeding opportunities (Czajka et al. 2011), so there is no question of displacement

or competition. However, whether one has to love the Rose-ringed parakeets when they eat all the buds in the front garden or linger noisily in the garden is, of course, another matter altogether. But most people are excited to see this exotic parakeet with us.

2. DISCUSSION

Changeability, becoming and passing and not stability characterise our world. Nevertheless, many people prefer a determined and controllable world that makes sense and is not governed by chance. The introduction of neozoa and neophytes means changes, some of them positive, others negative, as outlined in this article. From a scientific point of view, it might be exciting to investigate what qualifies these successful newcomers to survive so well in our industrialised world, such as fast growth, rapid reproduction, high dispersal ability, phenotypic plasticity, ecological competence, generalist life style or associations with humans.

As stated above, our planet is facing great challenges and problems, some of which are of our own making. Since modern humans have already successfully withstood so many dangers and threats, an optimist will hope that future problems and challenges can also be overcome; after all, cultural evolution does not stop and innovations will continue to occur exponentially (Ridley 2010, 2015). Nevertheless, we must take responsibility for planet Earth with all its living beings. It is up to us whether we want to and are able to preserve our environment and biodiversity for our descendants. However, it is important in all considerations and measures that we must accept a changing and not static world.

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