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> Invasive alien species in Switzerland

An inventory of alien species and their threat to biodiversity and economy in Switzerland

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An inventory of alien species and their threat to biodiversity and economy in Switzerland

Mit deutscher Zusammenfassung – Avec résumé en français

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> Abstracts

Globalization increases trade, travel and transport and is leading to an unprecedented homogenization of the world's biota by transport and subsequent establishment of organisms beyond their natural barriers. Some of these alien species become invasive and pose threats to the environment and human economics and health. This report on alien biota in Switzerland lists about 800 established alien species and characterises 107 invasive alien species (IAS) in Fact Sheets: five mammals, four birds, one reptile, three amphibians, seven fish, four molluscs, 16 insects, six crustaceans, three spiders, two «worms», seven fungi, one bacteria, and 48 plants. A general chapter explains some common patterns in pathways, impacts and management, and gives recommendations for the management of alien species. The main body of the report is organised into taxonomic groups, and includes an overview, lists of alien species, Fact Sheets on the invasive species, and an evaluation of the status, impacts, pathways, control options and recommendations. The Fact Sheets summarize information on the invasive species under the headings taxonomy, description, ecology, origin, introduction, distribution, impact, management and references.

Keywords:
harmful organisms,
alien species,
invasive species,
biodiversity

Mit der zunehmenden Globalisierung nimmt auch der Handel, Verkehr und das Reisen zu und führt zu einer noch nie dagewesenen Homogenisierung der Biodiversität; Organismen werden über die natürlichen Grenzen hinaus transportiert. Einige dieser Neuankömmlinge können sich etablieren, und wiederum einige von diesen werden invasiv und bedrohen die einheimische Vielfalt, richten wirtschaftlichen Schaden an oder schädigen die menschliche Gesundheit. Dieser Bericht über die gebietsfremden Arten der Schweiz listet über 800 etablierte gebietsfremde Arten auf und stellt die 107 Problemarten in Datenblättern vor: fünf Säugetiere, vier Vögel, ein Reptil, drei Amphibien, sieben Fische, vier Weichtiere, 16 Insekten, sechs Krebstiere, drei Spinnen, zwei «Würmer», sieben Pilze, ein Bakterium und 48 Pflanzen. Das erste Kapitel erläutert einige allgemeine Einführungswege, negative Einflüsse und Gegenmassnahmen und gibt Vorschläge für den Umgang mit gebietsfremden Arten. Der Hauptteil besteht aus den Kapiteln zu den einzelnen taxonomischen Gruppen. Die Listen werden begleitet durch einen erläuternden Text, die Datenblätter stellen die Problemarten vor und schliesslich wird eine Auswertung der Situation, der Auswirkungen, der Einführungswege, mögliche Gegensteuerungsmassnahmen und Empfehlungen zu den jeweiligen taxonomischen Gruppen gegeben. Die Datenblätter bieten Information zu Taxonomie, Beschreibung, Ökologie, Herkunft, Einführungswege, Verbreitung, Auswirkungen, Ansätze zur Gegensteuerung und ein Literaturverzeichnis.

Stichwörter:
Schadorganismen,
gebietsfremde Organismen,
invasive Organismen,
Biodiversität,
Neobiota,
Neophyten,
Neozooa

La mondialisation implique une augmentation du commerce et des transports et entraîne une uniformisation sans précédant des biomes par le transfert et l'implantation des organismes vivants au delà de leurs barrières naturelles. Certaines de ces espèces exotiques deviennent envahissantes et représentent une menace pour l'environnement, l'économie et la santé publique. Ce rapport sur les organismes biologiques exotiques en Suisse inventorie environ 800 espèces non-indigènes établies dans le pays et détaille 107 espèces envahissantes sous forme de fiches d'information: cinq mammifères, quatre oiseaux, un reptile, trois amphibiens, sept poissons, quatre mollusques, 16 insectes, six crustacés, trois araignées, deux «vers», sept champignons, une bactérie et 48 plantes. Un chapitre général explique les modes d'introduction principaux des espèces exotiques et leur impact sur le milieu. Il donne également des recommandations sur la gestion et la lutte contre les organismes envahissants. Le corps principal du rapport est présenté par groupe taxonomique pour chacun desquels sont proposés une discussion générale, la liste des espèces non-indigènes, les fiches d'information sur les principales espèces envahissantes et une évaluation du statut, de l'impact, des modes d'introduction, les méthodes de lutte et des recommandations générales. Les fiches résument pour des espèces particulièrement envahissantes ou potentiellement dangereuses les informations sur la taxonomie, la description, l'écologie, l'origine, l'introduction en Suisse et en Europe, la distribution, l'impact, la gestion et les références bibliographiques.

Mots-clés :
organismes nuisibles,
organismes exotique,
organismes envahissants,
diversité biologique,
néophytes,
animaux envahissants,
plantes envahissantes

La crescente globalizzazione implica un aumento del commercio, dei viaggi e dei trasporti e determina un'omogeneizzazione senza precedenti della biodiversità a seguito del trasferimento e del successivo insediamento di organismi viventi oltre le loro barriere naturali. Alcune di queste specie aliene diventano invasive, minacciano la biodiversità locale, causano danni economici o sono nocive per l'uomo. Il presente rapporto elenca le oltre 800 specie aliene presenti in Svizzera e propone delle schede informative per le 107 specie diventate invasive. Si tratta di cinque mammiferi, quattro uccelli, un rettile, tre anfibi, sette pesci, quattro molluschi, 16 insetti, sei crostacei, tre aracnidi, due «vermi», sette funghi, un batterio e 48 piante. Il primo capitolo illustra alcune delle vie di penetrazione più comuni di tali specie nonché il loro impatto negativo sul nostro ambiente. Inoltre, propone possibili contromisure e raccomandazioni per la gestione delle specie aliene. La parte centrale del rapporto è suddivisa per gruppi tassonomici. Le liste sono corredate di un testo esplicativo, mentre le schede trattano le specie problematiche. Infine, il rapporto presenta una valutazione della situazione, dell'impatto e delle vie di penetrazione, alcune contromisure e delle raccomandazioni concernenti i singoli gruppi tassonomici. Le schede contengono informazioni relative a tassonomia, descrizione, ecologia, provenienza, vie di penetrazione, diffusione, impatto, eventuali misure di gestione e indicazioni bibliografiche.

Parole chiave:
organismi nocivi,
organismi allogeni,
organismi invasivi,
biodiversità,
neofite,
animale invasivi,
piante invasive

> Vorwort

Die weitgehend durch Klima und Geologie bestimmte Verteilung der Tier- und Pflanzenarten auf der Erde wurde lange Zeit durch natürliche Barrieren, wie Meere, Gebirge, Wüsten und Flüsse, aufrechterhalten. Mit der Überwindung dieser Barrieren durch den Menschen ist, namentlich in den letzten hundert Jahren durch zunehmenden Handel und Tourismus, eine neue Situation entstanden. Die Erde ist klein geworden.

Der Mensch reiste und reist aber nicht alleine. Im «Gepäck» hat er – beabsichtigt oder unbeabsichtigt – Pflanzen- und Tierarten mitgeschleppt, von denen einige in der neuen Heimat zu massiven Problemen geführt haben. Bekannte Beispiele sind die Ziegen auf den Galapagos- Inseln oder die Ratten und Katzen in Neuseeland, die zum Aussterben von Arten geführt haben, die einmalig auf der Welt waren.

Im Gegensatz zu Inseln, die mit ihren spezifisch angepassten Arten einzigartige Ökosysteme darstellen, ist Europa bislang weitgehend verschont geblieben von Problemen mit gebietsfremden Arten. Über die Ursachen wird spekuliert. Es kann daran liegen, dass Europa nie Einwanderungen erlebt hat wie Nord-Amerika oder Australien, wo die neuen Siedler mit ihren mitgebrachten Haustieren und Nutzpflanzen einen massiven Einfluss auf die vorhandene Flora und Fauna ausgeübt haben. Vielleicht sind aber auch unsere Ökosysteme robuster, so dass neue Arten es schwerer gehabt haben, Fuss zu fassen und die einheimischen Arten zu verdrängen.

Allerdings mehren sich auch in Europa und bei uns in der Schweiz heute die Anzeichen für Invasionen: Kanadische Goldrute, Riesenbärenklau und Ambrosia sind Beispiele aus dem Pflanzenreich, die aktuell durch die Tagespresse gehen. Aus dem Tierreich sind es das Grauhörnchen, die Schwarzkopfruderente oder der Amerikanische Flusskrebs, die den Naturschützern und Behörden zunehmend Kopfzerbrechen bereiten. Und selbst Insekten fallen vermehrt negativ auf, z.B. der Maiswurzelbohrer oder der Asiatische Marienkäfer, die unsere Nutzpflanzen direkt oder indirekt bedrohen. Die Folgen dieser Entwicklung sind heute noch nicht abschätzbar.

Nach der Biodiversitätskonvention ist die Schweiz verpflichtet, Massnahmen gegen invasive gebietsfremde Arten zu ergreifen und deren Verbreitung einzudämmen oder zu verhindern. Nach dem Motto «Gefahr erkannt – Gefahr gebannt» ist es für die Schweiz von zentraler Bedeutung, potenziell gefährliche Arten zu erkennen. Das vorliegende Kompendium ist hierfür gedacht. Es beschreibt in umfassender Weise von den Flechten bis hin zu Säugetieren gebietsfremde Arten mit Schadenpotenzial, die schon hier sind oder die vor den Toren der Schweiz stehen.

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> Summary

Globalization is increasing trade and travel on an unprecedented scale, and has inadvertently led to the increased transport and introduction of alien species, breaking down the natural barriers between countries and continents. Alien species are not bad *per se*, in fact many species are beneficial for humans, e.g. most crop species. However, some alien species have become harmful, and pose threats to the environment and humans. Invasive alien species (IAS) are increasingly recognized as one of the major threats to biodiversity.

All signatories to the Convention on Biological Diversity (CBD), including Switzerland, have agreed to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species.

There is a widespread view that IAS are of less concern in Central Europe than on other continents (and more especially on islands). Possible reasons for this include the small size of nature reserves, the high human impact on all 'natural' environments, and the long association of alien species and humans leading to familiarisation and adaptation. However, the number of cases of dramatic impact is increasing and awareness among scientists and the public is steadily growing. Thus, the threats from IAS should not be underrated. One of the major consequences, which is undoubtedly unfolding before our eyes, is global homogenization, with the unique character of places such as Switzerland being lost, the characteristic flora and fauna invaded by organisms which reproduce to eventually form the largest proportion of biomass in certain ecosystems.

Time lags, i.e. the gap between establishment and invasion, makes prediction of invasiveness of alien species very difficult. Well-established species showing no hint of any harm to the environment may still become invasive in the future. There are three major categories of factors that determine the ability of a species to become invasive: intrinsic factors or species traits; extrinsic factors or relationships between the species and abiotic and biotic factors; and the human dimension, incorporating the importance of species to humans.

This report compiles information about alien species in Switzerland from published sources and experts in Switzerland and abroad. Imminent future bioinvasions are also included. The availability of national lists varies greatly between taxonomic groups. Thus, unfortunately, it is not possible to list all the alien species of Switzerland, since not all resident species are known yet. However, for groups that are well known, complete lists have been compiled. For some groups only invasive species rather than alien species are treated, and other groups could not be covered at all.

The broad taxonomic groupings used are vertebrates, crustaceans, insects, arachnids, molluscs, other animals, fungi and plants. For each group, we present an overview, a list of alien species, Fact Sheets for the invasive species, an evaluation of the status,

impacts, pathways and control options for the group, and recommendations. The Fact Sheets summarize information on the invasive species under the headings taxonomy, description, ecology, origin, introduction, distribution, impact, management and references.

Definitions of the important terms used in the report are given, since frequently-used terms such as ‘invasive’ are often used in different ways.

The situation regarding IAS in Switzerland is similar to that in other Central European countries, in particular Austria, which is also a land-locked country containing part of the Alps. This report lists about 800 alien species and characterises 107 IAS in Fact Sheets: five mammals, four birds, one reptile, three amphibians, seven fish, four molluscs, 16 insects, six crustaceans, three spiders, two ‘worms’, seven fungi, one bacteria, and 48 plants.

Pathways can be divided into those for species deliberately introduced and those for species accidentally introduced. Pathways for deliberate introductions include the trade of species used in aquaculture, for fisheries, as forest trees, for agricultural purposes, for hunting, for soil improvement and solely to please humans as ornamentals. Most of these can also transport hitchhiking species and people can accidentally introduce species while travelling. In general, most aquatics and terrestrial invertebratesand diseases are accidental arrivals, whereas most plants and vertebrates are deliberately introduced. The global trend for the latter groups also holds true for Switzerland, e.g. 75% of the 20 Black List plants were introduced principally as ornamentals, and 35 of the 37 vertebrates were deliberately introduced. Thus, many damaging invaders were deliberately introduced, often with little justification beyond the wish to “improve” the landscape, e.g. ornamental plants and waterfowl.

The impacts of IAS are often considerable, in particular when ecosystem functioning is altered or species are pushed to extinction, as has been shown for many bird species on islands. The environmental impacts can be divided into four major factors: competition, predation, hybridization and transmission of diseases. The most obvious examples for competition are between introduced and native plants for nutrients and exposure to sunlight. Resource competition has also led to the replacement of the native red squirrel *(Sciurus vulgaris)* by the introduced American grey squirrel *(S. carolinensis)* in almost all of Great Britain and it is predicted that this trend will continue on the continent. The musk rat *(Ondatra zibethicus)* causes declines of native mussels population (Unionidae) by predation and the amphipod *Dikerogammarus villosus* is a serious predator of native freshwater invertebrates. A well-known example of hybridization from Europe is the ruddy duck *(Oxyura jamaicensis),* which hybridizes with the endangered native white-headed duck *(O. leucocephala).* In some cases IAS can harbour diseases and act as a vector for those diseases to native species. This is the case with American introduced crayfish species to Europe, which are almost asymptomatic carriers of the alien crayfish plague *(Aphanomyces astaci),* but the native noble crayfish *(Astacus astacus)* is highly susceptible to the disease, and thus is struggling to coexist with populations of the American crayfish species.

In addition to impacts on biodiversity, many IAS cause enormous economic costs. These costs can arise through direct losses of agricultural and forestry products and through increased production costs associated with control measures. A North American study calculated costs of US$ 138 billion per annum to the USA from IAS. A recently released report estimates that weeds are costing agriculture in Australia about Aus$ 4 billion a year, whereas weed control in natural environments cost about Aus$ 20 million in the year from mid 2001 to mid 2002. In Europe, the costs of giant hogweed *(Heracleum mantegazzianum)* in Germany are estimated at € 10 million; € 1 million relating to each of the environment and health sectors, and the remainder represents costs to the agricultural and forestry sectors. Economic damage by the western corn rootworm *(Diabrotica virgifera)* is increasing as it spreads through Europe. Some IAS also have implications for human health, e.g. giant hogweed produces copious amounts of a sap containing phototoxic substances (furanocoumarins), which can lead to severe burns to the skin. The raccoon dog *(Nyctereutes procyonoides),* introduced as a fur animal, can, like the native red fox *(Vulpes vulpes),* act as a vector of the most dangerous parasitic disease vectored by mammals to humans in Central Europe, i.e. the fox tapeworm *(Echinococcus multilocularis).* Known impacts of species introduced into Switzerland are presented, although some recent invaders have not yet been reported to have impact in Switzerland; in these cases impacts assessed in other countries are given. Demonstration of environmental impacts is often difficult because of the complexity of ecosystems, but alien species occurring in high numbers, such as Japanese knotweed *(Reynoutria japonica)* totally covering riversides, or an animal biomass of alien species of up to 95% in the Rhine near Basel, must have impacts on the native ecosystem. All species use resources and are resources to other creatures and so they alter the web and nutrient flow of the ecosystems they are living in.

Recommendations for the management – in its widest sense – of groups of invasives and individual species are given in the respective chapters and Fact Sheets. Preparing a national strategy against IAS is recommended to deal with IAS in an appropriate way and as anticipated by the CBD. This action plan should identify the agency responsible for assessing the risks posed by introductions, provide funding mechanisms and technical advice and support for control options. Prevention measures against further bioinvasions need to be put in place to stem the tide of incoming new species arriving accidentally with trade and travel or introduced deliberately for various purposes. New deliberate introductions must be assessed as to the threat they may present and only introduced on the basis of a risk analysis and environmental impact assessment. This report indicates some important pathways for consideration and shows that most invasive species are deliberately introduced. The use of native plants and non-invasive alien plants for gardening and other purposes should be promoted. Laws regulating trade in plant species on the Black List would be a first step in the right direction to reduce the impact of these species. However, restrictions for species already widely distributed within Switzerland will not drastically change the situation unless the populations already present are eradicated or controlled. Fish introductions are regulated by the Fisheries Act, which names those species for which an authorization for release is needed, and species for which release is prohibited altogether. This is a good basis, although the law could be better adapted to the current situation, as described in the fish section. The aquarium and terrarium trade is another important sector that could be more strictly regulated to stop releases of pets into the wild. A major problem with introductions of IAS is that the costs when they invasive are borne by the public, while the financial incentives for introducing them lie with individuals or specific businesses. Development of economic tools that shift the burden of IAS to those who benefit from international trade and travel is a neglected approach (also called the ‘polluter pays’ principle). Appropriate tools would be fees and taxes, including fees levied on those who import the organisms or goods. Awareness raising is a significant tool in the prevention and management of IAS, since some member of the public would adhere to advice if they knew about its importance and the reason for it. Scientists and decision-makers also need better access to information about invasive species, their impacts, and management options. To address the impacts of those invasive species already present in Switzerland, their populations need to be managed: either eradicated or controlled. Possible targets for eradication are the sika deer *(Cervus nippon),* the mouflon *(Ovis orientalis),* and the ruddy shelduck *(Tadorna ferruginea),* which will otherwise increase its range and spread to neighbouring countries. A pilot national eradication / control programme against a prominent invader, e.g. a Black List plant species, is recommended as a case study. Monitoring populations of some alien species is recommended to detect any sudden increases indicating potential invasiveness. By doing this, control or even eradication efforts can be employed before the populations become unmanageable. While compiling the information for this report it became clear that more information about the status of IAS in Switzerland is needed. More studies on alien species are highly recommended to assess the importance of IAS and to demonstrate their significance to policy-makers and politicians.

Limited resources dictate the need for setting priorities and allocating funds where it will have the greatest impact in combating IAS. Important points, for example, are to critically assess the feasibility of different approaches, and to target species for which there is no conflict of interest. Opposition to action against less-important ornamentals on the Black List and species of direct human health concern (giant hogweed) should be negligible.

> Zusammenfassung

Mit der zunehmenden Globilisierung ist ein starker Anstieg des Warentransportes, Verkehrs und Tourismus zu verzeichnen. Dies führt zu ungewollten wie beabsichtigten Einführungen von gebietsfremden Arten in einem noch nie dagewesenen Umfang, und der Verschmelzung von Biodiversitäten der unterschiedlichen Länder und Kontinente, so dass nur schwer zu überbrückende natürliche Ausbreitungsschranken plötzlich überwunden werden. Nicht alle gebietsfremden Arten sind automatisch als negativ zu bewerten. Tatsächlich sind viele Arten wichtige Bestandteile der Ökonomie eines Landes, man denke nur an die zahlreichen gebietsfremden Kulturpflanzen. Einige Arten entwickeln sich allerdings zu Problemarten und bedrohen die einheimische Biodiversität, richten wirtschaftlichen Schaden an oder stellen eine Gefahr für die Gesundheit dar.

Gebietsfremde Problemarten (invasive alien species) werden heute als eine Hauptbedrohung für die Biodiversität angesehen. Die Biodiversitätskonvention (CBD) verpflichtet die internationale Staatengemeinschaft Vorsorge gegen diese invasiven Arten zu treffen und diese gegebenenfalls zu bekämpfen.

Gebietsfremde Arten in Zentraleuropa werden oft als geringes Problem eingestuft, im Vergleich zu anderen Kontinenten und vor allem Inseln. Mögliche Gründe für diese Unterschiede sind die relativ kleinen Schutzgebiete, was die Möglichkeit für eine intensive Pflege eröffnet, die stark vom Menschen beeinflussten 'Naturräume' und das lange Zusammenleben von vielen gebietsfremden Arten mit dem Menschen, das zu vielfältigen Anpassungen geführt hat. Trotzdem nehmen die Fälle von dramatischen Auswirkungen von gebietsfremden Arten und das Bewusstsein in der Bevölkerung und bei den Wissenschaftlern zu. Zweifellos ist die globale Homogenisierung in vollem Gange und der einzigartige Charakter von lokalen Ökosystemen, wie zum Beispiel in der Schweiz, gehen für immer verloren, da die charakteristische Pflanzen- und Tierwelt von gebietsfremden Arten verändert wird und einige dieser Arten die grössten Anteile an der Biomasse von einigen Ökosystemen erreichen.

Die Zeitdifferenz, die zwischen der Ankunft einer Art und ihrer starken Ausbreitung auftreten kann, macht Voraussagungen der Invasivität von Arten aussserordentlich schwierig. Einige schon lange etablierte Arten können plötzlich und unerwartet invasiv werden. Drei Kategorien von Faktoren bestimmen die Invasivität von Arten: 1. die biologischen Merkmale einer Art, 2. das Zusammenspiel einer Art mit ihrer abiotischen und biotischen Umwelt und 3. die Beziehungen der Menschen zu dieser Art.

In diesem Bericht ist Information über gebietsfremde Arten der Schweiz sowohl von publizierten Dokumenten als auch von direktem Austausch mit Experten in der Schweiz und des Auslandes zusammengetragen. Bevorstehende Einwanderungen sind ebenfalls erfasst worden. Die Verfügbarkeit von Artenlisten in den einzelnen taxonomischen Gruppen ist sehr unterschiedlich, so dass es nicht möglich ist alle gebiets-

fremden Arten zu benennen. In einigen Gruppen ist das Wissen sogar der einheimische Arten so rudimentär, dass kein Versuch gemacht wurde, sie zu bearbeiten, und bei anderen Gruppen wurden nur Problemarten aufgenommen. Die Listen der gebietsfremden Arten wieder anderer Gruppen dagegen sind vollständig.

Die gebietsfremden Organismen wurden in folgende Gruppen aufgeteilt: Wirbeltiere, Krebstiere, Insekten, Spinnentiere, Weichtiere, andere Tiere, Pilze und Pflanzen. In jedem Kapitel befinden sich die Listen der gebietsfremden Arten, ein erläuternder Text, Datenblätter der Problemarten und eine Auswertung der Situation, der negativen Auswirkungen, der Einführungswege, der möglichen Gegensteuerungsmassnahmen und Empfehlungen für den Umgang mit diesen Arten. Die Datenblätter bieten Information zu Taxonomie, Beschreibung, Ökologie, Herkunft, Einführungswege, Verbreitung, Auswirkungen, Ansätze zur Gegensteuerung und ein Literaturverzeichnis.

Definitionen der wichtigsten Begriffe, wie sie in diesem Dokument benutzt werden, werden ebenfalls gegeben, da sie oftmals unterschiedlich gebraucht werden.

Die Situation der gebietsfremden Arten der Schweiz ist ähnlich wie in anderen mitteleuropäischen Ländern, vor allem Österreich, das eine ähnliche Topographie besitzt. Dieser Bericht über die gebietsfremden Arten der Schweiz listet über 800 etablierte gebietsfremde Arten auf und stellt die 107 Problemarten in Datenblättern vor: fünf Säugetiere, vier Vögel, ein Reptil, drei Amphibien, sieben Fische, vier Weichtiere, 16 Insekten, sechs Krebstiere, drei Spinnen, zwei 'Würmer', sieben Pilze, ein Bakterium und 48 Pflanzen.

Es können versehentlich eingeschleppte Arten und bewusst eingeführte Arten unterschieden werden. Eingeführt sind zum Beispiel Arten der Aquakulturen, der Fischerei, der Waldwirtschaft, der Landwirtschaft, der Jagd, zur Bodenverbesserung und einfach zur Bereicherung der Landschaft, wie Zierpflanzen. Viele der eingeführten Arten können allerdings andere Arten auf und in sich tragen und so einschleppen, und der reisende Mensch transportiert ebenfalls oftmals gebietsfremde Arten. Die meisten aquatischen und terrestrischen Wirbellosen und Krankheiten wurden versehentlich eingeschleppt, während Pflanzen und Wirbeltiere meist eingeführt worden sind. Dieser globale Trend findet sich auch bei den gebietsfremden Arten der Schweiz wieder, denn 75% der 20 Arten auf der 'Schwarzen Liste' wurden als Zierpflanzen eingeführt und 35 der 37 Wirbeltiere wurde zu einem bestimmten Zweck importiert. Das heisst, dass viele der Problemarten bewusst eingeführt wurden, oftmals mit einer geringfügigen Rechtfertigung, z.B. um die Landschaft mit Zierpflanzen und Wasservögeln zu 'bereichern'.

Die Auswirkungen, die gebietsfremde Arten auslösen können, sind oft beträchtlich, vor allem wenn die Funktion eines Ökosystems gestört wird, einheimische Arten verdrängt werden oder sogar aussterben, wie es bei Vogelarten auf Inseln dokumentiert worden ist. Vier Faktoren können zu solchen Problemen führen: 1. Konkurrenz zu einheimischen Arten, 2. ein gebietsfremder Räuber, 3. die Hybridisierung mit einheimischen Arten und 4. die Ausbreitung von Krankheiten durch einen gebietsfremden Vektor. Offensichtliche Beispiele für Konkurrenz sind der Kampf um Licht und Nährstoffe zwischen gebietsfremden und einheimischen Pflanzenarten. Der Konkurrenzkampf um Nahrung hat in Grossbrittanien zur fast völligen Verdrängung des Eichhörnchens *(Sciurus vulgaris)* durch das eingeführte Grauhörnchen *(S. carolinensis)* geführt und es ist zu befürchten, dass dieser Trend auch auf dem Festland weitergehen wird. Der Bisam *(Ondatra zibethicus)* hat als Räuber der einheimischen Muscheln *(Unionidae)* zu ihrem Rückgang beigetragen und der Amphipode *Dikerogammarus villosus* ist ein grosser Feind der einheimischen Wirbellosen der Gewässer. Ein bekanntes Beispiel für eine Hybridisierung ist die eingeführte Schwarzkopf-Ruderente *(Oxyura jamaicensis)*, die sich mit der stark gefährdeten Weisskopf-Ruderente *(O. leucocephala)* verpaart. In einigen Fällen können gebietsfremde Arten Krankheiten unter einheimischen Arten verbreiten. Dies ist der Fall bei der berüchtigten Krebspest *(Aphanomyces astaci)*, die von ebenfalls eingeführten nordamerikanischen Flusskrebsen, die fast keine Symptome zeigen, auf den einheimischen Flusskrebs *(Astacus astacus)*, der dramatisch mit einem sofortigen Zusammenbruch der Population reagiert, übertragen werden.

Neben diesen Auswirkungen auf die Umwelt, können gebietsfremde Arten auch enorme ökonomische Schäden verursachen. Die Kosten können durch den Verlust von land- und forstwirtschaftlichen Produkten und durch erhöhte Produktionskosten durch Bekämpfungsmassnahmen entstehen. Eine nordamerikanische Studie hat die jährlichen Kosten von gebietsfremden Arten in der USA auf 13,8 Milliarden US Dollar berechnet. Ein anderer Bericht schätzt die Kosten durch Unkräuter für die australische Landwirtschaft auf 4 Milliarden Australische Dollar, und 20 Millionen Aus. $ wurden während eines Jahres zwischen Mitte 2001 und Mitte 2002 für die Unkrautbekämpfung auf naturnahen Flächen ausgegeben. Die Kosten durch den Riesenbärenklau *(Heracleum mantegazzianum)* in Deutschland werden auf 10 Millionen € geschätzt, wobei je eine Millionen im Umweltbereich und Gesundheitswesen anfallen und der Rest in Landwirtschaft und Forst. Der Westliche Maiswurzelbohrer *(Diabrotica virgifera)* dehnt seine Verbreitung weiter nach Nordwesten aus und bereitet grosse Schäden an den Maiskulturen. Einige gebietsfremde Arten schaden der menschlichen Gesundheit, so produziert der Riesenbärenklau grosse Mengen eines Saftes der phototoxische Substanzen (Furanocumarine), die zu starken Verbrennungen der Haut führen können, enthält. Der Marderhund *(Nyctereutes procyonoides)*, als Pelztier eingeführt, kann, wie der einheimische Rotfuchs *(Vulpes vulpes)*, als Vektor des Fuchsbandwurmes *(Echinococcus multilocularis)*, der gefährlichsten Krankheit, die in Zentraleuropa von Säugetieren auf den Menschen übertragen wird, fungieren. Für diesem Bericht wurden bekannte Auswirkungen von gebietsfremden Arten in der Schweiz zusammengetragen. Für Arten, die noch nicht lange in der Schweiz vorkommen, wurde auf Berichten von Auswirkungen in anderen Ländern zurückgegriffen. Es muss erwähnt werden, dass Nachweise von Auswirkungen einer gebietsfremden Art in einem komplexen Ökosystem oft schwierig zu führen sind. Andererseits ist es offensichtlich, dass Arten wie der Japanische Staudenknöterich *(Reynoutria japonica)*, der oft ganze Flussufer säumt, oder eine tierische Biomasse von gebietsfremden Arten von 95% im Rhein bei Basel, eine Auswirkung auf das Ökosystem haben müssen. Alle Arten verbrauchen Nährstoffe und dienen als Nährstoff für andere Organismen und ändern so das Nahrungsnetz und den Nährstofffluss der Ökosysteme, die sie besiedeln.

In den Texten der jeweiligen Kapitel und den Datenblättern sind Empfehlungen zur Gegensteuerung (Prävention und Kontrolle) für die Gruppen und einzelnen Arten gegeben. Allgemein ist die Erstellung einer Nationalen Strategie im Hinblick auf gebietsfremde Arten zu empfehlen, um angemessene Schritte ergreifen zu können, und es von der Biodiversitätskonvention gefordert ist. Dieser Plan sollte eine zuständige Behörde identifizieren, die die Risiken von Einführungen und Einschleppungen beurteilt, für finanzielle Mittel sorgt und technische Unterstützung zur Bekämpfung bereitstellt. Massnahmen zur Prävention um weitere Bioinvasionen zu stoppen oder zu vermindern müssen ausgearbeitet werden. Einführungen von neuen Organismen sollten vorher auf ihre möglichen Gefahren für die Umwelt untersucht werden und nur auf der Basis einer Risikoanalyse eingeführt werden. Die Analyse der wichtigsten Einführungswege zeigt unmissverständlich, dass die meisten Problemarten bewusst eingeführt wurden (und werden). Die Nutzung von einheimischen Arten und fremden Arten ohne Potential zur Invasivität zum Beispiel in Gärten, Parks und Forsten sollte mehr gefördert werden. Gesetze, die den Handel mit Pflanzenarten der ‘Schwarzen Liste’ regeln, wären ein konsequenter nächster Schritt, um die Auswirkungen dieser Arten zu reduzieren. Wenn die Arten allerdings schon eine weite Verbreitung in der Schweiz besitzen, können nur Kontrollmassnahmen oder eine erfolgreiche Ausrottung Abhilfe schaffen. Die Fischereiverordnung reguliert Fischaussetzungen, indem sie Arten benennt für die eine Bewilligung nötig ist und Arten, deren Aussetzung verboten ist. Diese solide Basis könnte noch verbessert werden, um der Situation besser zu entsprechen, wie in dem Teil über Fische beschrieben. Ein weiterer Sektor, der mehr reguliert werden sollte, ist der Handel mit Haustieren (vor allem Aquarium and Terrarium), der immer wieder zu Aussetzungen führt. Ein Grundproblem der Einführungen ist, dass die Kosten von Problemarten von der Öffentlichkeit getragen werden, während der finanzielle Nutzen der Einführung einzelnen Importeuren oder bestimmten Wirtschaftszweigen zugute kommt. Die Entwicklung von ökonomischen Programmen, die die Last auf die verteilt, die auch den Nutzen aus der Einfuhr haben, ist ein vernachlässigter Denkansatz (Verursacherprinzip genannt). Möglichkeiten wären gegeben durch die Erhebung von Gebühren und Steuern, die für den Importeur zu bezahahlen wären. Eine wichtige Vorgehensweise, um die Probleme mit gebietsfremden Arten unter Kontrolle zu kriegen, ist die Schaffung eines geschärftes Bewusstseins der Problematik in der Bevölkerung. Wissenschaftler und Entscheidungsträger benötigen ebenfalls mehr Information über gebietsfremde Problemarten, deren Auswirkungen und den Möglichkeiten für eine Gegensteuerung. Einige Problemarten müssten bekämpft oder ausgerottet werde, um ihre Auswirkungen wirkungsvoll zu minimieren. Mögliche Zielarten für eine Ausrottung sind der Sikahirsch *(Cervus nippon),* das Mufflon (*Ovis orientalis*) oder die Rostgans *(Tadorna ferruginea),* die sonst ihre Verbreitung weiter ausdehnt und die Nachbarländer erreichen wird. Für eine erste grossangelegte Ausrottung oder Bekämpfung ist ebenfalls eine Pflanzenart der ‘Schwarzen Liste’ zu empfehlen. Ausserdem wäre die Beobachtung der Populationen von gebietsfremden Arten empfehlenswert, um etwaige starke Zunahmen früh zu erkennen. In diesem Fall könnten Gegenmassnahmen ergriffen werden, bevor die Populationen zu gross werden. Beim Zusammentragen der Informationen wurde schnell klar, dass viel mehr Information über gebietsfremde Arten benotigt wird. Daher sind mehr Studien zur Bedeutung von gebietsfremden Arten nötig, um Entscheidungsträger und Politiker auf die Lage aufmerksam zu machen.

Die limitierten Ressourcen, die zur Verfügung stehen, zwingen Prioritäten zu setzen, um die finanziellen Mittel dort einzusetzen, wo sie die meiste Wirkung zeigen im Kampf gegen Problemarten. Dabei müssen wichtige Punkte berücksichtigt werden, etwa, welche Methode den grössten Nutzen bringt, oder welche Arten für Bekämpfungsmassnahmen zuerst in Betracht gezogen werden sollten. Arten mit einem hohen Potenzial für Konflikte versprechen weniger Erfolg. Wenn Arten der 'Schwarzen Liste', welche keine grosse Wichtigkeit als Zierpflanzen besitzen, oder Arten die den Menschen gefährden, als Ziele ausgewählt werden, ist der zu erwartende Widerstand gegen Massnahmen eher gering einzuschätzen.

> Résumé

La globalisation a pour effet une augmentation sans précédant du commerce et des transports, dont une des conséquences est l'accroissement des déplacements et introductions d'espèces exotiques. Les espèces exotiques ne sont pas toutes nuisibles. En fait un grande nombre d'entre elles sont bénéfiques, comme par exemple les nombreuses plantes cultivées d'origine étrangère. Cependant, certaines espèces exotiques deviennent nuisibles et posent des problèmes à l'environnement et à l'homme en général. Les Espèces Exotiques Envahissantes (EEE) sont de plus en plus reconnues comme une des menaces les plus sérieuses posées à la biodiversité.

Tous les pays signataires de la convention sur la diversité biologique (CDB), dont la Suisse, se sont engagés à prévenir l'introduction, à contrôler ou éradiquer les espèces exotiques menaçant les écosystèmes, les habitats ou les espèces.

Il est communément avancé que les EEE causent moins de problèmes en Europe Centrale que dans d'autres continents ou régions. Les raisons possibles sont, entre autres, la taille limitée des réserves naturelles, l'impact humain important dans tous les milieux « naturels » et la longue association, en Europe, entre les espèces exotiques et l'homme, ayant conduit à une familiarisation de ces espèces et une adaptation à l'environnement humain. Cependant, le nombre de cas d'espèces exotiques causant des dégâts importants est en augmentation en Europe, un phénomène dont les chercheurs, mais également le public, ont de plus en plus conscience. De fait, la menace des espèces envahissantes ne doit pas être sous-estimée. Une des conséquences les plus visibles est le phénomène d'uniformisation, menant à la perte de paysages uniques, y compris en Suisse. La flore et la faune caractéristiques sont de plus en plus envahies par les organismes exotiques qui se reproduisent, pour finalement composer la plus grande partie de la biomasse de certains écosystèmes.

Le délai qui s'écoule entre la phase d'établissement et d'invasion d'une espèce exotique ('time lag'), rend la prédiction du phénomène d'invasion très difficile. Des espèces bien établies qui n'ont actuellement aucun impact reconnu sur l'environnement peuvent malgré tout devenir envahissantes dans le futur. Trois catégories de facteurs déterminent la capacité d'une espèce à devenir envahissante: les facteurs intrinsèques liés à l'espèce, les facteurs extrinsèques, c.-à-d. les relations entre l'espèce et les facteurs biotiques ou abiotiques, et la dimension humaine, par exemple l'importance de l'espèce pour l'homme.

Ce rapport est une compilation des connaissances sur les espèces exotiques en Suisse, rassemblées à partir de publications et d'avis d'experts suisses et étrangers. Des informations sur les invasions biologiques imminentes sont également inclues. La connaissance des espèces présentes en Suisse variant fortement d'un groupe taxonomique à l'autre (pour certains taxa, même les espèces indigènes sont loin d'être toutes connues), il n'a malheureusement pas été possible d'établir une liste exhaustive d'espèces exoti-

ques pour tous les groupes. Une liste complète a été établie seulement pour les groupes taxonomiques bien connus. Pour certains groupes, seules les espèces envahissantes ont été compilées alors que quelques groupes n'ont pas pu être traités.

Les grands groupes taxonomiques traités sont les vertébrés, les crustacés, les insectes, les arachnides, les mollusques, les autres animaux, les champignons et les plantes. Pour chaque groupe, nous présentons une discussion générale, la liste des espèces non-indigènes, les fiches d'information sur les espèces envahissantes et une évaluation du statut, de l'impact, des modes d'introduction, les méthodes de lutte et des recommandations générales. Les fiches d'information résument, pour des espèces particulièrement envahissantes ou potentiellement dangereuses, les informations sur la taxonomie, la description, l'écologie, l'origine, l'introduction en Suisse et en Europe, la distribution, l'impact, la gestion et les références bibliographiques.

Les définitions des termes anglais les plus importants utilisés dans ce rapport sont données, parce que les mots fréquemment utilisés comme « invasive » sont parfois utilisés dans des sens différents.

La situation concernant les EEE en Suisse est similaire à celle d'autres pays d'Europe Centrale, en particulier l'Autriche, un pays également enclavé et Alpin. Ce rapport inventorie environ 800 espèces non-indigènes et détaille 107 espèces envahissantes sous forme de fiches d'information : cinq mammifères, quatre oiseaux, un reptile, trois amphibiens, sept poissons, quatre mollusques, 16 insectes, six crustacés, trois araignées, deux « vers », sept champignons, une bactérie et 48 plantes.

Les modes d'introduction des espèces exotiques sont différents selon qu'il s'agit d'espèces délibérément introduites ou d'espèces introduites accidentellement. Les introductions délibérées concernent principalement les espèces importées pour l'aquaculture, la pêche, la chasse, la sylviculture, l'agriculture, l'horticulture et la protection des sols. Les organismes introduits involontairement sont souvent transportés par inadvertance avec d'autres importations ou par des voyageurs. En général, la plupart des invertébrés et des pathogènes ont été introduits accidentellement, alors que les plantes et les vertébrés l'ont souvent été intentionnellement. Cette tendance est également valable pour la Suisse. Sur les 20 plantes envahissantes de la liste noire, 75% ont été introduites principalement en tant que plantes ornementales et 35 des 37 vertébrés exotiques établis en Suisse ont été introduits délibérément. Il est donc important de constater que beaucoup d'envahisseurs, dont certains parmi les plus nuisibles, ont été introduits intentionnellement, souvent sans autre soucis que d'améliorer le paysage, comme c'est le cas pour les plantes et animaux d'ornement.

L'impact des EEE est parfois considérable, en particulier quand l'envahisseur altère le fonctionnement d'un écosystème ou pousse les espèces indigènes vers l'extinction, comme cela a été souvent observé avec les oiseaux en milieu insulaire. Les impacts écologiques peuvent être causés par quatre mécanismes majeurs : la compétition, la prédation, l'hybridation et la transmission de maladies. Parmi les exemples les plus significatifs de compétition, nous pouvons citer la compétition entre les plantes indigènes et exotiques pour les nutriments et la lumière. La compétition pour les ressources a également conduit au remplacement de l'écureuil roux indigène *(Sciurus vulgaris)* par l'écureuil gris américain *(S. carolinensis)* dans la plus grande partie de la Grande-Bretagne, et on s'attend à un même phénomène sur le continent. Le rat musqué *(Ondatra zibethicus)* est responsable du déclin des populations de moules indigènes par prédation, et l'amphipode *Dikerogammarus villosus* est un sérieux prédateur des invertébrés aquatiques indigènes. Un exemple bien connu d'hybridation en Europe est illustré par l'érismature rousse *(Oxyura jamaicensis),* un canard américain qui s'hybride avec l'érismature à tête blanche *(O. leucocephala),* une espèce européenne en danger d'extinction. Dans certains cas, les EEE peuvent abriter des maladies et agir comme vecteur d'infection pour les espèces indigènes. C'est le cas des espèces américaines d'écrevisse introduites en Europe, porteuses résistantes de la peste de l'écrevisse *(Aphanomyces astaci),* alors que l'écrevisse européenne *(Astacus astacus)* est très sensible à la maladie et a du mal à survivre au côté des espèces américaines introduites.

En plus des impacts sur la biodiversité, les EEE ont des impacts considérables pour l'économie. Ces impacts économiques peuvent être liés aux pertes directes de produits agricoles ou forestiers ou à l'augmentation des coûts de production associés à la lutte contre les envahisseurs. Une étude américaine a calculé que les EEE coûtait aux Etats-Unis la somme de 138 milliards de dollars par an. De même, un récent rapport australien estime que les mauvaises herbes coûtent à l'agriculture australienne environ 4 milliards de dollars australiens par an et que le coût de la lutte contre les plantes envahissantes dans les milieux naturels atteint 20 millions de dollars par an. En Europe, le coût de la berce du Caucase *(Heracleum mantegazzianum)* est estimé à € 10 millions en Allemagne, un million chacun pour les secteurs de l'environnement et de la santé publique, le reste représentant le coût pour les secteurs agricoles et forestiers. L'impact économique de la chrysomèle des racines du maïs *(Diabrotica virgifera)* augmente en même temps que sa dissémination en Europe. Certaines EEE ont un impact sur la santé publique. Par exemple, la berce du Caucase contient des substances phototoxiques (furanocoumarines) qui peuvent causer des brûlures sérieuses. Le chien viverrin *(Nyctereutes procyonoides),* introduit pour sa fourrure, peut, comme le renard indigène *(Vulpes vulpes),* être vecteur le l'échinococcose du renard *(Echinococcus multilocularis),* une dangereuse maladie parasitaire pouvant être transmise à l'homme. Les impacts connus des espèces introduites en Suisse sont présentés dans ce rapport. Comme plusieurs envahisseurs récents n'ont pas encore montré d'impacts écologiques en Suisse, les impacts observés dans d'autres pays sont également présentés. Mesurer les impacts écologiques des EEE est souvent une tâche difficile à cause de la complexité des écosystèmes. Cependant, les espèces exotiques présentes en très grand nombre, comme la renouée du Japon qui couvre totalement les bords de certaines rivières, ou une faune aquatique exotique composant 95% de la biomasse animale dans le Rhin près de Bâle ont forcément un impact important sur les écosystèmes indigènes. Toutes les espèces utilisent des ressources et sont elle-mêmes ressources d'autres organismes vivants et, de ce fait, les espèces exotiques altèrent les chaînes alimentaires des écosystèmes dans lesquelles elles ont été introduites.

Des recommandations pour la gestion (au sens le plus large) des espèces envahissantes sont données dans les chapitres respectifs et les fiches d'information. Une stratégie nationale appropriée contre les EEE est recommandée afin de gérer le problème de la manière la plus appropriée, selon les exigences de la CDB. Le plan d'action devrait identifier l'agence responsable pour l'évaluation des risques posés par les introductions et proposer les mécanismes de financement ainsi que le support technique pour les moyens de lutte. Des mesures de prévention contre les invasions biologiques futures doivent être mises en place pour contenir l'implantation de nouvelles espèces, qu'elles soient accidentellement introduites avec le commerce ou les voyages ou importées de façon intentionnelle pour des raisons diverses. Les nouvelles introductions délibérées doivent être évaluées pour le danger qu'elles représentent et les espèces introduites uniquement après une analyse de risques et une étude d'impact écologique. Ce rapport mentionne les modes d'introduction les plus importants et montre qu'un grand nombre d'EEE ont été délibérément introduites. L'utilisation pour le jardinage de plantes indigènes et de plantes exotiques non-envahissantes devrait être promue. Une législation réglementant le commerce des plantes de la liste noire serait un premier pas dans la bonne direction pour réduire l'impact de ces espèces. Cependant, des restrictions d'utilisation pour les espèces déjà largement présentes en Suisse ne changeront pas grand-chose à la situation, à moins d'éradiquer ou de contrôler les populations déjà présentes. Les importations et implantations de poissons exotiques sont régulées par la loi fédérale sur la pêche, qui cite les espèces pour lesquelles une autorisation d'introduction est nécessaire, et celles dont l'introduction est prohibée. C'est une bonne base, bien que la loi pourrait être mieux adaptée à la situation actuelle, comme suggéré dans le chapitre relatif aux poissons. Le commerce des animaux d'aquarium et terrarium est un autre secteur important qui devrait être mieux régulé pour limiter les lâchers d'animaux de compagnie dans la nature. Un problème majeur lié aux EEE est que le coût de ces invasions est payé par le public alors que ces introductions sont motivées par des intérêts financiers privés. Le développement d'outils économiques transférant le coût des EEE aux bénéficiaires des échanges commerciaux impliquant ces organismes exotiques est une approche pour l'instant négligée (principe du pollueur-payeur). Par exemple, des contributions ou taxes pourraient être imposés aux importateurs d'organismes vivants ou de marchandises. La sensibilisation du public est également un outil important dans la prévention et la gestion des EEE. Une partie du public adhèrerait sans aucun doute aux recommandations s'il était au courant de leur importance et de leur raison d'être.

Les chercheurs et décisionnaires ont également besoin d'un meilleur accès à l'information concernant les espèces envahissantes, leur impact et les moyens de lutte. Pour limiter l'impact des espèces envahissantes déjà présentes en Suisse, leurs populations doivent être gérées, c.-à-d. éradiquées ou contrôlées. Parmi les espèces pouvant être éradiquées, on peut citer le cerf sika *(Cervus nippon)*, le mouflon *(Ovis orientalis)* et la tadorne casarca *(Tadorna ferruginea)* qui, dans le cas contraire, risquent d'élargir leur distribution et d'envahir des pays voisins. Un programme national pilote d'éradication ou de lutte, par exemple contre une plante de la liste noire, est recommandé comme étude de cas. Il est également recommandé de surveiller les populations de certaines espèces exotiques pour détecter les hausses soudaines de population pouvant indiquer un caractère envahissant. En faisant cela, des programmes de contrôle, ou même d'éradication, pourraient être décidés avant que les populations ne deviennent totalement ingérables. En accumulant l'information nécessaire à la rédaction de ce rapport, il est apparu clairement que trop peu d'information était disponible sur les EEE en

Suisse. Il est fortement recommandé d'étudier plus en détails ces espèces, en particulier leur impact, afin de démontrer leur importance aux décisionnaires et politiques.

Les ressources financières étant limitées, il est nécessaire de dicter des priorités dans la lutte contre les EEE et d'allouer ces ressources là où elles auront l'impact le plus important. Il est nécessaire d'évaluer de manière critique la faisabilité de différentes méthodes de lutte, et de cibler en priorité les espèces pour lesquelles il n'y a pas de conflit d'intérêt. Par exemple, parmi les plantes de la liste noire, une action contre la berce du Caucase, une plante de faible intérêt ornemental et posant de sérieux problèmes de santé publique, ne devrait pas susciter d'opposition.

1 > Introduction

The values of societies and the views on issues such as alien species change over time, and today the seriousness of alien species with their detrimental impacts on biodiversity, economics and human health is widely accepted and management options for invasive alien species (IAS) are sought. In the past people did not have the knowledge we have today and took many familiar species with them to new areas they were settling. Acclimatization societies were established with the goal of introducing European species to the new colonies and the newly discovered species of exotic lands into Europe. Thus, people cheered the arrival of the English sparrow in North America. The poet William Cullen Bryant wrote in 'The Old World Sparrow':

"A winged settler has taken his place
With Teutons and men of the Celtic race.
He has followed their path to our hemisphere;
The Old World Sparrow at last is here."

This report compiles published information about alien species and other information from experts in Switzerland and abroad on the alien flora and fauna of Switzerland. Species occurring in Europe but not (yet) in Switzerland but known to have invasive characteristics are also included in this publication. The fact that they are invasive and occur in neighbouring countries puts them on a Watch List for which monitoring and/or prevention measures would be advisable.

Names of scientists who wrote chapters are given at the beginning of each one, but the many other people whose help was vital in preparing this report are acknowledged at the end of this chapter.

Availability of lists varies tremendously between taxonomic groups, thus, unfortunately, it is not possible to list all the alien species of Switzerland. However, for groups that are well known, complete lists could be assembled. For some other groups only invasive species are given, and some groups are not covered at all. For these latter groups, lists of native species are not even available and the introduced or native status of many species discovered in Switzerland cannot be demonstrated with certainty. These species are called cryptogenic. It has to be emphasized that a report on the alien species of a region can only give a snapshot of the current situation, since more species will invade and be introduced as time goes by. As long as knowledge about the diversity and distribution of native taxa is incomplete, only invasions of taxonomically uncommon or high-impact species will be detected. Invasions of cryptic taxa often go unnoticed (Müller and Griebeler, 2002). In conclusion, a consistent approach between taxonomic groups is not possible due to gaps in knowledge. The groups are discussed in this report on the basis of the available knowledge, which reflects difficulties in monitoring and taxonomy and also the importance of the different groups.

The taxonomic groups chosen, i.e. vertebrates, insects, crustaceans, arachnids, molluscs, other animals, plants and fungi, are the basis of separate chapters presenting lists of alien species and additional information about them, Fact Sheets for the invasive species, and finally an evaluation of the status, impacts, pathways, control options and recommendations for the alien species of each group. The Fact Sheets summarize information on the invasive species under the headings taxonomy, description, ecology, origin, introduction, distribution, impact, management and references. A special focus is given to information on impacts of the species on the environment and economy to indicate their detrimental nature and the importance of managing them. This information is often difficult to find but crucial to show the true potential threat to Switzerland without being hysterical about it.

All signatories to the Convention on Biological Diversity (CBD), including Switzerland, are obliged to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species. There are other international instruments, ratified by Switzerland, calling for management of invasive species, e.g. the Convention on the Conservation of Migratory Species of Wild Animals and the Convention on the Conservation of European Wildlife and Natural Habitats. This report can also be used in response to the call from the CBD Secretariat for countries to produce lists of alien species and can provide information for a national strategy on IAS.

The importance of IAS is increasingly recognized in Central Europe, indicated by the recently published book *Neobiota in Österreich* (Essl and Rabitsch, 2002) and the very recently produced *Gebietsfremde Arten; Positionspapier des Bundesamtes für Naturschutz* in Germany (Klingenstein et al., 2005).

The following sections of this chapter explain the definitions used in the report, then present a predominantly global perspective of the IAS issue, with examples from Switzerland. Evaluations of pathways, origins of the species, number of alien species in comparison to native species, their impacts, management options and other trends are given in the chapters on the taxonomic groups. An overall evaluation of these factors was attempted, but it became obvious that that was not a constructive exercise, since the clear trends in some taxonomic groups were diluted and combining groups with very different knowledge bases made it difficult to compare the results. However, within the groups, trends are often very obvious and for these readers are referred to the chapters on the taxonomic groups.

1.1 Definitions

Definitions used in relation to IAS are as varied as the species themselves. The term ‘invasive’, for instance, is used in one extreme, to describe a population that is expanding (invading somewhere) to another, for species which have a negative impact on native species, ecosystems and habitats. A set of widely used definitions is provided by the Convention on Biological Diversity, available on their websites (see Article 2, Use of Terms at: *http://www.biodiv.org/convention/articles.asp?lg=0&a+cbd–02* and Annex 2 of the item 8 at: *http://www.biodiv.org/doc/meeting.aspx?mtg=sbstta–06&tab=1)*.

As long as the terms are not harmonized, it is crucial to give the definitions used in a document. Thus, short definitions used in this report are presented below. In some chapters, separate definitions were used for reasons of clarity, and these are given at the beginning of the relevant chapters.

> **Introduction:** the movement, by direct or indirect human agency, of a species or lower taxon into a new area. Indirect agency is, for instance, the building of a canal, while direct movement includes deliberate and accidental introductions. This can be either within Switzerland or from another country into Switzerland, breaching formerly insurmountable barriers for the species. The most obvious natural barriers for a species in Switzerland are the Alps between the Ticino and the rest of the country, but also the different watersheds, towards the North Sea, the Black Sea and the Mediterranean Sea.
> **Deliberate introduction:** the purposeful movement by humans of a species into a new area. This includes also species introduced into confinement, e.g. aquariums and zoos. Thus, the introduction is defined here as the initial movement into a new area. They can subsequently escape or be released into the environment.
> **Accidental introduction:** a species utilizing humans or human delivery systems as vectors. This also includes contaminants and diseases of deliberately introduced species.
> **Native species:** a species living within its natural range.
> **Alien species:** a species introduced outside its natural distribution.
> **Invasive alien species (IAS):** an alien species which threatens ecosystems, habitats and species. These are addressed under Article 8(h) of the CBD.

Some species are difficult to handle under these definitions because of a lack of information, e.g. it is often not possible to determine whether a European species arrived with human help or on its own wings or legs. Thus, these definitions should not be treated as cast in stone but are flexibly used for the purpose of this report.

1.2 Invasive alien species – a global overview

This report can only give a glimpse of the complex issue of IAS, to set the stage for an assessment of their importance. A good place to start browsing through the IAS literature is in books published on the topic, e.g. the classic Elton (1958), Drake et al. (1989), Di Castri et al. (1990), Williamson (1996), Mooney and Hobbs (2000), Shine et al. (2000), Low (2001), McNeely (2001), Wittenberg and Cock (2001), Baskin (2002), Kowarik and Starfinger (2002), Leppäkoski et al. (2002), Pimentel (2002), Kowarik (2003), Mooney et al. (2005) and others.

Changes in distribution of species are a natural phenomenon; ranges expand and retract and species colonize new areas outside their natural range by long-distance dispersal, for example reptiles on floating wood to new islands. However, these events are rare and mostly restricted by natural barriers. The relatively recent globalization of trade and travel has inadvertently led to the increased transport of organisms and introduction of alien species, tearing down these natural barriers. Alien species are not bad per se, in fact many species are used for human consumption, e.g. most crop species are aliens in the majority of regions where they are grown. However, some of them may subsequently become harmful and pose threats to the environment and human populations. IAS are increasingly recognized as one of the major threats to biodiversity. These negative effects are best documented in bird extinctions on islands where the majority since 1800 have been caused by IAS (BirdLife International, 2000). This global problem needs global and local responses, or, even better, proactive measures, and solutions.

The complexity of the IAS topic stems from the very different species involved, their diverse origins, the variety of pathways used, their varied impacts on new environments, their relationships with indigenous and other alien species, the ecosystem changes caused, their dependence on other factors such as global warming, their human dimensions including changes in political and ethical views, and their on-going evolution.

Invasive alien species are found in virtually every taxonomic group. The following examples will attest this statement.

The West Nile virus causing encephalitis hitched a ride to the New World in an infected bird, mosquito or human (Enserink, 1999).

The bacterium *Vibrio cholerae* (Pacini), the causal organism of the human disease cholera, is a member of brackish water communities and is frequently found in ballast water of ships (McCarthy and Khambaty, 1994), by which means some new highly virulent strains have been redistributed leading to epidemic outbreaks of cholera. Another bacterium, *Erwinia amylovora* (see Fact Sheet in chapter 9) is a serious threat to the fruit industry in Switzerland.

Some fungal pathogens are amongst the IAS with the most disruptive impacts on ecosystems. Some well-known examples include fungi attacking trees, e.g. chestnut blight (*Cryphonectria parasitica* (Murrill) Barr) was introduced with alien chestnut trees to North America, where it virtually eradicated the American chestnut *(Castanea dentata* (Marsh.) Borkh.), which was a dominant tree in eastern forests, thereby changing the entire ecosystem and composition of the forests (Hendrickson, 2002) and is now, albeit with less severity, attacking trees in Switzerland.

Weeds are another predominant group of IAS known to cause economic problems as well as deleterious effects on the environment. The giant reed *(Arundo donax* L.) is used in many countries, for example as windbreaks, and is readily invading natural areas; the small herb common ragweed *(Ambrosia artemisiifolia* L.) is swiftly expanding its exotic range in Europe causing severe allergic problems for the human population.

Many different kinds of worms found their way to new areas with human assistance, especially parasitic worms from the Plathelminthes and Nemathelminthes, for example the nematode *Anguillicola crassus*, which attacks the native eel *(Anguilla anguilla* L.).

A spectacular disaster caused by an introduced snail was the introduction of the carnivorous rosy wolfsnail *(Euglandina rosea* (Férussac)) to many subtropical and tropical islands destroying the diverse endemic snail faunas. Another example of an introduced mollusc in Europe is perhaps the most aggressive freshwater invader worldwide, the zebra mussel *(Dreissena polymorpha* (Pallas)), inflicting not only huge economic costs but also severe biotic changes as it functions as an ecosystem engineer species (Karateyev *et al*., 2002).

Small introduced crustaceans dominate the fauna of many rivers and lakes worldwide due to the increased ship traffic that transports organisms in ballast water to new areas, and also to the creation of canals connecting formerly insurmountable natural barriers between watersheds. Thus, alien species (mainly crustaceans and molluscs) dominate the Rhine in total abundance and produce a biomass of more than 80% (Haas *et al*., 2002).

Interestingly, introduced insects, despite their diversity, have not shown a high potential for causing environmental problems, although they can be devastating pests in agriculture and forestry. However, several ant species destroy native faunas, especially on islands – but also, e.g. the Argentine ant *(Linepithema humile* (Mayr)), in southern Europe.

The infamous cane toad *(Bufo marinus* (L.)) is spreading quickly through Australia feeding on everything smaller than itself and poisoning the bigger predators, such as quolls *(Dasyurus* spp. E. Geoffroy St.-Hilaire).

One of the most devastating introduced reptiles is the brown tree snake (*Boiga irregularis* (Merrem)) on Pacific islands; it arrived on Guam on military equipment and brought a silent spring to the island by feasting on the bird species. Moreover, it causes frequent power cuts and is a danger to babies because of its venom.

The Nile perch *(Lates niloticus* (L.)), introduced into Lake Victoria to improve fisheries, caused the extinction of more than 100 fish species of the cichlid family; most of them endemic to the lake – before the predator came it was called an evolutionary laboratory, afterwards an ecological disaster.

The American ruddy duck *(Oxyura jamaicensis* (Gmelin)) was introduced to England as an addition to the wildfowl fauna, where it ostensibly does no harm, but then it spread to Spain where it has swiftly endangered the native close relative, the white-headed duck *(O. leucocephala* (Scopoli)) by hybridization.

Feral mammals introduced to islands brought many bird species to the brink of extinction or beyond by feeding on their eggs and chicks (e.g. Long, 2003).

However, some taxonomic groups seem to include more invasive species than others do. Mammals are a major threat to island faunas and floras. Whereas rats, mongooses, mustelids and feral cats devastate the local bird and reptile fauna of islands, feral goats *(Capra hircus* L.) can diminish the native flora drastically. Weeds alter the vegetation on many archipelagos to the detriment of the entire ecosystem. Island ecosystems, including isolated lakes, are particularly vulnerable to these invaders. However, all continents and habitats seem to be vulnerable to invasions, although there appear to be some differences between continents. In the highly populated area of Central Europe, IAS seem to be of less importance to biodiversity than on other continents with large tracts of more natural habitats. The smaller reserves in Central Europe are easier to manage and control of alien species in these areas is often more practical. The long association between introduced species and the human population in Europe is a very different situation compared to other continents, as all habitats are highly altered and human-made habitats dominate. These human-made habitats are often regarded as valuable heritage in Central Europe and some of them are dominated by alien species introduced centuries ago.

Comparing the numbers of species introduced to species that have established and species that have become invasive, one has to bear in mind the long lag phases which often occur. Most introduced species take some time before they become invasive, i.e. enter the log phase. Kowarik (2003) shows that for woody alien plants in one part of Germany, the average time lag between first introduction and expansion is about 147 years. The occurrence of time lags makes predictions on invasiveness of alien species very difficult. A species doing no harm today can still become an invasive of tomorrow, especially in combination with other global changes. There are three major factors that determine the ability of a species to become invasive:

1. Intrinsic factors or species traits, such as the ability to adapt to different conditions, a wide tolerance of abiotic factors, pre-adaptations to different climatic zones, and a high reproductive rate.
2. Extrinsic factors or relationships between the species and abiotic and biotic factors, such as the number of natural enemies, the number of competing species (native and alien), other interactions with native and alien species (pollination, dispersal, food source, ecosystem engineers), climatic conditions, soil conditions, degree of disturbance (natural and human-induced), global climate change, change in land-use patterns, and control and eradication of other IAS.
3. Human dimension. The attractiveness and importance of species to humans influence introduction pathways, vectors, the number of specimens introduced, the number of introductions, and the potential for eradication or control.

Predictions about the invasive potential of a species prior to introduction, as now made in Australia and New Zealand, remain difficult, despite recent progress in science. The best indicator is still whether a species has become invasive in a similar area elsewhere (i.e. its invasion history).

1.3 Status of alien species in Switzerland

As pointed out above, the accelerating pace of movement of people and goods is increasing the number of introductions of already established species and new arrivals. Therefore lists of alien species cannot be comprehensive, but give only a snapshot of the current knowledge. Moreover, the lack of both knowledge and taxonomists for some groups precludes lists for such groups being presented.

The situation regarding IAS in Switzerland is similar to that in other Central European countries, in particular Austria, which is also a land-locked country containing part of the Alps. Some of the taxonomic sections present numbers of alien species recorded in other countries for comparison. A comparison between countries for all taxa cannot be given here, since the definitions and criteria used differ considerably between country reports and make it impossible to use the figures for comparison with neighbouring countries. The different levels of knowledge for the different groups and countries is another source of inaccuracy. Some features specific to Switzerland will allow a different guild of species to invade. The deep, cold lakes, for example, are probably preventing or at least reducing invasions by aquatic weeds that thrive in warm, shallow water.

This report lists about 800 alien species and describes 107 IAS in Fact Sheets, i.e. five mammals, four birds, one reptile, three amphibians, seven fish, four molluscs, 16 insects, six crustaceans, three spiders, two 'worms', seven fungi, one bacteria, and 48 plants. As mentioned above, some of these species, e.g. the grey squirrel *(Sciurus carolinensis* Gmelin), have not yet entered Switzerland, but their arrival in the near future is likely.

1.4 Pathways

Pathways can be divided into those for species deliberately introduced and those for species accidentally moved around. Examples of species in the first category are species used in aquaculture, for fisheries, as forest trees, for agricultural purposes, for hunting, and plants used for soil improvement and solely to please humans as ornamentals. Most of these can also transport hitchhiking species and people can accidentally introduce species on cargo, their boots, etc. To summarize, most aquatics and invertebrates in general, are accidental arrivals, whereas most plants and vertebrates are deliberately introduced. Minchin and Gollasch (2002) and Carlton and Ruiz (2005) give excellent accounts of pathways and vectors in more depth. The latter divide pathways into cause (why a species is transported), route (the geographical path) and vector (how a species is transported).

The global trend that vertebrates and plants are mainly deliberately introduced also holds true for Switzerland. 75% (15) of the 20 Black List plants were introduced chiefly as ornamentals and 35 of the 37 vertebrates have been deliberately introduced. In general, the introduction pathways of species into Europe, rather than into Switzerland, have been analysed in this report, since some species arrived in Switzerland by expanding their populations from neighbouring countries. In conclusion, many serious invaders were deliberately introduced, often without much incentive beyond the wish to colour the landscape, e.g. with ornamental plants and waterfowl.

Prediction and prevention of new invaders is difficult since trade in species can be changed by changing demands. A group not currently a problem may yet become problematic in the near future. If, for example, the pet trade in reptiles shifts from predominantly tropical and subtropical species to species originating in regions in the same latitudes as Europe, such as North America and China, the situation could become much worse.

1.5 Impacts of invasive alien species

The impacts of IAS are often considerable, in particular where ecosystem functioning is being altered or species are being pushed to extinction, as has been shown for many bird species. Most extinctions are likely to be caused by a combination of factors and are not attributable to a single cause, but there is no doubt that IAS play an important role. The environmental impacts can be divided into four major factors:

> competition,
> predation (including herbivory), and more subtle interactions such as
> hybridization and
> transmission of diseases.

All these factors alone or in concert with other factors can decrease biodiversity and cause extinction. The most obvious examples for competition are between introduced and native plants for nutrients and exposure to sunlight. Resource competition has also led to the replacement of the native red squirrel *(Sciurus vulgaris* L.) by the introduced American grey squirrel *(S. carolinensis)* in almost all of Great Britain and it is predicted that this trend will continue on the continent. The latter forages more efficiently for food and is stronger than the native species (Williamson, 1996). Impacts due to predation and herbivory are very extensive on island fauna and flora, as mentioned above. The brown tree snake eliminated most of the bird species on Guam, and feral goats are a menace to native vegetation on islands, where they were often released as a living food resource. A well-known example of hybridization from Europe is the ruddy duck, which hybridizes with the native white-headed duck, as mentioned above. In some cases IAS can harbour diseases and act as a vector for those diseases to native species. This is the case with American introduced crayfish species to Europe, which are almost asymptomatic carriers of the crayfish plague *(Aphanomyces astaci* Schikora), but the native noble crayfish *(Astacus astacus* (L.)) is highly susceptible to the disease, and thus is struggling to coexist with populations of the American crayfish species. Introduced species can interact with natives in a variety of ways and indirect effects can be very difficult to demonstrate. Direct and indirect effects can lead to very complex interactions and a combination of effects can cause complex impacts.

In addition to impacts on biodiversity, many IAS impose enormous economic costs. These costs can arise through direct losses of agricultural and forestry products and through increased production costs associated with control measures (US Congress, 1993; Pimentel et al., 2000). One often-cited example is the costs inflicted on water plants by the zebra mussel, which clogs water pipes and other structures in the Great Lakes in North America. Costs for environmental problems are more difficult to calculate than costs imposed in the agricultural and other economic sectors. A North American study calculated costs of US$ 138 billion per annum to the USA from IAS (Pimentel et al., 2000). Some of the costs given in this paper are estimates rather than actual, however, even give or take an order of magnitude, it is still an enormous figure and shows the importance of IAS. A recently released report (Sinden et al., 2004) estimates that weeds are costing agriculture in Australia about Aus$ 4 billion a year, around 20% of which is borne by the consumer, the other 80% by the producer. According to this report, costs associated with lost production and controlling weeds are equivalent to 0.5% of gross domestic product, or 14% of the value of agricultural production in Australia. The Aus$ 4 billion estimate is conservative, as it does not include the impact on the natural environment, the effect of pollen from the weeds on human health, and the cost of volunteer weed control. It also hides the combined Aus$ 1.8 billion cost to the economy of salinity and soil acidity. The amount spent on weed control rose by Aus$ 68,000 for each additional native plant that was threatened by the invasive weeds. Weed control in natural environments cost about Aus$ 20 million in the year from mid 2001 to mid 2002. Turning to Europe, the costs of *Heracleum mantegazzianum* Sommier et Levier (giant hogweed) in Germany are estimated at € 10 million; € 1 million each to the environment and health sectors, and the remainder represents costs to the economy.

Some IAS also have implications for human health. Giant hogweed was introduced from the Caucasus to Europe as an ornamental plant. It produces copious amounts of a sap containing phototoxic substances (furanocoumarins), which can lead to severe burns to the skin. Regularly children, in particular, are hospitalized after contact with the plant, especially when they have been playing with the hollow stems and petioles, using them as ‘peashooters’. The raccoon dog *(Nyctereutes procyonoides* Gray), introduced as a fur animal, can, like the native red fox *(Vulpes vulpes* (L.)), act as a vector of the most dangerous parasitic disease vectored by mammals to humans in Central Europe, i.e. the fox tapeworm *(Echinococcus multilocularis* Leuckart) (Thiess et al., 2001). Although the raccoon dog is only an additional vector, this can have effects on the population dynamics of the parasite and lead to an increase in the disease in humans.

Known impacts of species introduced into Switzerland are presented in the chapters on the taxonomic groups and their Fact Sheets. Some recent invaders are without demonstrated impact in Switzerland; in these cases impacts assessed in other countries are given. These provide a glimpse of the possible future. An example is *Procambarus clarkii* Girard (an American crayfish species) which has caused considerable economic losses in Italy (Gherardi et al., 1999). Demonstration of impacts is often difficult because of the complexity of ecosystems, but alien species occurring in high numbers, such as *Reynoutria japonica* Houtt. (Japanese knotweed) totally covering the banks of a stream in a valley, or an animal biomass of alien species of up to 95% in the Rhine near Basel, must have impacts on the native ecosystem. All species use resources and are resources to other creatures and so they alter the web and nutrient flow of the ecosystems they are living in.

1.6 Discussion

This report compiles the available information about IAS in Switzerland. During the compilation it became clear that it is impossible to list all alien organisms, for the simple reason that there is a gap in taxonomic knowledge, not only in Switzerland, but Europe and the world, reflecting a need for more taxonomic work. There are probably more than ten times the species described so far actually existing right now on the planet, and for the species that *have* been described we often know little more than their names. This gives a good indication that there will be more species of both native and alien origin found in Switzerland in the years to come. Since all knowledge and management are based on the concept of 'species', it seems obvious that taxonomic work is crucial.

Despite the widespread view that IAS are of less concern in Central Europe than on other continents (and more especially on islands) for various reasons, including the small size of nature reserves and the high human impact on all 'natural' environments, and the long association of alien species and humans leading to adaptation, however, the number of cases of dramatic impacts is increasing and the awareness among scientists and the public is steadily evolving. Thus, the threats from IAS should not be underrated. One of the major consequences, which is undoubtedly unfolding before our eyes, is global homogenization (catchily called McDonaldization), with the unique character of places such as Switzerland being lost, the characteristic flora and fauna invaded by organisms which often accomplish to form the largest biomasses in certain ecosystems. This is fact and cannot be argued about, while confirmation of impacts is difficult to obtain and can be controversial. The concept of 'bad species' and 'good species' in our ecosystems is a rather anthropomorphic view. Even if a population of a native species is enhanced, it is not necessarily good for the ecosystem but can disturb the natural balances and nutrient and energy flows in the ecosystem. After an era of exploitation, it is now time to address global warming and global swarming.

IAS should not be seen as a specific topic but rather as a part of conservation, trade, and other activities. The main question to be answered is not how to deal with IAS, but what should Switzerland look like, what are the goals for conservation, what should a particular nature reserve or the national park look like? These goals need to be set and IAS management will be part of this bigger picture to conserve and reinstate the unique ecosystems and habitats of Switzerland. The intact ecosystems can deliver ecosystem services in a sustainable manner.

1.7 Recommendations

This section gives some important advice and recommendations, which emerged while compiling the report. Recommendations for groups of invasives and specific species are given in more detail in the respective chapters and Fact Sheets.

Preparing a national strategy against IAS is recommended to deal with IAS in an appropriate way and as demanded by the CBD. This action plan should identify the agency responsible for assessing the risks posed by introductions, provide funding mechanisms and technical advice and support for control options. This is necessary not only to fulfil international commitments, but also to protect Switzerland's ecosystems from the detrimental effects of future invasions.

Prevention measures against further bioinvasions need to be put in place to stem the tide of incoming new species arriving accidentally with trade and travel or introduced deliberately for various purposes. New deliberate introductions must be assessed as to the threat they may present and only introduced on the basis of a risk analysis and environmental impact assessment. Scrutinizing imported goods can minimize accidental invasions. The report indicates some important pathways for consideration. Most of the known invasive species, apart from insects, are deliberately introduced, in particular as ornamentals and for fishing or hunting. The use of native plants and non-invasive alien plants for gardening should be promoted. Every meadow ploughed, pond filled, or forest cut for roads, homes or industrial zones leaves less space for the native flora and fauna. Gardens and parks supporting native plants could be a great boost for native biodiversity.

Laws regulating trade in plant species on the Black List would be a first step in the right direction to reduce the impact of these species on the environment, economics and human health. However, restrictions for species already widely distributed within Switzerland will not drastically change the situation unless the populations already present are eradicated or controlled. Arrivals of new species with potential for being invasive need to be targeted well before they secure a beachhead and become unmanageable. Fish introductions are regulated by the Fisheries Act, which names species for which an authorization for release is needed and species for which release is prohibited altogether. This is a good basis, although the law could be better adapted to the current situation. This is described in the chapter on fish. The aquarium and terrarium trade is another important sector that could be more strictly regulated to stop releases of pets into the wild. With the increasing prohibition of the red-eared slider *(Trachemys scripta* Seidel) in Europe, other species will probably replace it in the pet trade. These species are not regulated and, if they are from a more temperate region, they would be of even more concern than the red-eared slider.

A major problem with introductions of IAS is that the costs when they establish and become invasive are borne by the public, while the financial incentives for introducing them lie with individuals or specific businesses. Development of economic tools that shift the burden of IAS to those who benefit from international trade and travel is a neglected approach. This is also called the 'polluter pays' principle. Appropriate tools would be fees and taxes, including fees levied on those who import the organisms or goods. The money raised can be used for prevention and management of IAS.

Awareness raising is a significant tool in the prevention and management of IAS, since some people would adhere to advice if they knew about its importance and the reason for it, e.g. 'freeing' of pets into the environment. Scientists and decision-makers also need better access to information about invasive species, their impacts, and management options. This lack of organization of information can be addressed by databases or global compendia. This report is a basis for collating information on published eradication and management methods for harmful species occurring in Switzerland (including key contacts).

Some key invasive groups to watch for in the future are plants, vertebrates, diseases and some invertebrates, as the most invasive species belong to these groups. Introductions of crayfish species, for instance, should be regulated; thus the European native species are of concern, although so far most attention is focussed on the American species.

To address the impacts of some invasive species already present in Switzerland, their populations need to be managed: either eradicated or controlled.

Monitoring for populations of some alien species is recommended to detect any sudden explosion in their populations and to watch for their potential invasiveness. By doing this, control or even eradication efforts can be employed before the populations become unmanageable. In most cases, the transition from a 'sleeper' species to an invasive species will go undetected without vigilant monitoring.

Despite the efforts in this report to document impacts of alien species which have invasive characteristics, much information is still needed to assess the different impacts, direct and indirect, to the native biodiversity. More studies on alien species are highly recommended to ascertain the importance of IAS and to demonstrate their significance to policy-makers and politicians.

The first Swiss-wide efforts to combat the populations of selected IAS are recommended. The most efficient control options need to be explored and implemented. Some species of high concern, such as giant hogweed, seem to be good targets for eradication campaigns throughout Switzerland. Populations of giant hogweed are currently exploding all over Europe (see, e.g., Kowarik (2003) for Germany and Czech Republic), they cause direct harm to people, and successful eradication has been achieved using mechanical and chemical control.

Priority setting is always difficult. The limited resources need to be spent where they have the greatest impact in combating IAS. Important points, for example, are to consider the feasibility of an approach (will the goal be reached?) and to target species with no conflict of interest. Opposition to action against less-important ornamentals on the Black List and species of direct human health concern (giant hogweed) will be negligible. Other possible targets for eradication are a deer species (sika deer – *Cervus nippon* Temminck) or the mouflon *(Ovis orientalis* Gmelin), both species with a weak lobby.

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2 > Vertebrates – Vertebrata

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All the Fact Sheets for vertebrates have been placed at the end of this chapter. They are presented in alphabetical order to make individual ones easier to locate, not in taxonomical sequence as in the text and lists below.

2.1 Mammals – Mammalia

There are currently about eight mammalian neozoa with established populations in Switzerland (Table 2.1), another species (coypu) is irregularly found, and the grey squirrel is discussed as a threat to Switzerland. Of the established species, one is greatly reduced in numbers (European rabbit) due to unfavourable climatic conditions, hunting, and introduced diseases such as myxomatosis and rabbit haemorrhagic disease (RHD) (see below). Three have only small, localized populations (Siberian chipmunk, sika deer, mouflon), one is currently in the process of invasion (raccoon dog), two are well-established and spreading through Switzerland (raccoon, musk rat) and one is abundant (brown rat).

The **European rabbit** *(Oryctolagus cuniculus* L.) was widely distributed throughout Central and Southern Europe before the last glacial period (Kaetzke et al., 2003). During this period the distribution retracted dramatically and the European rabbit survived only on the Iberian Peninsula. Later it was distributed by humans, because it was prized for its meat, first along the Mediterranean Sea coast and then to Central Europe. However, it arrived relatively recently in Switzerland, where it was locally introduced in the 19th century (Long, 2003). The distribution in Switzerland was always very patchy in lowlands around Basel, Genève and in the Valais and Ticino (Hausser, 1995) with a decreasing trend in its population sizes. While the European rabbit was able to adapt very well to the hot and arid interior of Australia, it suffers under cold winter temperatures and is restricted by the depth of the snow which covers its food (Flux, 1994). The small population of the European rabbit in Switzerland and the very few suitable habitats render this alien species unimportant. This is an interesting contrast to many other countries around the globe where the species is recognized for its detrimental effects on agriculture, forestry and the environment, including the more than 800 islands where it has been introduced. It should be noted that releases of other alien members of the family Leporidae should be discouraged. A North American species introduced for hunting at several locations in Europe, including Switzerland, France and Italy is *Sylvilagus floridanus* (J.A. Allan). The main concern is the possibility of transmission of diseases to native species, e.g. myxomatosis and RHD.

The only introduced squirrel is the **Siberian chipmunk** *(Tamias sibiricus* (Laxmann)). It was released into parks in Genève by pet lovers and established a small but stable population (Long, 2003). Its native distribution covers a large part of northern Asia and it is expanding its range westwards, and arrived in Finland in recent years (Grzimek, 1975). This small beautiful squirrel is frequently kept as a pet and has escaped or been deliberately introduced in several European countries. In Switzerland only one small colony is known, but it has also established populations in Freiburg im Breisgau in Germany and in Italy (Personal observation; Andreotti et al., 2001). In Russia it is known to destroy half the average forest nut production and cause great damage to grain crops. Since the chipmunks mainly feed on the ground, they can severely affect crops and also damage gardens and orchards (Long, 2003). A Belgian study, which compared the abundance of birds in areas with and without the alien squirrel, concluded that *T. sibiricus* has no impact on bird populations (Riegel, 2001). In most of Europe, released populations have not increased and spread significantly, and it seems that the Siberian chipmunk is dependent on a rich food source, as it is most often found in parks and graveyards with a variety of different plant species (Krapp, 1978a, b). Thus, it should be regarded as a species with a low invasion potential. However, the release of pet animals should be of great concern and should probably be better regulated. In particular, the danger of diseases carried by alien pets to wildlife, other pets and humans should not be underrated, as demonstrated by the recent arrival of diseases with introduced pet rats from Africa to the USA.

Another squirrel species, although one that has not yet arrived in Switzerland, is of great concern, as it is established in Italy and spreading. The **grey squirrel** *(Sciurus carolinensis* Gmelin) (see Fact Sheet) is one of the rare cases where the impact on a native congeneric species, i.e. the red squirrel *(Sciurus vulgaris* L.), is well documented. In Great Britain, except for some mountainous conifer forests, the red squirrel has been replaced completely by the grey squirrel. Today, the population in northern Italy is rapidly expanding its range and threatens to invade Switzerland in the next 20 years or so. Swiss authorities should follow the expansion closely and put prevention methods in place to stop or delay the spread at the border. Whereas the invasion into the Ticino is more imminent, the modelled expansion of the grey squirrel to France is of greater concern, as from here it can expand into Switzerland around Genève. Moreover, if isolated populations outside the invasion front are encountered, they should be eradicated as long as they are small. Swiss authorities should also initiate discussion with Italian authorities to implement the approved action plan to eradicate the species in the Italian part of the Ticino valley.

The re-introduction of beavers in some countries has been problematic in the past. In some areas, at least in Austria and Finland and perhaps Germany (Geiter et al., 2002), the American congeneric *Castor canadensis* Kuhl was introduced instead of the **European beaver** *(C. fiber* L.) (Freye, 1978; Englisch, 2002). These two species are very similar and indeed were considered to be one species until recently, but the karyotypes differ. No further introductions of the American species should be made in Europe. The introductions of *C. fiber* of different origins within Europe seem to be of less concern in many parts, since the species is genetically relatively uniform, with only a few obvious subspecies. In general, specimens used for re-introductions should come from the same subspecies or populations, original to the specific area, whenever possible.

The North American **muskrat** *(Ondatra zibethicus* (L.)) (see Fact Sheet) showed a tremendous expansion of its range in Europe in the 100 years after its first introduction to Prague (Elton, 1958). A discussion of the process of the spread is given by Williamson (1996). The invasion front is moving swiftly southwards in Switzerland. It has the potential to colonize all aquatic bodies in the lowland parts of Switzerland. The damage to waterways and the costs to control this species are enormous (Reinhardt et al., 2003). However, given the severity of the damage and the negative impact on native mussels (Unionidae) through predation, an eradication or control programme should be considered. Options should be explored together with neighbouring countries, e.g. Germany. Eradication is probably not achievable given the large population already present in Switzerland and the existence of sources for new invasions in Germany and France. On the British Isle the muskrat was eradicated in 1939, but the population was still small and confined to several centres of introduction in England, Scotland and Ireland. The British Isles are not connected to continental Europe, thus it is easier to prevent re-infestation. It has also been suggested that the UK climate is not ideal for the species, so that eradication was more easily achieved.

Another large rodent, the **coypu** *(Myocastor coypus* (Molina)) has been found in Switzerland on several occasions and in different areas, mainly in the north-west (Hausser, 1995). Its origin is the southern half of South America and it is confined to water edges. Like the muskrat, it was deliberately introduced into the wild for hunting because of its fur; like most aquatic animals, it has very dense fur to help it conserve heat in cold water. However, most coypu colonies are derived from animals that escaped from fur farms and established short-lived populations in Central Europe. They are not well-adapted to cold winters, thus severe winters often cause high mortality and local extinction. In the Mediterranean area (e.g. southern France and northern Italy) coypu populations thrive and they damage dams by burrowing and reduce crop yields (Southern, 1964). It can be concluded that the coypu is unlikely to establish permanent populations and cause an environmental impact in Switzerland, because of the prolonged frost periods. Most of the sightings will be of single specimens or temporary populations. However, it needs to be stressed that it is difficult to be confident about this prediction. The coypu was successfully eradicated from England, and casualties amongst non-target organisms, which had been considerable during the muskrat eradication, were reduced by using cage traps and releasing non-target species back into the wild (Williamson, 1996).

The ubiquitous **brown rat** *(Rattus norvegicus* (Berkenhout)) (see Fact Sheet) is a species that adapted very well to human environments. The origin of the genus *Rattus* is the warm climate of South-east Asia, but *R. norvegicus* is from the northern part of the distribution, and is thus better adapted to a cold climate. However, it is surprising how well this species spread with humans all around the globe. Its omnivorous character, together with its ability to live in close vicinity to humans, led to its success. The recorded impacts from this rodent are considerable. Its negative impact on the environment is mainly evident on islands, where it has even caused bird extinctions. In urban areas, the normal habitat in Central Europe, the environmental impact is probably less pronounced, although it is an additional omnivorous predator. However, its impact on structures and foodstuffs and its role as a disease vector in human settlements are unambiguous and the brown rat is controlled in many cities.

The **raccoon** *(Procyon lotor* (L.)) (see Fact Sheet) is the only member of the family Procyonidae introduced to Europe. It was introduced from North America and released in Germany in 1934. From that and other subsequent releases, it spread through Germany and reached Switzerland in 1976. The spread continues and it will eventually inhabit the lowland parts of Switzerland to Genève in the south and the Valais. The impact of the species is disputed. A definitive conclusion cannot be reached without studies being carried out in Switzerland to assess its impact on the native wildlife and as a vector of diseases (Hohmann et al., 2002). This addition to the native fauna may have to be accepted, since control measures are not very effective and its impacts have not (yet) been demontrated. If incidences of diseases carried by the raccoon increase, hunters will have to focus more on this species.

The only introduced dog (Canidae) in Central Europe is the east Asian **raccoon dog** *(Nyctereutes procyonoides* (Gray)) (see Fact Sheet), which was for decades and at many places in the former USSR extensively released as a fur animal. The acclimatization of the species and the value of the fur are questionable. However, it spread westwards and recently reached France. Incorrect identification based on field observations by laypeople may be frequent, because they are not familiar with this species and it can be confused with other predators, such as the raccoon. Thus, identification of dead animals is the most reliable way of evaluating its spread through Europe. Opinions about its impact vary between it being a benign species and a species causing severe impact on native wildlife. One argument is that, as a generalist on abundant food resources, it does no harm to rare organisms. Others argue that predation on bird species and amphibians might have a negative impact (Kauhala, 1996). The status of many amphibians as endangered in Central Europe and the fact that amphibians were found in proportions of up to 45% in the diet of the raccoon dog (Barbu, 1972) indicates the potential harm. It also plays a role as a vector of diseases to humans and other predators (Weidema, 2000). It is recommended that the spread of the raccoon dog should be monitored and its impact in Switzerland evaluated. However, a control programme seems unlikely to achieve success, because of the raccoon dog's secretive behaviour and its continuing invasion from the East. The raccoon dog and the raccoon are two additional predators with which native animals have to cope. Thus, although the impacts of the introduced predatory species are not so different from those of native origin, if they add to the total predator load, they are likely increase the predatory pressure, and destabilize existing populations and population cycles.

The only established alien deer (Cervidae) in Switzerland is the **sika deer** *(Cervus nippon* Temminck). It is a fairly small deer species, intermediate in size between the native roe deer *(Capreolus capreolus* (L.)) and red deer *(Cervus elaphus* L.). The summer coat is chestnut brown to buff brown with white spots, while it is uniform grey-brown during winter. The rump patch is white with a black upper border and the white tail has a black stripe. The typical antlers have four points each. The sika deer is mostly nocturnal, although this might be an adaptation to disturbance and hunting, since most deer species, if undisturbed, would probably be diurnal. It was introduced from its original range in eastern Asia to several countries in Europe, as well as North America, Africa, Madagascar, Australia and New Zealand (Long, 2003), as a game animal, for meat, and as a conservation measure. The sika deer in its natural distribution range, like most (Asiatic) deer species, is under threat due to high hunting pressure and many subspecies are rare (Kurt, 1988). Many sika deer introductions were successful, including one in southern Germany, which was the source of the Swiss population. The enclosure near Schaffhausen was opened in 1941 and a slowly increasing population established (Hausser, 1995). This population is still restricted to the north of the river Rhine. The sika deer is a serious forest pest, browsing young trees and also removing bark (Welch et al., 2001). Native deer show the same behaviour and their large populations have created an unresolved problem in many places. However, an additional, alien, deer species can intensify tree damage (Eisfeld and Fischer, 1996). It can damage crops, as do other ungulates, and can be a road hazard. A serious threat to the native red deer could potentially come from hybridization with the alien sika deer (Krapp und Niethammer, 1986; Welch et al., 2001). However, hybridization has not yet been demonstrated in Germany or Austria (Geiter et al., 2002; Welch et al., 2001). Thus, there is an urgent need to monitor the Swiss population of sika deer and study whether hybridization with the red deer occurs. The outcome of the study will be important for a decision on how to manage the sika deer population – eradication, containment or 'harvest' hunting. The other fact to be taken into consideration is the status of the endangered populations of sika deer in its native range. A population in Switzerland could be valuable for the conservation of the species. A problem with many European populations is the lack of knowledge concerning which subspecies were introduced, and many are of mixed origins. Thus, given that sika deer is common in other introduced areas, the species should preferably be eradicated in Switzerland or at least contained in the infested area.

The **mouflon** *(Ovis orientalis* ssp. *musimon* Gmelin or *O. ammon* ssp. *musimon* (Pallas)) has established a small population over the last 20 years or so in the Valais, where they are slowly increasing in numbers. The mouflon is a member of a species-complex of wild sheep. The views on species status in that group vary considerably between authors. The mouflon was introduced to Central Europe from Corsica and Sardinia. However, the status of these populations is not clear. While some argue that the mouflon is native to these islands, Poplin (1979) and others provide evidence that the populations on Corsica and Sardinia are descendants from domestic animals that were introduced from Asia in the Neolithic Age. The animals were still very similar to their wild ancestors when brought to the Mediterranean islands. In about 1980, the mouflon entered the Valais from a population in France and established populations in the lower Valais. In some localities the mouflon competes with the chamois *(Rupicapra rupicapra* (L.)), but in general the environmental impact will not be significant (Andreotti et al., 2001). As long as the population in Switzerland is small, no significant economic damage will occur. A decision on the future of the mouflon in Switzerland needs to be taken before the populations spread any further. Excluding the game hunting aspect, it is an alien species with no value, and today the value of native species is a predominant consideration in nature conservation, therefore control of the species could be considered. It is recommended that the species at least be contained to the present infested area, using hunting as a measure of control.

A list of species presenting a potential threat to native biodiversity is not complete without mentioning **domestic animals**. Cats *(Felis catus* L.), ferrets *(Mustela furo* L.), dogs *(Canis familiaris* L.) and goats *(Capra hircus* L.) are examples of domestic animals for which an environmental impact is documented (Long, 2003). As with most IAS, the impacts of the above-mentioned domestic animals are greatest on islands, however there are demonstrated impacts in Europe. Domestic cats are very efficient hunters and will kill wild prey, despite being fed. Based on a survey, the total number of mammals, birds, amphibians and reptiles killed by domestic cats in England per year has been estimated to exceed 89 million, including 25 million birds (Woods et al., 2003). Feral cats, which depend entirely on wild food resources, add to this figure. Domestic populations can occur at high densities, because they are fed and belong to households. Urban and rural habitats, where the domestic cats mainly hunt, do not have many endangered species, but are a valuable habitat in highly populated Central Europe. Thus, the effect on native biodiversity is significant. However, a management plan for domestic cats, such as by-laws to keep cats indoors near nature reserves, is a thorny topic. The impact of hybridization with the wild cat *(Felis silvestris* Schreber) is not clear, but it seems to be a conservation issue in some areas (Randi et al., 2001).

The feral ferret is a domesticated form of the eastern polecat *(Mustela putorius* L.) and escaped animals are widely found. Potentially there could be damage to native small mammal and ground-nesting bird populations and from introgression of genes into the wild form, but there is very little information about feral ferrets in the wild (e.g. whether there are self-sustaining populations). Feral dogs are more of a problem for game animals than to biodiversity in Central Europe. Problems with feral goats in Central Europe, in contrast to island ecosystems on a global scale, are rare and local and limited to hybridization with the native ibex (*Capra ibex* (L.)).

About half of the alien mammal species occurring in (or threatening to invade) Switzerland (i.e. muskrat, coypu, grey squirrel, sika deer, raccoon and raccoon dog) are given as examples of species threatening European wildlife and habitats in the Appendix of Recommendation No. 77 (1999) on eradication of non-native terrestrial vertebrates of the Bern Convention on the Conservation of European Wildlife and Natural Habitats (for details on the recommendation for management, see *http://www.nature.coe.int/english/main/Bern/texts/rec9977.htm)*. This recommendation was adopted by the Standing Committee and specifies the recommended action to be taken against IAS, including monitoring, control of sale, and efficacy of eradication efforts. The recommendation sets another framework for dealing with IAS in Europe.

Despite the low number of mammalian neozoa, some patterns can be observed and are discussed below. The ten species listed above are members of nine families. Two of these families have no native members in Europe: Capromyidae occur only in the New World, and Procyonidae in either the New World and east Asia or exclusively in the New World, depending on whether the red panda, *Ailurus fulgens* (Cuvier), is included or not. The different phylogenetic origin of the ten species is reflected in the very different biologies of the species, which include small rodents, large herbivores and carnivores.

Five species are of Asian origin (four from eastern Asia and one from western Asia), four from the New World (one of those from South America), and one is Mediterranean.

The pathways of their introductions reveal a clear pattern, which is generally true for introduced mammals: they were deliberately introduced into Europe. Only one species arrived as a stowaway animal in cargo, ships and other vehicles – the ubiquitous brown rat. The majority of the species are fur animals which were released and escaped from farms (four species); the two large ungulates were released to enrich the hunting fauna, one was used as a food resource and the other to enrich the fauna and for aesthetic reasons. One other interesting aspect is how the species arrived in Switzerland. The pathway analysis presented above shows how the species were transported into Europe. Only four of the ten species in Table 2.1 were actually introduced directly into Switzerland. The most (potentially) damaging species have spread into Switzerland from an introduction elsewhere in Europe, mainly Germany and France. This highlights the importance of international dialogue and collaboration on IAS issues.

Some of the most destructive alien species on a global scale are mammals (Long, 2003). Although the number of introduced species is fairly small in comparison to other groups, the impact is considered to be enormous, especially in island ecosystems. The large herbivores cause a major impact on plants because of their size and the amount they eat, while small carnivores (e.g. Mustelidae) and omnivorous mammals (e.g. Muridae) are intelligent and adaptable species, which are able to prey on a varied diet and can thrive in close proximity to humans. The latter trait facilitates their wide spread by human-mediated transport. The potential impacts of mammalian neozoa in Switzerland are discussed in the species descriptions and the Fact Sheets. Fact Sheets are provided for the five species which are likely to cause some impact. There is no obvious general pattern, besides the fact that the small mammals have had the highest impact through predation on native species and damage to human constructions, including waterways. The date of introduction and perceived impact show no correlation, since the potential for impact rather than the actual impact in Switzerland is used. Thus, the grey squirrel, which has not yet been found in Switzerland, is one of the species of concern. On the other hand, the two species introduced in the 19th century comprise one highly damaging species and one which is now almost extinct.

The small number of introduced species means that general patterns observed in larger data pools are unlikely to be replicated, due to chance.

There are about 86 mammal species currently reproducing in Switzerland, of which nine are neozoa (coypu included), thus about 10% are introduced. When the list of species is compared to those of the neighbouring countries Austria and Germany, there is a high overlap in species composition (Englisch, 2002; Geiter et al., 2002). The total number is a little smaller (Austria: 11; Germany: 11); the most obvious difference is the absence of fallow deer *(Cervus dama* (L.)) and mink *(Mustela vison* Schreber), both established in the other two countries. Gibb and Flux (1973) list twice as many introduced mammals to New Zealand, i.e. 25, and the damage they cause is enormous, since the islands had only two native mammal species (both bats). The niches occupied elsewhere by terrestrial mammals were occupied in New Zealand by native bird species.

The management options for the species are discussed in the text on individual species, above. The invasive or potentially invasive species are very difficult targets for eradication and control. The same traits that make them successful in the invasion process renders them difficult to control, e.g. adaptability and a high fecundity.

Tab. 2.1 > Established alien mammals in Switzerland.

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Oryctolagus cuniculus (L., 1758)	Leporidae	Iberian Peninsula	19th century	Released for food	Alteration of plant succession Agricultural pest	The species does not thrive in Switzerland due to the cold winters
Tamias sibiricus (Laxmann, 1769)	Sciuridae	Asian	1975?	Escaped and released to establish population from pet lovers	Great damage to grain crops and forest nut production in its native area	Only small local population in parks in Genève
Sciurus carolinensis Gmelin, 1788	Sciuridae	Eastern North America	-	Released for aesthetic reasons	Replaces the native red squirrel Stripping bark of trees can cause damage in plantations	This species is not yet found in Switzerland, but is rapidly spreading in Italy
Ondatra zibethicus (L., 1766)	Arvicolidae	North America	1935	Escaped from fur farms and released to provide wild fur harvest	Dramatic economic costs due to damage to waterways Predation on native mussel populations	Effective control options should be considered
Myocastor coypus (Molina, 1782)	Capromyidae	South America	-	Escaped from fur farms and released to provide wild fur harvest	Damage to crops by feeding and water banks by burrowing	A permanent establishment seems unlikely because of harsh winters
Rattus norvegicus (Berkenhout, 1769)	Muridae	Southeast Russia and northern China	19th century	Transported inadvertently in ships and other vehicles	Transmission of human diseases High control costs Damage to crops and structures	Generally, urban populations are controlled
Procyon lotor (L. 1758)	Procyonidae	North and Central America	1976	Releases as a fur animal and to enrich the fauna Escapees from captivity	Predator of invertebrates and vertebrates, with a possible impact through bird nest predation Nuisance in urban areas Problem in orchards? Vector of diseases	It will spread through the entire Mittelland within the next few years/decades
Nyctereutes procyonoides Gray, 1834	Canidae	East Asia	2003	Acclimatization as a fur animal	Predator of vertebrates Vector of diseases	It is only currently spreading into Switzerland from Germany and France
Cervus nippon Temminck, 1836	Cervidae	South-eastern Russia, eastern China, Japan and Korea	1941	Released for sport hunting and for conservation of the species	Serious forest pest Hybridization with red deer (everywhere?)	Only one restricted population in Switzerland
Ovis orientalis musimon Gmelin, 1774	Bovidae	Western Asia	1985?	Released as a game animal	Local competition with chamois	Only a small population in the lower Valais

2.2 Birds – Aves

About a quarter of the 510 bird species recorded for Switzerland are alien. This is not surprising, since most birds are good flyers and many migrate regularly. The latter can easily go astray, especially during freak weather events. Hurricane 'Lothar', for example, was responsible for the accidental occurrence of a pelagic bird (generally found far out at sea), the European storm-petrel *(Hydrobates pelagicus* (L.)), in land-locked Switzerland (Keller and Zbinden, 2001). About 200 species breed regularly in Switzerland.

Some bird species are spreading naturally through Europe and into Switzerland. They are not included in the list, although their spread might be triggered by human alterations to the landscape. The spread of these species is indirectly facilitated by human action, but they are not alien as defined here. The collared dove *(Streptopelia decaocto* (Frivaldszky)) has spread phenomenally from the Balkans north-west through most of Europe (Glutz von Blotzheim, 1980). Several hypotheses have been put forward to account for this spread, including an increased amount of food in rural areas and genetic changes in the bird population, but there is no agreement on the explanation.

The species considered in this report are exclusively those which were released or escaped and became established, but not those that expanded their range to include Switzerland. However, species escaping from captivity and observed in the wild or found to breed irregularly are not included. Thus, the list provided here takes into account only birds with established populations in Switzerland or in neighbouring countries, from which spread into Switzerland can be reasonably expected.

Firstly, bird species with established populations in Switzerland (six species) are discussed, and secondly, alien species established in nearby countries which have the potential to spread to Switzerland are considered.

The **cormorant** *(Phalacrocorax carbo* L.) is a common guest during winter in Switzerland, but the first breeding pairs are now established along the Aare near Bern. The birds are probably from the population kept under semi-wild conditions in the zoo. Following the banning of hunting in numerous countries, the cormorant is spreading again in Europe and in many places the conflict between conservation and fishing interests is fervidly debated. Thus, in this specific case and in general, species should be held in secure captivity. Bearing in mind recently acquired knowledge about invasive bird species and the ease with which some are able to establish, keeping populations under semi-wild conditions in zoos and similar facilities is no longer always appropriate. In the recent past, zoos have increased this kind of open confinement to simulate a more natural situation for the benefit of visitors. Unfortunately, as it creates a new pathway for introductions, this approach has to be changed. A similar case is the cattle egret *(Bubulcus ibis* (L.)), which is frequently kept as free-flying populations in zoos, and individuals escape occasionally from captivity. Birds of exotic origin kept under semi-natural conditions can cause another problem: introgression of genes into native populations.

The **mute swan** *(Cygnus olor* (Gmelin)) (see Fact Sheet) was released on park ponds in the 17th century and has subsequently spread to all suitable habitats. It has a stable population, so only local problems occur, and it is also a popular species with the human population, so that control should be limited to public education concerning the impact of feeding waterfowl (Schmid et al., 1998). Stopping the feeding of the swans will eliminate the high densities of mute swans. The mute swans would then distribute themselves more evenly, due to their territoriality based on intraspecific aggression.

A second member of the Anatidae, the **greylag goose** *(Anser anser* (L.)), the wild form of the domestic goose, is not native in Switzerland, but has a growing breeding population in several places, apparently originating from illegally released specimens (Kestenholz and Heer, 2001), although the presence of wild birds that expanded their range cannot be ruled out. Greylag geese are native in an area extending from north-western to south-eastern Europe. They were probably released to enrich the local avifauna in Switzerland. It can be assumed that the populations will grow, without hunting pressure. No environmental impact is expected, since the Swiss population is not far from the southern border of the natural distribution, but there might be damage to crops and droppings on lawns close to lakes could mean the swans are considered a nuisance.

The **ruddy shelduck** *(Tadorna ferruginea* (Pallas)) (see Fact Sheet) is a Central Asian and northern African species, which is a favourite asset of waterfowl collections throughout Europe for its striking plumage of an almost orange-brown body and a whitish head. In many cases the birds are not kept in cages and regularly escape. Some isolated breeding pairs are recorded in many countries. However, Switzerland has the only viable population of this species in Europe, and it is in the process of building up numbers. Its spread to neighbouring countries should be prevented, since if it were to cause subsequent damage and environmental impact, Switzerland would have some responsibility. Therefore, it is recommended that this unnecessary population should be eliminated while it is of manageable size.

The **mandarin duck** *(Aix galericulata* (L.)) (see Fact Sheet) is the only alien duck species to have established in large numbers in Europe. As it is one of the most ornate waterfowl species, it was and is frequently held on park ponds in Europe, from where it escapes into the wild. Its origin is the eastern part of Asia, where populations have been dramatically reduced by habitat changes (mainly logging) and over-hunting. Consequently, the European populations might be of some importance for the species, especially if there is no demonstrated impact. Thus, a strategy for this species in Europe might recommend accepting it.

The native range of the **common pheasant** *(Phasianus colchicus* (L.)) covers a large part of Asia with about 40 subspecies described. It has been kept in pheasant exhibitions for at least a thousand years in Europe (Geiter et al., 2002). However, it is believed that it established in the wild much later, perhaps only in the 18th century, but its history cannot be established with certainty, since the numerous releases obscure the sustainability of wild populations. It is a favourite game bird all over Europe and millions are released every year. Thus naturalized populations are supported by frequent releases and are harvested by hunting, e.g. each year up to 20 million are released and 12 million are shot in the UK (Kestenholz and Heer, 2001). Almost all wild populations in Europe seem to be of hybrid origin from several subspecies, because of the many releases of different genetic material. Apparently, many wild populations are not able to sustain themselves without human help, e.g., by releases and winter feeding. Schmid et al. (1998) estimate a population of fewer than 1,000 for Switzerland, mainly in the lowland parts. It is recommended that releases of this alien species are stopped, so that naturalized populations may dwindle away.

One domestic species needs to be mentioned in this section, the **feral pigeon** *(Columba livia* f. *domestica* L.). It is descended from the rock dove *(Columba livia* L.), which lives on sea-cliffs and in mountains in southern Europe and the UK. The feral pigeon is abundant in most cities of Europe and elsewhere because members of the public supplement their natural food. Today they are often recognized as a problem species due to their faeces altering the colour and destroying the surfaces of old buildings, statues and other artificial structures, and for their role in spreading disease. Most control methods have not been successful. The main hindrance is feeding, making education of the public a crucial aspect of feral pigeon control in cities.

Species in other European countries which are expanding their range are discussed below, as they may enter Switzerland in the near future.

The most successful avian invader in Europe is the **Canada goose** *(Branta canadensis* (L.)), following extensive releases and the availability of suitable habitat for this North American species throughout Central and northern Europe. It is rapidly increasing its population and expanding its range (Delany, 1993). If this spread continues, it is likely to invade Switzerland in the near future. While single individuals ahead of an invasion front could be eliminated, the spread of the species in Europe could only be addressed through an international effort. Competition with native waterfowl has been frequently observed (Madsen et al., 1999) and hybridization with greylag goose is of concern in countries with native populations of the latter species (Gebhardt, 1996). The growing populations of Canada goose are a cause for concern due to damage to crops and faeces deposited in parks and on golf ranges (Kestenholz and Heer, 2001). In spring pastures they cause damage by grazing, trampling and fouling. Fouling is also responsible for eutrophication and associated algal blooms on small, still waters (Welch et al., 2001).

Another goose species, which in recent times rapidly spread from a nucleus population in the Netherlands, is the **Egyptian goose** *(Alopochen aegyptiacus* (L.)). Its native range is Sub-Saharan Africa, where it is a ubiquitous species. The Egyptian goose was already present in captivity in the UK in the 17th century, and probably around 1967 some birds escaped confinement in the Netherlands (Bezzel, 1996). If the affected countries employ no counter-measures it seems likely that the Egyptian goose will eventually spread into Switzerland, but that will take some time, unless further escapes occur in or close to Switzerland. Generally, as for other waterfowl, this species should be kept in closed cages to minimize escapes. During the breeding season, Egyptian geese are very aggressive, and this could have some impact on native waterfowl.

The introduction of North American **ruddy duck** *(Oxyura jamaicensis* (Gmelin)) (see Fact Sheet) into Europe led to one of the best-known cases of concern about an alien species in relation to conservation of a globally threatened native species, i.e. the white-headed duck *(Oxyura leucocephala* Scopoli)), classified as Vulnerable by IUCN (the World Conservation Union) (Hughes et al., 1999). The two species readily hybridize and it is likely that unless counter-measures are taken the white-headed duck population will be completely absorbed. A European action plan for eradication of the destructive invader has been set up to safeguard the small populations of white-headed duck in the western and eastern Mediterranean. The plan does not cover Asia, but it is to be hoped that the ruddy duck will be eradicated in continental Europe and considerably reduced in the UK, so that its spread to Asia becomes unlikely. The spread of the ruddy duck within the UK and then through Europe was facilitated by the fact that it is a migratory species. While the 'Action Plan for the White-headed Duck' (Green and Hughes, 1996) names eight threats and limiting factors, the introduction of the ruddy duck is the only one that is considered critical for its implementation. Tragically the white-headed duck population was just recovering in Spain, from a minimum of 22 birds in 1977 to about 2,700 today due to a conservation programme, but it is now being hit by hybridization with the ruddy duck. Over 4,200 ruddy ducks have now been shot in the UK, where shooting at large wintering sites is crucial to the success of the action plan. Switzerland has endorsed the eradication plans and agreed to take action against the ruddy duck within its borders. Shooting of the ruddy duck has to be conducted in a co-ordinated way by hunting and conservation authorities. Firstly, the correct identity has to be confirmed, since the two *Oxyura* species can be very similar. It is clear from the current situation that ruddy ducks thrive in Europe, build up large viable populations, and spread rapidly. Therefore, keeping ruddy ducks in captivity needs to be regulated. While the ultimate goal for such a serious problem species is the prohibition of keeping them in captivity, an interim measure should be the monitoring of all specimens kept and acceptance of collections only in secure facilities.

In Europe several parrot species frequently escape from captivity and some of those are able to establish in the wild under favourable conditions. Most of these colonies are in parks in cities, where a rich food source of fruit-bearing trees and bird feeders during the harsh winter time together with temperatures on average 2° C above the surrounding landscape allow their survival. The climate seems an important factor for these species that naturally inhabit lower latidudes. The most common parrot species are the **rose-ringed parakeet** *(Psittacula krameri* (Scopoli)) and the **monk parakeet** *(Myiopsitta monachus* (Boddaert)), which have established large colonies in several European cities, including some in neighbouring countries: France, Germany, Austria and Italy. There are single reports of breeding attempts of both species in Switzerland. They are apparently limited to city environments and it is not known whether there is any genetic exchange between the colonies in Europe. The colonies are probably isolated and will not spread that far. The rose-ringed parakeet nests in tree cavities, so that it will compete with native wildlife. The monk parakeet is unusual, building large communal nests on trees, buildings and power pylons. In their home ranges both species are recognized as agricultural pests. Other parrot species are found irregularly throughout Europe. Any parrots encountered in the wild in Switzerland should be captured.

This section, dealing with alien bird species established in Switzerland and those species that are established in neighbouring countries and spreading, illustrates the varied importance of bird families involved. There are four Anatidae, one Phasianidae and one Phalacrocoracidae established. Moreover, three further Anatidae are spreading in neighbouring countries and are expected to arrive in Switzerland in the near future. In addition, two Psittacidae are well established in cities of neighbouring countries. Thus, Anatidae dominate the species list of alien birds currently establishing colonies in the wild in Europe. Estimates of the number of established alien bird species in Europe vary depending on the author, but for example Kestenholz and Heer (2001) list 22 species, of which eight belong to the Anatidae and eight to the Phasianidae. In conclusion, the Swiss composition of alien birds mirrors the European situation, with the exception of having fewer introduced Phasianidae. The latter group has been predominantly released in the UK and France as game birds. The six established species in Switzerland represent about 3% of all breeding species (approximately 205). As birds are a vagile and migratory group, a comparison of breeding species is obviously the best approach to compare native versus alien species.

The total of six alien bird species established in Switzerland is comparable with neighbouring countries (Table 2.2), especially given that Germany is much bigger. Schuster (2002) lists five species (three Anatidae, one Phasianidae, one Psittacidae) for Austria. Ten alien bird species (six Anatidae, three Phasianidae, one Psittacidae) are found in Germany (Geiter et al., 2002). Italy (Andreotti et al., 2001) has about eight species, but the taxonomic composition is different with one Anatidae, one Odontophoridae, two Phasianidae, two Psittacidae, one Paradoxornithidae and one Estrildidae.

Tab. 2.2 > Alien birds established (✓) in selected countries of Europe.

Family	Species	Country			
		Germany	Austria	Switzerland	Italy
Anatidae	*Aix galericulata* (L.)	✓	✓	✓	
	Cygnus olor (Gmelin)	native	✓	✓	✓
	Branta canadensis (L.)	✓	✓		
	Alopochen aegyptiacus (L.)	✓			
	Anser cygnoides (L.)	✓			
	Anser indicus (Latham)	✓			
	Cygnus atratus (Latham)	✓			
	Tadorna ferruginea (Pallas)			✓	
	Anser anser (L.)	native	native	✓	
Phasianidae	*Phasianus colchicus* (L.)	✓	✓	✓	✓
	Meleagris gallopavo L.	✓			
	Syrmaticus reevesi (Gray)	✓			
	Alectoris chukar (Gray)				✓
Odontophoridae	*Colinus virginianus* (L.)				✓
Phalacrocoracidae	*Phalacrocorax carbo* L.	native	native	✓	native
Psittacidae	*Psittacula krameri* (Scopoli)	✓	✓		✓
	Myiopsitta monachus (Boddaert)				✓
Paradoxornithidae	*Paradoxornis alphonsianus* (Verreaux)				✓
Estrildidae	*Amandava amandava* (L.)				✓

After Geiter et al., 2002 (Germany); Schuster, 2002 (Austria); this report (Switzerland); Andreotti et al., 2001 (Italy).

The composition of established alien birds in Switzerland seems to reflect human activities, i.e. the frequency of release of the species, rather than their ecological traits. Therefore, an evaluation of what makes a bird species invasive is less informative than a discussion of the attractiveness of species to humans.

Due to the small number of six established species (or 11, if we consider the spreading species of neighbouring countries), there is no obvious pattern to their origin. Three of the established species are from within Europe, two from Asia, and one from Africa/Asia.

The year of introduction (i.e. when it was first found established in the wild) varies greatly. However, the very recent significant increase of establishment of species of Anatidae and Psittacidae, not only in Switzerland but also other European countries, gives rise to concern and points to the need to prevent further introductions.

The pathways of introduction differ greatly between the three main groups, but are characteristic for each group. The Anatidae are either released for aesthetic reasons (e.g. mute swan) or have escaped from the numerous ornamental waterfowl collections. The members of the Phasianidae are released as game birds for hunting. The Psittacidae are, of course, escapees from captivity. The success of establishment in all three groups is based on the support they receive from the human population, since some are released and most are fed in the wild (or receive some other human support).

The environmental and economic impact of established alien birds in Switzerland is probably fairly negligible and limited to some local effects. The exception on a European scale is the ruddy duck, which is the critical issue for a native globally endangered species. The possible and certain impacts are summarized in Table 2.3.

Birds seem to cause less concern and actual impact on biodiversity, as outlined above, than mammals, but their impressive capability for spread underlines the concern about both potential future spread and the unsatisfactory level of knowledge for predicting spread and impact. The rapid increase in the number of newly introduced bird species recorded in recent times and the spread of some older introductions underline the urgency of implementing effective strategies to address the issue.

The pathway analysis indicates where prevention of future introductions will be most efficient. The three major pathways identified are listed below, together with measures to help close them.

Escaped birds from captivity (Psittacidae and Anatidae). Measures to prevent escapes of alien bird species from captive collections can include strict standards of security for aviaries, a register and documented bird monitoring, and penal and administrative sanctions in the event of violation.

Released birds for aesthetic reasons and to enrich the native fauna (Anatidae). Legislation to prevent deliberate introductions should be established, or improved and implemented. As can be easily seen from the cases of species spreading through Europe towards Switzerland, this issue needs to be tackled on a European scale. The international conventions are in place and need to be implemented, e.g. Convention on Biological Diversity (CBD), Bern Convention, Bonn Convention, Ramsar Convention. It should be noted here that the domestic duck can also pose a problem for the wild mallard *(Anas platyrhynchos* (L.)) because of hybridization. These noticeable hybrids are most often observed in urban areas, but they should be eliminated in the wild.

Species released as game birds (Phasianidae). An environmental risk assessment needs to be undertaken for all species considered for release in Europe. In the past chukar *(Alectoris chukar* (Gray)) were released in the Alps, including Switzerland. They can hybridize with the native rock partridge *(Alectoris graeca* (Meisner)). The chukar is the eastern equivalent of the rock partridge. These releases are unnecessary and pose a potential danger to the indigenous rock partridge, which is one of the nine European endemic bird species.

Management options for the species which can cause problems are detailed in the text relating to the species and in the Fact Sheets, e.g. ruddy duck and ruddy shelduck should be shot.

Four main recommendations are drawn from this compilation:

> Based on international obligations to safeguard the globally endangered white-headed duck, the ruddy duck has to be eliminated (shot) whenever it is found in Switzerland. Furthermore, the species should not be kept in captivity.
> Switzerland has a responsibility in relation to the potential spread of the ruddy shelduck. It should prevent the spread of the Swiss population and consider eradicating it.
> Birds held in captivity should be monitored closely and escape prevented. Containment of birds under semi-wild conditions should be restricted or prohibited.
> All releases of birds into the wild should be subject to authorization, whereby releases of alien species should be avoided and releases of native birds should be made using genetic material typical of the region.

Tab. 2.3 > Established birds (neozoa) in Switzerland and species to watch for (last three species).

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Phalacrocorax carbo L.	Phalacrocoracidae	Europe	2000	Escaped from captivity	Breeding colonies destroy trees and other vegetation below trees. Impact on fishery heatedly debated. Fish farms	First breeding attempts recorded
Cygnus olor (Gmelin)	Anatidae	North-eastern Europe	1690	Releases for aesthetic reasons	Decline of submerged aquatic vegetation	A much-liked species
Anser anser (L.)	Anatidae	Parts of Europe	1983	Released as an enrichment of the avifauna	Probably no environmental impact Damage of crop possible	Wild form of the domestic goose
Tadorna ferruginea (Pallas)	Anatidae	Central Asia and northern Africa	1997	Escaped from captivity	Aggressive behaviour towards other waterfowl	CH has responsibility for the only viable population in the introduced European range
Aix galericulata (L.)	Anatidae	East-Asia	1958	Escaped from captivity	Competition for tree holes with other cavity breeding species?	Population is small in CH, but other European populations expanding
Phasianus colchicus (L.)	Phasianidae	Asia	18th century?	Released as game	Competition with native game birds? Indirect effects by predator control to relieve pheasants from predation	Pheasant densities are mainly determined by the extent of releases
Branta canadensis (L.)	Anatidae	North America	-	Released as an enrichment of the avifauna	Competition with native waterfowl Hybridization with greylag goose Damage to crops Droppings can be a nuisance and cause eutrophication in water	Has not yet reached Switzerland
Alopochen aegyptiacus (L.)	Anatidae	Sub-Saharan Africa	-	Escaped from captivity	Aggressive behaviour towards other waterfowl	Has not yet reached Switzerland
Oxyura jamaicensis (Gmelin)	Anatidae	North America	-	Escaped from captivity	Hybridization with the globally endangered white-headed duck threatens the extinction of the latter species	There is no established population, only records of single birds. These need to be shot under an EU-wide effort.

2.3 Reptiles – Reptilia

Three snake species have been relocated within Switzerland, from southern locations to colder, northern localities. Two of these relocations were very local. The re-introduction of the European pond terrapin used alien genetic material. The only alien reptile species in Switzerland as a country are aquatic turtles released from aquariums, but they seem not to have established populations yet (Table 2.4).

The case of the **Italian wall lizard** *(Podarcis sicula* (Rafinesque-Schmaltz)) in Switzerland is rather mysterious (Hofer et al., 2001). It is not known whether the species is native or alien nor is it proven that an established population exists at all. Since specimens were found along the railway tracks in the Ticino, an accidental introduction from Italy seems likely.

The **dice snake** *(Natrix tessellata* (Laurenti)) is one of the most endangered snakes in Switzerland, because it is at the north-western limit of its range (thus it is naturally rare). It is native to the Ticino, but was released north of the Alps at several lakes (Gruschwitz et al., 1999). Although it is rare in Switzerland, it should not be relocated to the north of the Alps. At the Lac de Genève, where it now occurs together with another rare snake species, the viperine snake *(Natrix maura* (L.)), it is probably competing with the native species for food and habitat, since the two species have a rather similar biology, one occurring in south-western Europe and the other in south-eastern Europe (Hofer et al., 2001).

Small populations of the **western whip snake** *(Coluber viridiflavus* (Lacépède)) might have established at the Neuenburgersee and in the Valais, from specimens collected in the Ticino and released in these areas. The impacts of these populations are probably negligible and the populations themselves might not persist. Populations of the **Aesculapian snake** *(Elaphe longissima* (Laurenti)) at the Neuenburgersee and Bieler See may have originated in the same way and again have little impact. The latter species does seem to be established (Hofer et al., 2001).

The status of the **European pond terrapin** *(Emys orbicularis* (L.)) in Switzerland is not yet resolved (Hofer et al., 2001). Some populations might still be native, but there were many re-introductions of the species. In most instances the origin of the specimens released is not known, but releases of non-native material could lead to genetic introgression into possibly surviving native populations. However, this concern remains hypothetical because of the lack of knowledge of the status of extant populations.

The North American **red-eared slider** *(Trachemys scripta* (Seidel)) (see Fact Sheet) is representative here of a guild of potential IAS – aquatic turtles from several genera. In past years, several countries restricted the importation of this species, because of the potential threat. However, this merely leads to a shift to other species by the aquarium trade. The red-eared slider is still the species most often found in the wild in high numbers and many places, although, because of the direct releases in parks etc., the species is predominantly recorded around agglomerations (Geiger and Waitzmann, 1996). The red-eared slider is probably not yet established in the wild in Switzerland, but this might change through adaptation and future releases of specimens from a more northern natural distribution in North America. Reproduction has been repeatedly observed in areas of Europe with a Mediterranean climate. However, even without reproduction, the populations in certain areas of Switzerland are extremely high owing to frequent releases and the longevity of the species. Therefore there is the potential for native biodiversity to be affected, even if reproduction fails. A recent study by Cadi and Joly (2004) found both weight loss and high mortality in the native turtle *Emys orbicularis* (L.) in mixed groups and argues for applying a precautionary principle. The introduced species also outcompetes the native turtle for preferred basking places (Cadi and Joly, 2003). The red-eared slider is one of the species mentioned in the Recommendations of the Bern Convention, as described above.

Since no alien reptile species has established populations in Switzerland, no general pattern can be discussed here, except to note that the situation in neighbouring countries is rather similar.

Reptiles depend to a large extent on climate, especially temperature, because they can regulate their body temperature only to a certain degree. Thus, tropical and subtropical species, which are most frequently kept in terrariums, are not of concern, apart from escapes of the occasional crocodilian or dangerous snake. However, this is more a matter of interest for the media than a true threat. A real concern for native biodiversity are species from North America and east Asia (China), mainly turtles, which could become established in the Swiss climate. Two measures should be implemented to restrict this threat:

1. Raising awareness in the human population of the potential problem, and especially in herpetological clubs and organizations.
2. Implementing laws to minimize releases and escapes of species which could potentially cause problems, e.g. article 25 of the Eidgenössisches Tierschutzgesetz (Swiss Animal Protection Act) stipulates the penalties for releases of this kind.

Tab. 2.4 > Established alien reptiles in Switzerland.

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Natrix tessellata (Laurenti)	Colubridae	Ticino – Switzerland	1920s	Released	Competition with *Natrix maura*	Relocation within Switzerland
Emys orbicularis (L.)	Emydidae	?	1800s?	Released	Genetic introgression with native populations?	Re-introduction
Trachemys scripta (Seidel)	Emydidae	North America	Fairly recent	Released Escaped?	Competition with native turtles in Europe Predator Destroying and disturbing floating bird nests	Perhaps not established, but long-lived

2.4 Amphibians – Amphibia

Currently 20 amphibian species are found in Switzerland. One species *(Rana ridibunda* Pallas), i.e. 5% of the total Swiss species number, is introduced and established and will be discussed below and in a Fact Sheet. A second species has been relocated within Switzerland *(Triturus carnifex* (Laurenti)) and a third species is found occasionally but has not yet been able to establish a population, i.e. the North American bullfrog *Rana catesbeiana* Shaw (Table 2.5).

The **marsh frog** *(Rana ridibunda*) (see Fact Sheet) is the only introduced alien amphibian species at the national level. It was introduced between 1920 and 1950, probably from Hungary, as was the case with specimens released in the UK (Zeisset and Beebee, 2003). The most probable explanation for the introductions is that they were imports for human consumption. The marsh frog has now established with a wide distribution in Switzerland, mainly in the west and the Valais and in the north-eastern region. The species should not be supported, as native amphibian species are, by local conservation groups, and releases on conservation grounds or as a food resource need to be stopped. The role of the genetic peculiarities in the green frog complex are not fully understood, but in most places where the marsh frog is increasing the other two related species are decreasing. Thus, a displacement is evident.

Another species introduced into a new range is the **Italian crested newt** *(Triturus carnifex)* (see Fact Sheet), which is native to the south of Switzerland (Ticino) but was introduced to the canton of Genève. Genetic studies showed that the Genève population is closest genetically to a population in Tuscany, Italy (Arntzen, 2001). Most probably the species was imported for zoological experiments and released into a pond at the University of Genève. It completely replaced the closely related great crested newt *(Triturus cristatus* (Laurenti)) in that area. However, it is a complex situation and there is hybridization between the two species. The distribution and spread of the Italian crested newt should be monitored to provide information for future decisions about this species and its threat.

The **American bullfrog** *(Rana catesbeiana)* (see Fact Sheet) has not (yet) colonized Switzerland, but there are some recent unconfirmed records of the species. However, it is established in the neighbouring countries of Germany, France, and especially Italy in the Po valley with some rapidly expanding populations. Research has demonstrated its high potential to cause a decline in native amphibians and reptiles. Thus, bullfrogs should not be tolerated in the wild. Monitoring of suspect water bodies and raising awareness in the human population for this potential menace to native biodiversity is of high priority.

In Switzerland only one frog is introduced and established, this is 5% of the 20 amphibian species currently found in Switzerland. In Austria (Schuster and Rabitsch, 2002) and Germany (Geiter et al., 2002) no established amphibians are listed, although it is possible that the American bullfrog has established unnoticed in the recent past –

there is an increasing number of records from Germany. The introduced species in Switzerland, the marsh frog, is native in Austria and Germany.

Species of edible frogs may be illegally released as a food resource and game animal. In certain areas, notably western Switzerland, *R. ridibunda* is still imported in large numbers for human consumption and it is likely that some escape. This has been particularly true in the past with less rigid control of transport and containment. Thus, the current populations have most probably developed from these escapees. It seems likely also that some amphibians are released or escape from captivity as pets. Thus the pet trade should have a responsibility to educate the public about the potential threat of alien species to native biodiversity. Trade in certain species, such as the American bullfrog, should be prohibited.

All three species discussed here are known to cause severe damage to native amphibians by preying on the smaller species, through competition as tadpoles, as vector of diseases, or through hybridization. No negative economic impact has been reported.

The major recommendations to reduce the risks caused by alien amphibian species are:

> A stricter regulation of the (pet) trade and implementation of laws and conventions.
> Besides the legislative options, the public needs to be made aware of the potential threats to native biodiversity. Some of them might voluntarily act in a more responsible way.
> Any established populations of American bullfrogs should be eradicated.

Tab. 2.5 > Established alien amphibians in Switzerland.

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Rana ridibunda Pallas	Ranidae	East Europe, probably Hungary	1920s?	Released (as food resource?) Escaped from imports for human consumption	Competition with native amphibians Genetic changes in native green frog complex	Spreading
Triturus carnifex (Laurenti)	Salamandridae	South Europe, including the Ticino	Few decades ago	Released or escaped from containment for scientific studies	Replaced the great crested newt	Native to Switzerland
Rana catesbeiana Shaw	Ranidae	Central and eastern North America	Recent	Released or escaped	Feeding on native amphibians and reptiles Competition with native amphibians Disease vector	Probably no breeding population in CH, as yet

2.5 Fish – Pisces

The situation with regard to introduced fish species in Switzerland is interesting because, with the exception of asp *(Aspius aspius* (L.)), all other species are individually mentioned in Appendixes 2 or 3 of the Fisheries Act of 1993 (Ordinance relevant to the federal fisheries law). In this Act, Appendix 2 describes situations (garden ponds, aquaculture plants, etc.) in which certain alien fish taxa can be released without authorization, while Appendix 3 names fish taxa which are unwanted in Switzerland. In this section, species mentioned in these two Appendixes are referred to as Appendix 2 and Appendix 3 species, respectively. A total of 15 species will be discussed below (Table 2.7), although in some cases natural breeding has not yet been reported from Switzerland. In such cases, populations are based on frequent releases. However, the species lists in Appendixes 2 and 3 suggest all 15 species should be dealt with here, since they are regulated in Switzerland. The common carp *(Cyprinus carpio* L.) is not included in the species discussed in this section, because it is assumed to be an archaeozoa, arriving with the Romans in Central Europe. It was also found in most of Europe before the glacial era. Organisms which occurred before glacial times in Central Europe often stimulate discussions about definitions of native and alien species.

The **bighead carp** *(Aristichthys nobilis* Richardson) (see Fact Sheet) has not yet been reported to reproduce in Switzerland. However, it is assumed that the species could breed, and that is the reason for adding the species to Appendix 3. It is reported to breed in the Danube (Donau).

The **asp** *(Aspius aspius)* is a very recent invader in Switzerland, first recorded in 1994 in the Rhine (Rhein) at Basel (Zaugg et al., 2003). It is probably expanding its range following its introduction into the Rhine in Germany, downstream of Basel. Its natural range seems to be Central and eastern Europe from Germany eastwards, including the Danube system. The Rhine population was either introduced for fishing purposes (Ladiges and Vogt, 1979) or spread from the Danube after the completion of the Rhine–Danube Canal. This is the only alien fish species which was not introduced directly into Switzerland but into a neighbouring country, in this case Germany, and is naturally spreading up the river Rhine. The asp is a large fish (up to one metre long) and prefers large rivers. It is one of the few cyprinids that is a piscivore. The adults eat mainly fish, but also mammals and birds, while the more gregarious living young eat smaller animals such as invertebrates. It is assumed that the species will colonize more parts of Switzerland. Since the natural range is close to Switzerland, the species might be acceptable, as a natural expansion rather than an invasion.

The **goldfish** *(Carassius auratus* (L.)) is a favourite species for aquariums and garden and park ponds. Today, it has acquired an almost pan-global distribution through its ornamental use. It either escapes or is released into the wild. Its native range is Central and eastern Asia. The *Carassius* species (two more are discussed below) are difficult to identify and some records might be misidentifications (Arnold, 1990). Goldfish feed on a wide range of food including plants and small animals. In some places they are regarded as a nuisance due to the production of stunted populations. They produce large numbers of individuals, which mature at a much reduced size, thereby diminishing the usefulness of the population for sport or commercial fishing (Lehtonen, 2002). There are indications that they compete with native fish species and increase turbidity through their bottom dwelling behaviour, as does the common carp, thereby altering the aquatic community. Introductions limited to closed systems are possible without authorization (Appendix 2 species).

The **crucian carp** *(Carassius carassius* (L.)) is probably native to Central and eastern Europe, but was widely distributed by humans throughout western Europe in the Middle Ages for fishing. It was in the recent past, if not still, being sold as a bait fish. The crucian carp is a hardy species that can survive adverse conditions, such as low oxygen levels and frost. It is also an Appendix 2 species, and therefore its use as a bait fish is illegal. The crucian carp is rarely found in Switzerland.

The third *Carassius* species is the **Prussian carp** *(Carassius gibelio* (Bloch)). The taxonomy of the three *Carassius* species is complicated and this species is sometimes considered conspecific with *C. auratus*. The species are very similar in many ways, including appearance, biology, food and potential impact. The actual distribution and the history of introductions and spread are not well known, since the species were probably often misidentified (Arnold, 1990). The Prussian carp is listed in Appendix 2, thus its release outside contained captivity must be authorized.

The **grass carp** *(Ctenopharyngodon idella* (Cuvier & Valenciensis) (see Fact Sheet) is of Chinese origin, but as it is one of the most important aquacultural fish, it has acquired a wide distribution on five continents. Although natural reproduction has not been reported in the wild in Switzerland, it is a species of concern because of its potential to cause massive impacts on ecosystems by removing higher aquatic plants and thereby causing shifts in the producer guilds to other plant species. This impact at the bottom of the food chain can cause major alterations to ecosystems. The grass carp showed some potential to control water weeds in Switzerland, but Müller (1995) concludes that it only controls the symptoms of eutrophication instead of ameliorating the causes of the deteriorating water quality. The grass carp is listed in Appendix 3 and therefore all releases are prohibited.

The **silver carp** *(Hypophthalmichthys molitrix* (Valenciensis)) (see Fact Sheet) is a highly specialized phytoplankton feeder. In many cases it was released to reduce phytoplankton densities or stop algal blooms. Its origin is China, but today it is found in many countries around the world. Spawning requires very specific conditions, but has been recorded in the Danube. Its reproduction in Switzerland cannot be ruled out with certainty, so the species was included in Appendix 3.

The **stone moroko** *(Pseudorasbora parva* (Temminck & Schlegel)) (see Fact Sheet) is a very small cyprinid. It is the only established fish species accidentally introduced to Europe and Switzerland, with shipments of grass carp from China. Whereas the deliberately introduced fish species are of value to the commercial or sports sectors, the stone moroko has no value to humans. Thus, the potential for conflicts over management and legislative measures for the species is reduced and it is an Appendix 3 species.

The **American catfish** *(Ameiurus melas* and *A. nebulosus* (Le Sueur)) (see Fact Sheet) belong to the family Ictaluridae, which is restricted to the subtropical and temperate zones of North America, and were introduced into Europe to investigate their potential as a fish for human consumption. However, they are of little value. The two species are very similar not only in appearance but also in their biology. They are listed in Appendix 3, because of their potential negative impacts on native biodiversity.

The brightly coloured **pumpkinseed** *(Lepomis gibbosus* (L.)) (see Fact Sheet) is an example of an ornamental fish introduced into Europe. It has an interesting breeding behaviour and is very showy. However, in some cases the species flourished and has reached high densities. In these circumstances, this predatory fish will almost certainly have an impact on the food web through selective feeding. It is an Appendix 3 species.

One of the most popular sport fish in North America, the **largemouth bass** *(Micropterus salmoides* (Lacépède) (see Fact Sheet), was widely distributed in North America outside its natural range, and imported to Europe in the 1880s. The adult is a specialized fish predator and a decline in native fish species was observed in Italy after its introduction (Welcomme, 1988). It was also one factor, amongst others, in the extinction of the Atitlán grebe *(Podilymbus gigas* Griscom) which was endemic to Guatemala (BirdLife International, 2000). The bird's population dropped drastically to 80 as a result of competition and predation by the introduced largemouth bass, but recovered to a high of 232 in 1975 when the numbers of the bass plummeted (LaBastille, 1984). Later the grebe became extinct through other factors.

The only established alien Percidae is the **pike-perch** *(Sander lucioperca* (L.)), a species from Central and eastern Europe. It is one of the most popular sport fishing species and a highly priced commercial fish. Hence it has been widely released and has built up self-sustaining populations. It prefers large rivers and lakes, where it is a ferocious solitary pelagic predator. In the UK negative impacts on native fish populations have been confirmed; populations of *Esox lucius* L. and *Perca fluviatilis* L. declined after the introduction of pike-perch (Welcomme, 1988). In Switzerland, releases of the pike-perch without authorization are allowed in contained water bodies and where the pike-perch already occurs without negative effects on the fauna and flora (Appendix 2 species). However, the latter is difficult to prove or disprove, so that this predatory species can be released in many open waters. It was found in 137 localities during the survey for the fish atlas of Switzerland (Zaugg et al., 2003). More rigid legislation would be desirable for this species.

The **rainbow trout** *(Oncorhynchus mykiss* Walbaum) is probably the most widely distributed freshwater fish species and may be regarded as a species of global distribution today. It is a highly prized game fish as well as being widely valued for commercial use. In Switzerland its natural reproduction is suspected but has been proved only in the 'Alpine Rhinesystem'. The observed populations are probably based on extensive stocking of the species. Zaugg et al. (2003) found it in 39% of the Swiss lakes and regarded it as a common species. A self-sustaining population is undesirable, because it would be difficult to control its spread or prevent competition for breeding grounds with the native brown trout *(Salmo trutta* ssp. *fario* L.). Where rainbow trout is extensively released, it will have a negative impact on native salmonids. Mahan (2002) showed that the introduction of the rainbow trout into a North American lake caused a decline of an endemic congeneric species *(O. negratis)* with local extinctions. Drake and Naiman (2000) explain the impact on the habitat. The exception of authorization

(Appendix 2 species) for stocking in alpine lakes should be re-addressed, because of the potential impact on amphibians. Amphibian populations in naturally fishless ponds and lakes will suffer from introductions of alien predatory fish species.

A favourite species for fly-fishing, the **brook trout** *(Salvelinus fontinalis* (Mitchill)), is today a common species in alpine and subalpine lakes of Switzerland (Zaugg et al., 2003). This species probably competes with the native brown trout. Impacts on lake communities have not been studied in Switzerland. In a North American study Bechara et al. (1992) investigated the impact of brook trout on native communities. Overall, their results suggest that size-selective predation by brook trout can cause profound changes in the structure of epibenthic communities at primary as well as secondary trophic levels. Releases of this species are restricted, since it is also an Appendix 2 species.

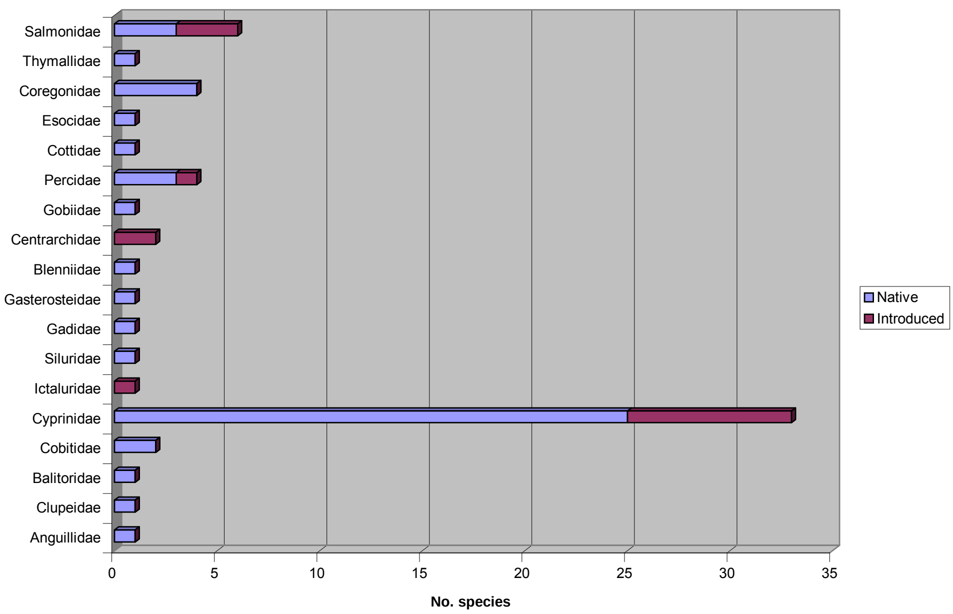
The **lake trout** *(Salvelinus namaycush* (Walbaum)) was chosen to stock many high altitude lakes based on its cold-tolerant, northern distribution in North America. It is a large predatory fish, which can probably cause negative impacts on native fish species. The lake trout is a favourite in recreational fishing. Stocking alpine lakes with this Appendix 2 species is permitted. This will have an effect on amphibians sharing the habitat.

The frequent stocking of water bodies with alien fish species, and also native fish species from abroad, for sport and commercial fishing increases the possibility of introducing diseases (see for example the nematode *Anguillicola crassus* in the Nemathelminthes section in the chapter on 'other selected invertbrate groups'), in addition to the issue of the potential establishment of the alien fish species themselves. Environmental risk studies are recommended before any fish introductions to investigate potential threats. Once the decision to introduce a species is taken, the material may be imported as eggs and some type of quarantine measures should be adopted for imported material prior to its release into natural waters.

The 15 introduced species in Switzerland belong to five families (Fig. 1.1) (as explained above, not all of the species definitely have established populations, but they are included here, since they are listed in Appendixes 2 and 3). Two families are naturally restricted to North America, thus they are new to Switzerland. The Cyprinidae are the most species-rich family in the world with about 2,000 species, so it is not surprising that the highest number of native as well as introduced species belong to this family. It is also interesting to note that eleven families with only one species occur in Switzerland, although several had more members before some became extinct. Today 50% of the salmonids in Switzerland are introduced (three species).

The high number of introduced salmonids reflects their popularity as game fish and for aquaculture. On the other hand, as Table 2.6 shows by comparing the total number of species per family and the number of species introduced to Switzerland, the number of species is a stochastic phenomenon – the smaller families produced a higher percentage of invaders.

Fig. 2.1 > Numbers of native and introduced fish species in different families in Switzerland.



Tab. 2.6 > Total number of members of five fish families worldwide and the number of species in these families introduced into Switzerland.

	Total no. species per family	No. species introduced to Switzerland	Percentage of introduced to total number [%]
Cyprinidae	2000	8	0.4
Ictaluridae	35	1	2.9
Centrarchidae	30	2	6.7
Percidae	159	1	0.6
Salmonidae	66	3	4.5

The lack of certainty about which species are actually established, and which of these are invasive, combined with the different definitions used in national reports, which leads to anomalies regarding which species are listed and how they are categorized, makes a comparison with other European countries such as Austria and Germany difficult. However, the situation appears to be very similar, with the exception of species from Central Europe which are native to Germany. As discussed above, many species are of North American and Asian origin and were widely introduced to Europe, so that they occur also in neighbouring countries.

The 15 introduced species represent about 25% of the current fish fauna. This value is fairly high compared with the figures for the other groups of vertebrates, in which introduced species form less than 10% of the Swiss fauna. This reflects the economic importance of fish species, but also indicates the potential threat to native biodiversity.

The origin of the 15 species is obviously correlated with the climate, since all species are from temperate climates in the Northern Hemisphere, with six each from North America and Asia, and three from other parts of Europe. Mikschi (2002) lists two cichlid species for thermal waters in Austria, and these tropical species can only survive in these warm waters. Three other species from the Neotropics (Poeciliidae) became extinct after their release in the same waters.

The exact pathways for fish introductions are often not known and in many cases introductions have been carried out with more than one motive. Taking the most likely pathways for each species, those released for commercial and sport fishing and aquaculture will amount to 11 of the 15 species. Two species are ornamental releases and escapes, and one was introduced as a control measure for unwanted vegetation. Interestingly, only one species arrived accidentally. However, its arrival is also connected with aquacultural practices, since it was a contaminant in grass carp shipments. In conclusion, the potential threats to native biodiversity are primarily due to fishing activities. Fish releases need to be considered carefully, their threats evaluated, and specimens quarantined to prevent spread of diseases. The number of introductions on a global scale has dramatically decreased since the 1960s, when they peaked, partially because growing awareness of possible negative consequences has led to legislation, but also because of a saturation effect as some species had been introduced to all suitable recipient areas (Welcomme, 1988).

The demonstrated impacts of the 15 species are detailed in Table 2.7 and in the accounts for individual species, above. They encompass the entire range of effects measured, i.e. predatory and grazing pressure, competition with native species, changes in water quality, community and food-web changes, disease vectoring and hybridization.

All potentially harmful species are regulated by Swiss law and are listed in Appendix 2 or 3. This is a very good basis for management of alien fish species in Switzerland, although some of the Appendix 2 species which harm native biodiversity can be stocked in alpine lakes without authorization. This is especially worrisome in the case of predatory fish released into previously fishless lakes, where they can damage the amphibian populations.

Therefore it is recommended that the species of Appendix 2 are re-addressed and stricter regulations are provided for those species.

Another point of concern are species native to Switzerland released outside their native range, as noted in the sections of this chapter on reptiles and amphibians. The roach *(Rutilus rutilus* (L.)), for example, is native to the northern side of the Alps but was released in the Ticino, where it competes with the native fish fauna.

Tab. 2.7 > Alien fish species in Switzerland.

Scientific name	Family	Origin	Year	Pathway	Impact	Note
Aristichthys nobilis Richardson	Cyprinidae	China	?	Released for fishing	Changes of community and habitat?	Appendix 3 species
Aspius aspius (L.)	Cyprinidae	Central and eastern Europe	1994	Released for fishing in Germany Migration through new canal systems	Harmless	Not in the Appendixes
Carassius auratus (L.)	Cyprinidae	Central and eastern Asia	?	Released and escaped; imported as ornamental fish	Competition with native fish species? Community changes by increasing water turbidity?	Appendix 2 species
Carassius carassius (L.)	Cyprinidae	Europe	?	Released for fishing Bait fish	Competition with native fish species? Community changes by increasing water turbidity?	Appendix 2 species
Carassius gibelio (Bloch)	Cyprinidae	Probably Asia	?	Released for fishing	Competition with native fish species? Community changes by increasing water turbidity?	Appendix 2 species
Ctenopharyngodon idella (Cuvier & Valenciensis)	Cyprinidae	China	?	Aquaculture Released to control aquatic vegetation	Can change the ecosystem by removing aquatic plants	Appendix 3 species
Hypophthalmichthys molitrix (Valenciensis)	Cyprinidae	China	1970	Released for control of phytoplankton	Community and food-web changes by feeding on phytoplankton	Appendix 3 species
Pseudorasbora parva (Temminck & Schlegel)	Cyprinidae	East Asia	1990	Accidental introductions with other cyprinid imports	Community and food-web changes by selective feeding on zooplankton Chances in water chemistry No commercial value	Appendix 3 species
Ameiurus melas and *A. nebulosus* (Le Sueur)	Ictaluridae	Central and eastern North America	?	Aquaculture Aquarium releases	Predator Competition with native fish species Little commercial value	Appendix 3 species
Lepomis gibbosus (L.)	Centrarchidae	Eastern North America	?	Ornamental reasons Released for fishing	Predator of small invertebrates and vertebrates	Appendix 3 species
Micropterus salmoides (Lacé-pède)	Centrarchidae	Central and eastern North America	?	Released for fishing	Decline of native fish species	Appendix 3 species
Sander lucioperca (L.)	Percidae	Central and eastern Europe	?	Released for fishing	Ferocious predator	Appendix 2 species
Oncorhynchus mykiss Walbaum	Salmonidae	North America Stock from Germany	1887	Released for fishing Aquaculture	Predator of native fish and am-phibians Competition with native salmonids	Appendix 2 species
Salvelinus fontinalis (Mitchill)	Salmonidae	Eastern parts of North America Stock from Germany	1883	Released for fishing Aquaculture	Competition with native salmonids	Appendix 2 species
Salvelinus namaycush (Walbaum)	Salmonidae	North America	1888	Released for fishing	Predator of native fish Competition with native salmonids	Appendix 2 species

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3 > Crustaceans – Crustacea

Prepared by Rüdiger Wittenberg

It is not possible to draw up a comprehensive list of established alien crustaceans in Switzerland owing to gaps in knowledge for some groups and some regions. Another complicating factor is the rapid changes in species composition in the large rivers. Some new invaders are showing an explosive expansion in their ranges and densities. Despite these shortcomings, a preliminary list has been compiled using available information. As with all lists of alien and invasive alien species, it is crucial to update and add new information about distribution, impacts and management options as it becomes available. However, this list is believed to be a good basis for future expansion, since a comparison with neighbouring Austria shows similarities in species and species numbers.

Table 3.1 summarizes available information on 17 established alien crustacean species in Switzerland. Six of them are considered to be harmful to the environment. More information on these species is presented in the Fact Sheets at the end of this chapter.

There is little information available on *Daphnia parvula* Fordyce (Cladocera) and *Atyaephyra desmaresti* (Millet) (Atyidae) and their invasions might be of little significance for native biodiversity.

The copepod *Cyclops vicinus* Uljanin is thought to have impacted native species by its predatory behaviour.

The amphipod *Corophium curvispinum* (Sars) (Corophiidae) (see Fact Sheet) is a considerable threat to native ecosystems. This species is an ecosystem engineer and occurs at fairly high densities. In the Rhine between Basel and Bodensee it was the species with the third highest number of specimens per square metre, i.e. about 9,200 individuals (Rey and Ortlepp, 2002).

Six members of the family Gammaridae are established alien species in Swiss waters. Four of these are of Ponto–Caspian origin, while one invaded Central Europe from south-western Europe and one species came from North America. Of the three species *Echinogammarus ischnus* (Behning), *E. trichiatus* (Martynov) and *E. berilloni* Catta only the first-named is known to have a negative impact on the environment (see Table 3.1), while insufficient is currently known about the other species to judge. The American species *Gammarus tigrinus* Sexton may change the food web after invasion. Two *Dikerogammarus* species have invaded Switzerland, *D. haemobaphes* (Eichwald) and

D. villosus (Soyinski). The latter species is the largerst of the invaders and has considerable impact on the ecosystem (see Fact Sheet).

Introduced freshwater crayfish species, comprising four species in two families, Astacidae and Cambaridae, represent one of the greatest threats to Swiss biodiversity. *Astacus leptodactylus* Eschscholtz (see Fact Sheet) introduced from parts of south-eastern Europe and south-western Asia is of least concern, although it can potentially compete with native crayfish. The other three species *(Pacifastacus leniusculus* (Dana), *Orconectes limosus* (Rafinesque) and *Procambarus clarkii* Girard) (see Fact Sheets) are of North American origin. They are not susceptible to the crayfish plague (see the chapter on Fungi), but they are vectors of the disease, carrying it into European crayfish *(Astacus astacus* (L.)) populations. The severity of the disease in these populations raises grave concerns about the survival of the native crayfish species.

The three Isopoda species (see Table 3.1) may not pose a threat to Swiss freshwater ecosystems, despite the enormous densities of the tiny Ponto–Caspian invader *Jaera istri* Veuille.

With respect to the taxonomic composition of the established species, two groups are dominant, i.e. the amphipods with seven species and the crayfish with four species. The amphipods are a successful group of about 6,000 species (Pöckl, 2002). They often dominate ecosystems in numbers of individuals as well as in biomass owing to their high fecundity under optimal conditions. Their omnivorous behaviour renders them adaptive to changing species compositions. The rapid invasions and build up of tremendous densities of alien amphipods are legendary. The interactions of native and rapidly invading alien species are very complex and difficult to understand. The fluctuations in densities are considerable and sometimes new invaders replace earlier invaders. Haas et al. (2002) give an overview of changes in abundance of alien species in the Rhine. The crayfish, as the second dominant group, belongs to the Decapoda, whose major centre of distribution is in North America and there are only a few species in Europe. The economic importance of crayfish is, of course, the major incentive for introducing alien crayfish into Europe.

A comparison of alien crustaceans established in Switzerland and in neighbouring countries is not without flaws, because of gaps in knowledge. However, the 17 species listed here compare quite well with the 19 species recorded for Austria (Essl and Rabitsch, 2002). Geiter et al. (2002) list 26 species for Germany, but this includes species living in marine and brackish environments.

The origin of the alien crustaceans established in Switzerland is equally divided between North America (including three crayfish species), the Ponto–Caspian region (five of the seven amphipods) and Mediterranean parts of Europe. The Ponto–Caspian region is essentially the area of the Black and Caspian Seas and their adjacent rivers. Many species endemic to the Ponto–Caspian region have become established in Europe, the Baltic Sea and, more recently, the Great Lakes in North America. This extraordinary spread has been facilitated by the construction of numerous canals allowing species to disperse by active migration and, to a greater extent, with ship traffic (in ballast tanks and through hull-fouling). Many Ponto–Caspian crustaceans were also transplanted between water bodies as food for native fish to stimulate fish production within the former USSR.

Although the exact time and place of the first introductions of many species are not documented, the data available suggest that many of them have invaded Switzerland fairly recently. Thus, further spread and increase in species densities in the short or long term are very likely. Moreover, other species are expected to arrive via river systems.

With the exception of the crayfish species, almost all the crustacean invasions of Switzerland have been facilitated by the construction of canals and ship traffic. In most cases it is difficult to prove the exact pathways for the various species. Natural migration of some mobile species along rivers and canals is likely to be important over short distances. However, the rapid expansion of most species and some isolated records indicate spread by ship traffic, either in ballast tanks or on hulls. The crayfish species, however, were deliberately introduced as a food resource for human consumption. Additionally, escapees from aquaculture facilities have founded several populations. A third pathway is the importation of live crayfish for consumption. Crayfish are a delicacy and have to be added to boiling water alive. Thus, they are imported alive and some may have escaped. Moreover, some specimens escape from aquariums and garden ponds, or are released by their owners, who no longer want to keep them.

The impacts of the species, especially the six high-risk species, are detailed in the Fact Sheets and in Table 3.1. The three North American crayfish species are of greatest concern with regard to the survival of the native crayfish populations, because they act as a vector of the devastating crayfish plague. The two amphipod species *D. villosus* and *C. curvispinum* alter the invaded habitats by predation, competition and causing changes to the substrate. Demonstrating impacts of alien species on native biodiversity and ecosystems is always difficult owing to the complex interactions. In conclusion, species thought to be harmless may turn out to have some, as yet undetected, negative impacts. This is especially true for freshwater ecosystems. Many of the alien species occur in enormous abundance. This must have some impact on the ecosystem, since each individual uses some resources and is a resource for others. Rey and Ortlepp (2002) found that the biomass in the Rhine near Basel was dominated by alien species – 97% of the animal biomass and more than 90% of the individuals were of alien origin. Thus, the original character of the Rhine has vanished; in this area it is not the typical Rhine anymore. Most of the alien species have invaded this stretch of the Rhine within the past five years. This suggests that their distribution will further expand and their dominance in other areas will increase. The dominance of alien species in European (and other continental) inland waters is dramatic.

In most cases, eradication of established problematic species is not feasible. Control has limited success in open freshwater systems, such as rivers. Some species, in particular the crayfish, have economic value and intensive fishing could reduce their numbers. However, a reduction in the crayfish population might not be a sufficient goal, given the great threat they pose to native crayfish. One crayfish plague-infested alien crayfish could be enough to wipe out a healthy population of their European relatives. Migrating specimens of alien crayfish were observed even in low-density situations, so a reduction might not prevent their spread. Thus, prevention of further introductions of species into and within Switzerland should have highest priority to safeguard native biodiversity and ecosystems. North American crayfish species are of greatest concern. With respect to releases of problematic freshwater species (e.g. for fishing and from aquarium dumping) an awareness-raising campaign would be crucial to sensitize the public to the potential problems caused by alien species. Accidental arrival of new species with ship traffic can only be minimized by effective treatment of ballast water and ships' hulls. Crayfish species other than those mentioned above must be regulated too. An Australian species, *Cherax destructor* Clark for example, has been found in Switzerland (Stucki and Jean-Richard, 2000) and is being kept as a pet in aquariums and garden ponds owing to its beautiful appearance. The release of pets is illegal, but the unfortunate fact is that it is used as a way of getting rid of unwanted individuals, and they are also capable of escaping from ponds.

Tab. 3.1 > Established alien crustaceans in Switzerland.

Scientific name	Taxonomic group	Origin	Year	Pathway	Impact	Note
Daphnia parvula Fordyce	Cladocera	America	1972	Ship traffic	Change in food web?	First European record in the Bodensee (Lake Constance)
Cyclops vicinus Uljanin	Copepoda	Europe	1954	Fish releases?	Predator of native crusta-ceans	Found in the Bodensee.
Atyaephyra desmaresti (Millet)	Atyidae	Mediterranean	?	Expanding along canals, ship traffic?	No impact shown	Likely to expand further throughout Europe
Corophium curvispinum (Sars)	Corophiidae	Ponto–Caspian	1980s	Ballast water Also migration	Change of ecosystem by transferring hard substrate to muddy areas. Reduces available habitat for hard substrate species	Rapid colonization of the Rhine
Echinogammarus ischnus (Behning)	Gammaridae	Ponto–Caspian	1990s	Ship traffic Migration	Modifies substrate sediment. Alters energy flow between pelagic and benthic organ-isms. Additional prey for fish. Excludes competing species	Invader of a large portion of Europe
Echinogammarus trichiatus (Martynov)	Gammaridae	Ponto–Caspian	-	Ship traffic	Not known	Likely to reach Switzerland in the near future
Echinogammarus berilloni Catta	Gammaridae	South-western Europe	20th century	Migration through canals	Not known	Probably still invading Europe
Dikerogammarus haemobaphes (Eichwald)	Gammaridae	Ponto–Caspian	1990s	Ship traffic Migration	Not known	Decreasing in Europe, because of the invasion of *D. villosus*
Dikerogammarus villosus (Sovinski)	Gammaridae	Ponto–Caspian	Late 1990s	Ship traffic	Predator of alien and native gammarids and other prey	Replacing earlier invaders
Gammarus tigrinus Sexton	Gammaridae	North America	1990s	Ship traffic Migration	Changes in food web?	Introduced from North America in ballast water
Astacus leptodactylus Eschscholtz	Astacidae	South-eastern Europe	1980s	Release for fishing	Competition with native crayfish species	Important competitor for native crayfish species, but also vulnerable to the crayfish plague
Pacifastacus leniusculus (Dana)	Astacidae	North America	?	Release for fishing	Competition with native crayfish species Vector of the crayfish plague	Very destructive invader, displacing native crayfish species
Orconectes limosus (Rafinesque)	Cambaridae	North America	Before 1976	Release for fishing	Competition with native crayfish species. Vector of the crayfish plague	Very destructive invader, displacing native crayfish species
Procambarus clarkii Girard	Cambaridae	Southern North America	?	Release for fishing	Competition with native crayfish species. Vector of the crayfish plague	Very destructive invader, displacing native crayfish species
Proasellus coxalis (Dollfuss)	Asellidae	South-western Europe	Second half of 20th century	Ship traffic	Not known	Rhine, but not common
Proasellus meridianus (Racovitza)	Asellidae	South-western Europe	Second half of 20th century	Ship traffic	Not known	Rhine, near Basel, but not common
Jaera istri Veuille	Jaeridae	Ponto–Caspian	End of 1990s	Ship traffic	Not known, but very abun-dant	One of the species with the highest abundance – likely to increase further

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4 > Insects – Insecta

Prepared by Marc Kenis

4.1 Introduction

Insects probably represent the most numerous exotic organisms in Switzerland. A list of insects that are considered to be of exotic origin has been drawn up, with the help of specialists (see Tables 4.1–4.6). It includes 311 species of exotic origin that have certainly or probably been introduced into Switzerland or neighbouring countries by human activities. It does not include species that are spreading naturally into Switzerland, unless they were first introduced into neighbouring countries. This list is by no means complete, but it will be maintained and new records will be added when data become available. In collaboration with taxonomists for the various insect groups, we also intend to publish this list in peer-reviewed journals, with more details on the occurrence, distribution and biology of the exotic species. The two published lists of alien organisms in Austria and Germany (Essl and Rabitsch, 2002; Geiter et al., 2002) have been of great help in the construction of the Swiss list.

Many problems were encountered in drawing up the list, the main ones being detailed below.

> There is an obvious lack of information sources in Switzerland. Up-to-date, published checklists are available for a few insect groups only (e.g. Diptera, Orthoptera, Odonata). The 'Centre Suisse de Cartographie de la Faune' (CSCF) is maintaining incomplete lists with the input of Swiss taxonomists, and several lists of other important insect groups are in the process of being completed (e.g. Coleoptera, Lepidoptera, Aphidoidea, etc.). The CSCF and individual taxonomists were very cooperative in helping us check and complete the list of exotic insects; nevertheless, it has been a rather difficult task. For some groups, there is presently little expertise in Switzerland, and no recent checklist is available (e.g. most primitive orders and Mallophaga, which are therefore not included in the list, and also parts of the Hymenoptera, Heteroptera, etc.). Additionally, it must be noted that in the few checklists published, the origin of the species is often not clearly indicated. For future checklists, we suggest including the 'exotic character' and the area of origin in the data set.
> Many alien insects in Switzerland originate from the Mediterranean region. Some of these species, particularly Hemiptera, were evidently introduced with their host plants, which are often planted as ornamentals or crops in Switzerland. However, for other species, it is not clear whether they were introduced by human activities or arrived naturally (e.g. the Heteroptera *Arocatus longiceps* and *Deraeocoris fla-*

vilinea). Some species undoubtedly migrated unaided from southern Europe to Switzerland, possibly because of global warming. This is, for example, the case for the dragonflies *Sympetrum meridionale* (Selys) and *Crocothemis erythraea* (Brullé). Likewise, many Lepidoptera species (e.g. *Helicoverpa armigera* (Hübner) and *Mythimna unipuncta* (Haworth), which used to be observed only occasionally in summer in southern Switzerland, are now overwintering in the country more frequently. Eastern European insect species are also increasingly observed in Switzerland. For most of them, it is not clear whether their introduction into Switzerland was natural or by human-mediated transport, and whether they are firmly established or not. In general, species whose establishment in Switzerland seems to be the result of a natural process were not included in our list. However, this phenomenon would merit further studies.

> High numbers of tropical or subtropical insects are found in Switzerland in houses, greenhouses and other confined environments. Many of them are important pests of greenhouse crops (e.g. several thrips and whiteflies) or stored products (e.g. various beetle and moth species). However, it is not always easy to determine whether these insects are firmly established, or regularly introduced from abroad with new plant material. Furthermore, some species that were thought to be confined to greenhouses are now found outdoors in natural environments. Examples include, among others, the scale insects *Icerya purchasi*, *Coccus hesperidum* and *Dynaspidiotus britannicus* (Kozar et al., 1994).

> Today, many insects, particularly those feeding on stored products and crops and occurring as ectoparasites of vertebrates are considered to be of cosmopolitan distribution and, therefore, it is often difficult to assess their exotic status and some will finally be concluded to be cryptogenic species. Only insects that are suspected to be exotic, for any reason (e.g. because they feed only on an exotic plant, or because the genus is considered exotic) are included in the list.

Invasive alien insects are serious threats to agriculture, economies, the environment and human and animal health worldwide. In some regions, such as North America, South Africa and many oceanic islands, exotic insect pests are considered to be as important as native pests, if not more so. Traditionally, problems have been less severe in Central Europe. Only a few exotic insects are known to cause serious damage in Switzerland, usually as stored product pests or on agricultural crops. However, in recent years several pests of economic importance have invaded Europe, stimulating more interest in the issue of exotic insects. For example, the western corn rootworm, *Diabrotica virgifera* ssp. *virgifera* is seriously threatening European maize production, and the horse chestnut leaf miner, *Cameraria ohridella*, is causing much public concern because of its spectacular damage to urban trees in Central Europe.

Worldwide, environmental impacts have been studied less for alien insects than for other groups of invasive organisms such as plants or mammals. However, many insects are known to cause serious environmental damage in invaded habitats. Here again, most of these cases are from outside Europe. For example, the hemlock woolly adelgid, *Adelges tsugae* Annand, is threatening unique forest ecosystems in North America (Jenkins et al., 1999); the scale insect *Orthezia insignis* Browne was in the process of pushing the endemic gumwood tree *Commidendrum robustum* DC. in Saint Helena to the brink extinction when a successful biological control programme was implemented (Fowler, 2004). In Europe, there have been few similar examples. Recently, however, the Argentine ant *Linepithema humile* has been causing changes in invertebrate and plant communities in the Mediterranean region by predation and displacement of native species (Gómez and Oliveras, 2003). The horse chestnut leaf miner is an urban pest in Central Europe but, in the Balkans, it is threatening the few remaining indigenous horse chestnut populations. In general, most alien insects have not been the targets of serious environmental impact studies. Their interaction with the native fauna and flora has been rarely investigated, particularly if their habitat is of little economic concern. Environmental impacts may be direct (on a plant for a herbivore, or on a prey for a predator), but the invader may also have an indirect impact on co-occurring organisms, e.g. through sharing the same food webs. Among the over 300 recorded exotic insects in Switzerland, surely more than one has an important environmental impact within the newly invaded ecosystem? Investigations on the impact of invasive species should not be restricted to species of economic importance, but should also focus on abundant species in poorly studied ecosystems, in which important environmental impacts may have been overlooked.

The gaps in knowledge of the Swiss insect fauna, as explained at the beginning of this chapter, precludes any conclusive evaluation of its status, i.e. what percentage of the Swiss insect fauna is alien, the origins of the alien species, and the pathways by which they reached Switzerland. However, the fact that many species were apparently introduced with their host plants and food indicates that trade in commodities is a major pathway of insect introduction into Switzerland. Furthermore, it is certain that the majority of the alien insect fauna was accidentally introduced. Prevention of entry of pest species is addressed by quarantine regulations and interception; however, species of environmental concern are mostly not covered by these measures. Control of alien insect populations is also focussed on species of economic importance.

4.2 Coleoptera

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There is no recent checklist of Coleoptera of Switzerland. However, Lucht (1987), in his catalogue of Coleoptera of Central Europe, includes distribution data for northern Switzerland. Furthermore, Claude Besuchet, Muséum d'Histoire Naturelle, Genève, is currently compiling a checklist for Switzerland, and he kindly helped us complete our list with his unpublished data.

Over 120 beetle species are known, or suspected, to be of exotic origin in Switzerland, which accounts for about 40% of the list of alien insects. Many of these exotic species are domestic pests, often feeding on stored products, construction material, etc. The main pests of stored products are found in the families Anobiidae, Bostrichidae, Bruchidae, Cucujidae, Curculionidae, Dermestidae, Mycetophagidae, Nitidulidae, Ptinidae, Silvanidae and Tenebrionidae. Most of them have been transported with their food and are now found worldwide. Their artificial cosmopolitan distribution renders the identification of their origin difficult. Some species, in particular many Dermestidae, may actually be native to Central Europe. Thus the inclusion of some species in the list is questionable.

Some of the stored product pests are of tropical origin and are strictly domestic in Switzerland, whereas others can also survive and reproduce under outdoor conditions. Many more species than those listed in this study are found associated with stored products in Switzerland. However, it is not always clear whether these species are established, or regularly introduced with imported goods. Our list includes only the species thought to be established, although, in several cases, the decision on whether to include them or not was rather subjective. For example, we did not include the coffee bean beetle, *Araecerus fasciculatus* De Geer, a species often found in imported coffee and cocoa beans in Swiss food factories, but not clearly established in the country.

Hoppe (1981) surveyed stored commodities in Switzerland and found the most destructive beetles to be the curculionids *Sitophilus granarius* and *S. orizae*, the silvanid *Oryzaephilus surinamensis* and the tenebrionids *Tribolium castaneum* and *T. confusum*, all considered to be of exotic origin.

Apart from stored product pests, few exotic beetles are recorded as agricultural pests in Switzerland. However, two important chrysomelid beetles are worth mentioning. The infamous Colorado potato beetle, *Leptinotarsa decemlineata* invaded Europe from North America in the 1920s and reached Switzerland in 1937. It is a major pest of potato in Europe and North America (see Fact Sheet). More recently, the western corn rootworm, *Diabrotica virgifera* ssp. *virgifera*, a Nearctic species, took the same road and arrived in Belgrade in 1992. Twelve years on, it has spread to more than 12 European countries, including Switzerland (see Fact Sheet). *D. virgifera virgifera* is considered the major pest of maize in North America and substantial economic damage has already been observed in Central and eastern Europe.

Some exotic beetles are damaging to forest and ornamental trees. Xylophagous insects are notorious for being easily introduced into new regions through the importation of timber or solid wood packing material. At least six Scolytidae in Switzerland are of alien origin. In particular, the Asian *Xylosandrus germanus* and the North American *Gnathotrichus materiarius* damage freshly cut logs and reduce timber quality. They both arrived in Switzerland in the 1980s (see Fact Sheet for *X. germanus*; Hirschheydt (1992) for *G. materiarius*). Other wood boring scolytids arrived in Switzerland very recently: *Tripodendron laeve* from East Asia or Scandinavia, *Xyleborinus alni* from East Asia, and *Xyleborus punctulatus* from Siberia (C. Besuchet, pers. comm.). Similarly, the cerambycids *Neoclytus acuminatus* and *Xylotrechus stebbingi*, xylophagous beetles from North America and the Himalayas, respectively, have recently been found in the Ticino (C. Besuchet, pers. comm.). Although these species have not yet caused economic or environmental damage in Switzerland, their introductions show that international movement of timber and timber products is an important introduction pathway for bark and wood boring beetles that may eventually lead to the establishment of serious forest pests. Among these potential introductions are the two Asian cerambycids *Anoplophora glabripennis* (Motschulsky) and *A. chinensis* (Forster). Both species are important pests in Asia, attacking and killing a whole range of tree species (see Fact Sheets for both species). They were both introduced into North America in the 1990s, where they are now the targets of large-scale eradication programmes. These species have been often intercepted at ports of entry into Europe and, in the last four years, field populations have been found at various sites in Europe (in Austria, Germany and France for *A. glabripennis*; in Italy and France for *A. chinensis*). Eradication programmes have been established but the population of *A. chinensis* in Italy, at least, is considered to be established. The potential damage these two species could cause in Europe is unclear, but it could be spectacular. *A. glabripennis* is usually introduced as eggs, larvae or pupae in solid wood packing material, i.e. crating, pallets or packing blocks from China. *A. chinensis* has been transported to North America, France and Italy in bonsai trees from Asia.

Not all introduced beetles in Switzerland are of economic importance. Many exotic species are found in decaying plant material, compost, litter, etc., in particular several fungus beetles (Latridiidae) and rove beetles (Staphylinidae), but also species in the families Hydrophilidae, Languridae, Merophysiidae, Orthoperidae, Ptiliidae, etc. Considering how little attention has been paid to these insects and their ecosystems, it is likely that many more exotic species remain unrecorded in Switzerland, and in Europe in general. Some of the recorded species are particularly abundant in their habitat, suggesting that direct or indirect interactions with the native fauna occur.

Finally, another invasive beetle worth mentioning in the multicoloured Asian ladybeetle, *Harmonia axyridis*. This coccinellid is a biological control agent widely used in greenhouses against aphids. It recently became established outdoors in several European countries. The first specimen was found in Basel in 2004 (Klausnitzer, 2004). It is also established since the late 1980s in North America, where it has become a human nuisance because of its habit of invading houses and buildings in large numbers. Furthermore, it seems to decrease the diversity of native Coccinellidae, and it has also become a pest of fruit production, particularly in vineyards (see Fact Sheet).

4.3 Lepidoptera

Advisors:
Ladislaus Reser, Natur-Museum Luzern; Rudolf Bryner, Twann

The Lepidoptera of Central Europe has been quite well studied, and the distribution of both native and exotic species is fairly well known compared with most other insect orders. In this group, the main difficulty in establishing a list of exotic species came from the high numbers of Mediterranean species that are occasionally observed in Switzerland. The exotic or invasive status of most of these species is unclear. For example, Rezbanyai-Reser (2000) lists Mediterranean Geometridae and Noctuidae which occasionally overwinter in the Ticino. Some species apparently became established only recently, such as the noctuids *Mythimna unipuncta* and *Acantholeucania loreyi* (Duponchel), perhaps as a result of climate change. Others, such as the well known noctuid pest *Spodoptera exigua* (Hübner), are occasional visitors that can overwinter in the warmest areas of the country. Many other southern or eastern European species, including migrant species, are occasionally recorded in Switzerland. In general, these Lepidoptera are not included in our list, because their introduction and establishment in Switzerland are natural phenomena and not mediated by human activity. A few species whose invasive status is in doubt are included in the list, such as the geometrid *Eupithecia sinuosaria,* a European species for which the spread through Central Europe has been particularly well studied (Rezbanyai-Reser et al., 1998). Similarly, *Caradrina ingrata* is a noctuid of eastern Mediterranean origin and is increasingly observed in urban areas, where it could have become established in warmer microclimates (Rezbanyai-Reser et al., 1997; Whitebread, 1997).

Many Lepidoptera of exotic origin are primary or secondary pests. Among the best-known exotic species are several leaf miners in the family Gracillariidae, which all invaded Europe in the last 30 years. Leaf miners are easily introduced into new areas because the mines on fresh or dead leaves are often inconspicuous and readily carried over long distances. In addition, several species pupate in or near the leaf mine, and these stages are less vulnerable to adverse conditions. The horse chestnut leaf miner, *Cameraria ohridella,* is a moth of unknown origin that was first found in Macedonia in 1984 and in Switzerland in 1998 (Kenis and Forster, 1998; see also Fact Sheet). In less than 20 years, it has invaded most of Europe. The rapid spread of the moth in Europe is explained by the transport of adults and dead leaves containing pupae in or on vehicles. It causes severe defoliation to horse chestnut *(Aesculus hippocastanum* L.) trees in urban areas in most European regions as well as to indigenous horse chestnut stands in the Balkans, where it represents a threat to the survival of the tree species in the wild. The North American species *Phyllonorycter robiniella* and *Parectopa robiniella* mine leaves of their original host, the North American black locust *Robinia pseudoacacia* L. (see Fact Sheet in the plants chapter). *Phyllonorycter platani,* a moth originating from the Balkans and Asia Minor, is commonly found on *Platanus* trees. *Phyllonorycter leucographella,* also of eastern Mediterranean origin, has spread all over Europe and feeds on *Pyracantha* and *Crataegus*. Another gracillariid, the eastern Asian *Caloptilia azaleella,* mines on *Rhododendron* in greenhouses. Ornamental Cupressaceae in Europe are attacked by another North American leaf miner, the yponomeutid *Argyresthia thuiella*.

The arctiid moth *Hyphantria cunea* is another interesting case of an invasive Lepidoptera. Originating from North America, *H. cunea* arrived in the 1940s in Hungary, from where it spread to most of Europe. It was first found in the Ticino in 1991 (Jermini et al., 1995; see also Fact Sheet). This polyphagous defoliator is considered a serious pest of forest and ornamental trees and shrubs in some eastern European countries and eastern Asia, where it was also introduced. *Cydia molesta* is an Asian species present in orchards in Switzerland where it feeds on various fruit trees. The noctuid *Helicoverpa armigera* is a cosmopolitan, polyphagous pest, probably of African origin, which occurs in Switzerland mainly in greenhouses. It is now also regularly found overwintering in the Tessin, where it probably arrived by itself. Another greenhouse pest of African origin is the banana moth, *Opogona sacchari,* which feeds on various woody and perennial ornamentals.

Several exotic moths are pests of stored products in Switzerland. Most of them have been introduced with commodities into most parts of the world. The pyralid *Plodia interpunctella* is a major pest of stored products in warehouses, grain elevators and food factories, as well as in private households. It feeds on grains, nuts and various other dried products. In Switzerland, it is particularly prevalent in chocolate factories, together with other pyralids, *Ephestia elutella* and *Cadra cautella* (Hoppe, 1981). The pyralids *E. kuehniella* and *Sitotroga cerealella* are also cosmopolitan species, found mainly in stored grains. These pests of stored products are usually well controlled in Switzerland and other developed countries, but their management makes extensive resource demands on the industry.

4.4 Hymenoptera

Advisor:
Bernhard Seifert, Staatliches Museum für Naturkunde, Görlitz, Germany *(Formicidae)*

Only two Symphyta in the Swiss fauna are known to be of exotic origin. The wood wasp *Sirex cyaneus* is a secondary forest pest. Larvae live in dead or dying trunks of *Abies,* mainly, but also *Larix* and *Pseudotsuga* (Schwenke, 1982). The insect originates from North America but invaded Europe a long time ago, without causing damage. It is interesting to note that a European congeneric species, *S. noctilio* F., in Europe nearly as harmless as *S. cyaneus,* has become a major introduced pest of pine plantations in Australia, New Zealand, South Africa and South America. The second exotic sawfly in Switzerland is the nematine tenthredinid *Nematus tibialis,* an American species established in Europe where it feeds on its original host, *Robinia pseudoacacia*.

Most Hymenoptera belong to the Apocrita, and of these the vast majority are parasitic insects. These are among the least known insects. There is no checklist of parasitic Hymenoptera for Switzerland, and new, undescribed species are found every year in Central Europe. Many European species are known to occur on other continents as well but, for most of them, it is impossible to know whether their wide distribution is the result of an introduction of exotic species into Europe, or vice versa. Only the few species deliberately introduced into Europe as part of biological control programmes are definitely exotic. For example, at least three alien parasitoid species have been introduced into Switzerland and have become permanently established. The aphelinid *Aphelinus mali* was released against the woolly aphid *Eriosoma lanigerum* as early as 1922 (Greathead, 1976). Another aphelinid wasp, *Encarsia perniciosi,* was introduced more recently against the San José scale *Quadraspidiotus perniciosus,* and the dryinid *Neodryinus typhlocybae* was released in the Ticino in 1998–99 to control the flatid planthopper *Metcalfa pruinosa* (Mani and Baroffio, 1997; Jermini et al., 2000). Other parasitoids were released in neighbouring countries and were subsequently recovered in Switzerland, such as *Aphytis proclia, Encarsia berlesei* and *E. lounhuryi,* all introduced in Italy to control scale insects (Greathead, 1976; Noyes, 2002). The encyrtid *Ooencyrtus kuvanae,* an Asian egg parasitoid of the gypsy moth, *Lymantria dispar* L., was released in many European countries. It is has not been recorded from Switzerland, but since it is present in all neighbouring countries, there is no doubt that it also occurs in Switzerland (Greathead, 1976; Noyes, 2002).

Other parasitic Hymenoptera of exotic origin are used as augmentative biological control agents in Swiss greenhouses. The most commonly used species, such as the whitefly parasitoid *Encarsia formosa,* are mentioned in our list because they have become part of greenhouse ecosystems although, in most cases, they cannot survive winter conditions outdoors.

Many exotic seed chalcids of the genus *Megastigmus* (Torymidae) have been accidentally introduced into Europe with seed trading, some of them having become pests in European seed orchards (Roques and Skrzypczynska, 2003). Only *M. spermothrophus,* the North American Douglas fir seed chalcid, is reported from Switzerland, but many other species are known from neighbouring countries and, thus, are probably present in Switzerland.

Two sphecid wasps have recently invaded Switzerland. The American *Isodontia mexicana* has been found in the Ticino and the Lemanic region since the early 1990s (Vernier, 1995, 2000). It feeds on crickets and, given its abundance, its impact on native ecosystems would merit further attention. *Sceliphron curvatum* is an Asian species which arrived in Europe in the 1970s. The first specimens were found recently in Switzerland (Gonseth et al., 2001). Its nests are commonly found in houses and other buildings.

Five exotic ant species are recorded for the Swiss fauna (Freitag et al., 2000; Neumeyer and Seifert, 2005). These are ‘tramp’ ants of tropical and subtropical origin but transported by human activities to most regions of the world. The most common is the Asian species *Monomorium pharaonis,* very abundant in buildings and often considered as an urban pest. *Hypoponera schauinslandi* is found in greenhouses and other heated buildings in Central Europe (Seifert, 2004). *Linepithema humile* is the famous Argentine ant, which has invaded a vast territory along the Mediterranean coast and has been occasionally recorded in Switzerland (e.g. Kutter, 1981). Neumeyer and Seifert (2005) state that it could soon become established in outdoor situations because of global warming. *Tapinoma melanocephalum* and *Paratrechina longicornis* have been observed in few occasions indoors in Switzerland and their establishment is not firmly established (Dorn et al., 1997; Freitag et al., 2000). Another ant, *Lasius neglectus* Van Loon, Boomsma & Andrasfalvy, an Asian species, is rapidly invading Europe, causing some damage in urban areas (Seifert, 2000). It is not yet recorded from Switzerland, but its occurrence in neighbouring countries (France, Italy and Germany) suggests that it may be already present.

Finally, the chestnut gallwasp, *Dryocosmus kuriphilus* Yasumatsu (Hym.: Cynipidae), is worth mentioning as a potential threat for the European chestnut, *Castanea sativa*, in Switzerland and the rest of Europe. This Chinese species was found for the first time in Northern Italy in 2002 and is considered as the most serious insect pest of *Castanea* spp. worldwide (Bosio, 2004). Attacks of *Dryocosmus kuriphilus* reduce growth of young chestnuts and fruiting. Yield reductions of 50–70% are observed and severe infestations may result in the dead of the tree.

4.5 Diptera

Advisors:
Bernhard Merz, Muséum d'Histoire Naturelle, Genève; Jean-Paul Haenni, Muséum d'Histoire Naturelle, Neuchâtel; Gerhard Baechli, Zoologisches Museum, Zürich; Wolfgang Billen, Amt für Landwirtschaft, Lörrach, Germany

Checklists of Swiss Diptera have been published recently (Merz et al., 1998, 2001). These do not contain information on the exotic or invasive status of the species but the authors (Drs. B. Merz, J.-P. Haenni and G. Baechli) were contacted and kindly reviewed the list to extract the species which are thought to be exotic.

Less than 20 dipteran species in Switzerland are of alien origin. Some are agricultural or horticultural pests. The Nearctic agromyzids *Liriomyza huidobrensis* and *L. trifolii* are pests of vegetables, mainly in greenhouses but occasionally found outdoors. Another agromyzid fly, *Napomyza gymnostoma*, was recently found in Switzerland (Eder and Bauer, 2003). *N. gymnostoma,* previously known as a harmless insect from some European countries, but not Switzerland, mysteriously became a serious pest of onions and leeks one or two decades ago in several Central and western European countries. Its origin is not known, although it may be a virulent ecotype of a European species that unexpectedly adapted itself to agricultural systems and crops. Its sudden pest status and spread may also be due to changes in pest control methods in leek and onion crops, or to global warming.

Two of the world's most serious fruit flies (Tephritidae), the olive fly *Bactrocera oleae* and the Mediterranean fruit fly, *Ceratitis capitata,* both originating from the Mediterranean region, are also established in Switzerland, where they have reached their climatic limit and, thus, cause little damage. Two North American tephritids have recently invaded the country. *Rhagoletis completa* feeds on walnut and is considered a pest in its native region. It was discovered in the Ticino in 1991 (Merz, 1991) and, since then, has spread rapidly to many regions north of the Alps (see Fact Sheet). Populations are increasing and severe damage has been observed in Switzerland and Italy. Another American species, *R. cingulata*, was found at the same time, in cherries (Merz, 1991, as *R. indifferens).* Until now, populations have remained very low and it does not seem to spread as quickly as *R. completa*.

The North American Drosophilidae *Chymomyza amoena* attacks various fruits of broadleaved trees, such as apple, walnut, plum, acorn, etc. It is present in high numbers in both urban and forest environments. Its spread and ecology in Switzerland have been studied in detail (e.g. Burla and Baechli, 1992; Band, 1995; Band et al., 1998, 1999). Another drosophilid, *Drosophila curvispina,* originating from east Asia, is present in the Ticino, Vaud and Valais (Bächli et al., 2002; Bächli, pers. comm.).

Other alien Diptera occurring in Switzerland are saprophagous or coprophagous. These species are often of cosmopolitan distribution. The calliphorid *Chrysomya albiceps* and the muscid *Hydrotaea aenescens* are found on human cadavers and other decaying matters. The black soldier fly, *Hermetia illucens* (Stratiomyidae), was found in very high numbers in composted plants in the Ticino (Sauter, 1989). In North America, this very common species is often associated with poultry houses and other farming or animal-rearing activities. Only one milichiid, *Desmometopa varipalpis,* is mentioned in our list as clearly exotic. However, the Milichiidae are small, often cosmopolitan and poorly known insects, and it is possible that other milichiid members of the Swiss fauna are also of exotic origin (B. Merz, pers. comm.)

Exotic mosquitos (Culicidae) represent a major threat to human health worldwide. The tiger mosquito, *Aedes albopictus,* was found in Switzerland for the first time in the Ticino in 2003 (see Fact Sheet). Besides causing human nuisance through its bites, *A. albopticus* is also a potential vector of various illnesses. In Asia, its region of origin, it is a natural vector of dengue fever and other arboviruses, as well as filaria for both human and domestic animals. In North America, it is a vector of the West Nile virus.

4.6 Hemiptera

Advisors:
Daniel Burckhardt, Naturhistorisches Museum Basel (Psyllina); Gerolf Lampel, Pensier, and Yves Gonseth, Centre Suisse de Cartographie de la Faune, Neuchâtel (Aphidina); Ralf Heckmann, Konstanz, Germany *(Heteroptera)*

This order probably encompasses the highest number of exotic pests worldwide. Small Hemiptera, particularly aphids, scales, whiteflies and psyllids, are very easily carried around the globe on plant material. Many are pests of worldwide distribution and it is sometimes difficult to assess their region of origin. Among the cosmopolitan species of doubtful origin and listed as exotic in Switzerland, for example, are the aphids *Myzus persicae, Aphis gossypii* and *Cinara cupressi,* the whitefly *Bemisia tabaci,* and the scales *Dynaspidiotus britannicus, Quadraspidiotus pyri* and *Planococcus citri*. Many other cosmopolitan species are not included in this list because they are supposed to be of European origin (e.g. the aphids *Acyrthosiphon pisum, Brevicoryne brassicae* and *Rhopalosiphum padi),* although their origin is unclear and the possibility that they entered Switzerland a long time ago cannot be ruled out.

Another problem, particularly prevalent in Hemiptera, is the high number of tropical or subtropical pest species introduced into greenhouses with their host plants. The most abundant species have been included in the list because there is no doubt that they have become established in Switzerland in indoor conditions. For example, the aphid *Aphis gossypii,* the whiteflies *Bemisia tabaci* and *Trialeurodes vaporarium* and the scale *Planococcus citri* are recurrent problems in protected crops and plants in Switzerland. Many other tropical and subtropical species are occasionally reported from green-houses and indoor plants, but it is difficult to say whether their presence results from a permanent establishment or from regular introductions. In addition to those species included in our list, Kozar et al. (1994) mentions several species of scale insects that have been recovered from greenhouses and indoor plants in Switzerland. Interestingly, three of these scale species previously known only from greenhouses *(Diaspidiotus distinctus, Coccus hesperidum* and *Icerya purchasi)* are now found established in the field (Kozar et al., 1994). Other 'greenhouse' Hemiptera of exotic origin and not mentioned in our list are bug species of the genera *Orius* and *Xylocoris* (Anthocoridae), commonly used as biological control agents against thrips, spider mites or aphids.

Many hemipteran species in Switzerland have migrated from neighbouring countries, especially the Mediterranean region. In most cases these have probably been intro-duced with their host plant. For example, most Psyllidae and Triozidae, included in the list feed specifically on plants of Mediterranean origin which are used in Switzerland as ornamentals. However, other southern European species may have entered Switzerland independently. In particular, four true bugs, the lygaeids *Arocatus longiceps*, *Orsillus depressus* and *Oxycarenus lavaterae*, and the mirid *Deraeocoris flavilinea* are clearly expanding their range from southern to Central Europe (e.g. Adlbauer and Rabitsch, 2000; Rabitsch, 2002). Whether the spread is purely natural or not remains unclear.

Most of the known exotic Hemiptera included in the list are recognized as pests, feeding on crops, ornamentals and forest trees in Switzerland. It is likely that many other exotic Hemiptera remain undetected because they feed on non-commercial plants. Among aphids, one of the best-known cases of exotic pests in Europe is the grape phylloxera, *Viteus vitifoliae* which invaded Europe from North America in the 19th century, causing serious damage to vineyards and endangering the European wine industry. The problem was solved by grafting European cultivars on less susceptible American rootstocks; however, the level of damage has increased again in recent years, including in Switzerland. Other aphid species, such as *Myzus persicae, Macrosiphum euphorbiae* and *Aphis gossypii,* attack a wide range of vegetable crops, both indoors and outdoors. They are also vectors of serious viral diseases. The Russian wheat aphid, *Diuraphis noxia* (Kurdjumov), a serious pest of cereals, has not yet been reported from Switzerland, but has already invaded France, Italy and Austria (CABI, 2001; Lethmayer and Rabitsch, 2002). Orchard trees in Switzerland, in particular apple trees, can be severely damaged by the North American woolly aphid *Eriosoma lanigerum* and the Asian *Aphis spiraecola*. In forestry, the most serious exotic aphid is certainly the woolly aphid *Dreyfusia nordmannianae,* a pest of firs *(Abies)* of Caucasian origin, but other species such as *Gilletteella cooleyi* on *Pseudotsuga* and *Elatobium abietinum* on *Picea,* both from North America, may cause some concern to foresters.

Only two exotic whitefly species (Aleyrodidae) are known to occur in Switzerland, *Bemisia tabaci* and *Trialeurodes vaporarium,* but these are among the main pests of vegetables in greenhouses. Control is achieved using aphelinid parasitoids in the genera *Encarsia* and *Eretmocerus*.

A number of exotic scale insects are also known as pests in Switzerland, particularly on orchard and ornamental trees. The San José scale, *Quadraspidiotus perniciosus,* is an Asian species that has invaded nearly all continents, including Europe, where it is still expanding its range. It is already distributed in most parts of Switzerland, where it causes serious damage to orchards, particularly apple, peach and plum (see Fact Sheet). Another congeneric species, *Q. pyri,* also attacks fruit trees, but its origin remains uncertain, and it may be indigenous. In recent years, serious damage by scale insects has been observed on urban trees. The diaspidid *Pseudaulacaspis pentagona,* an insect of Asian origin and known to be polyphagous attacking mainly mulberry and peach trees, has caused severe damage to ornamental trees such as *Sophora, Aesculus* and *Catalpa* in Swiss cities (Mani et al., 1997). Similarly, the coccid *Pulvinaria regalis* (see Fact Sheet) is a polyphagous exotic species of uncertain origin that has recently caused heavy damage to *Tilia* and *Aesculus* in Zürich (Hippe and Frey, 1999).

Only seven species of Auchenorrhyncha are listed as exotic in Switzerland. However, some of them are of economic importance. *Metcalfa pruinosa,* a flatid planthopper of American origin, has recently invaded the Ticino through Italy (see Fact Sheet). This polyphagous species is found on many trees and shrubs, but also on crops such as soyabean. It can be particularly harmful to fruits such as grape, pear, apple, citrus and peach. It is expected that *M. pruinosa* will expand its distribution to most of Switzerland. Another North American species, the vine leafhopper *Scaphoideus titatus,* recently entered Switzerland. It does not cause direct damage to vine, but it transmits a severe mycoplasma disease, the 'flavescence dorée' (Günthart, 1987). Two other North American species are present in Switzerland, the cicadellid leafhopper *Graphocephala fennahi* on *Rhododendron,* and the membracid treehopper *Stictocephala bisonia,* a polyphagous species found mainly in orchards, but neither of them causes serious damage.

The only heteropteran bugs of non-European origin known to occur in Switzerland are the two North American lace bugs *Corythucha ciliata* and *Corythucha arcuata*. *C. ciliata* is a serious pest of *Platanus* in urban areas in Europe. Heavy infestations cause discolouration of leaves and premature leaf fall. It was first observed in Switzerland in 1983 and its distribution now covers most of western Switzerland (see Fact Sheet). *Corythucha arcuata* is a similar species, feeding on oak. It was first found in Italy in 2000 and in 2003 in Switzerland (Ticino) (see Fact Sheet). Similarly, another American bug, the coreid *Leptoglossus occidentalis* Heidemann, has recently been found in high numbers in northern Italy. It feeds on various conifer seeds and is considered a serious pest in seed orchards in North America (Villa et al., 2001).

4.7 Orthoptera

Advisor:
Hannes Bauer, Naturhistorisches Museum, Bern

The Orthoptera of Switzerland and their distributions are listed in Thorens and Nadig (1997). Only two species established in the country are clearly exotic. The house cricket *Acheta domesticus* is a cosmopolitan species, probably of North African origin. In Central Europe, it lives mainly in buildings, although in summer it is also commonly found outdoors, particularly in the Valais. The house cricket is omnivorous, feeding mainly on refuse and, occasionally, on stored products.

The greenhouse camel cricket, *Tachycines asynomorus,* probably originates from east Asia, but is now found worldwide. It was introduced into Europe in the 19^{th} century. In Switzerland, it lives mainly in greenhouses, where it feeds on fruits, seedlings and insects. It is also occasionally found outdoors, e.g. in botanical gardens.

Some Mediterranean species such as the Egyptian grasshopper *Anacridium aegyptium* (L.) are occasionally caught in Switzerland. Specimens found in the Ticino may have migrated from the South, however, it seems that at least some catches in various regions may be related to the importation of food products. (Nadig and Thorens, 1991; Rezbanyai-Reser, 1993).

4.8 Dictyoptera

At least five exotic cockroach species are known to be established in Switzerland. Others may be introduced occasionally with imported goods. Unlike the native cockroaches, the exotic species are synanthropic, i.e. they are always found in association with humans. These cockroaches are of tropical and subtropical origin but they now occur worldwide. Some species, such as *Blatta orientalis* and *Periplaneta americana,* have been cosmopolitan for such a long time that their origin is uncertain. *B. orientalis, P. americana*, *P. australasiae* and *B. germanica* have been established in Switzerland for a long time, whereas *Supella longipalpa* is a recent introduction.

All these species are considered as serious urban pests. They are gregarious, nocturnal, and difficult to eradicate in houses. They can eat almost anything, e.g. human food and animal feed, bookbindings, wallpaper, excrement, leather products, etc. They can carry organisms causing human diseases, have a repulsive odour, and can cause allergic reaction and anxiety in some individuals. In Switzerland, the most problematic species are *B. germanica, S. longipalpa* and *B. orientalis,* whereas *Periplaneta* spp. are of minor importance (Landau et al., 1999).

4.9 Isoptera

There is no record of establishment of exotic termites in Switzerland. However, in recent years, subterranean termites of the genus *Reticulitermes* have invaded new areas (see Fact Sheet). The North American *R. flavipes* (Kollar) is introduced in some German and Austrian cities. The southern European *R. grassei* Clément occurs now in southern England and *R. santonensis* de Feytaud, a species of uncertain origin (and perhaps synonymous with *R. flavipes)* has spread from south-western to northern France. These termites undoubtedly have the potential to invade the warmest areas in Switzerland. They live in colonies in the soil, mainly in urban areas. They are particularly harmful to wooden elements in building but can also attack living trees. The spread of subterranean termites in France is causing major concern. New regulations have been set up to limit the spread.

4.10 Thysanoptera

Many exotic thrips species are found, regularly or occasionally, in Switzerland in greenhouses. However, it is not always clear whether they are firmly established in the country. At least four species are considered permanently established, mainly in greenhouses. Three of them, *Frankliniella intonsa, F. occidentalis* and *Heliothrips haemorrhoidalis* are polyphagous, cosmopolitan pests on ornamentals, vegetables, and fruits. *F. occidentalis*, the western flower thrips, is among the most destructive greenhouse pests in Switzerland (Ebener et al., 1989; Schmidt and Frey, 1995). It is also a vector of various viruses. The pest status of *F. occidentalis* is relatively recent. It occurs naturally in North America on wild flowers and emerged as a greenhouse pest in the Netherlands in 1983. Since then, it has spread all around the world (CABI, 2001). In Switzerland, *F. intonsa* is particularly associated with strawberry crops (Linder et al., 1998).

The gladiolus thrips, *Thrips simplex*, originates from South Africa and was introduced in many regions with gladiolus corms. It reproduces only on gladiolus corms and leaves but adults are found on many other plants (CABI, 2001). In Switzerland, it does not survive outdoors.

4.11 Psocoptera

Advisor:
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Psocoptera, or psocids, are rather poorly known insects. Most species live in woodlands, but some are domestic, i.e. they inhabit houses, warehouses, etc., feeding on organic matter. The domestic species can become a nuisance, although they rarely cause economic damage. Partial European and Swiss lists of Psocoptera exist, but the origin of the species is often unclear. Lienhard (1994) lists 29 species that are totally, essentially or occasionally domestic in Switzerland. Most of them are not, or very rarely, found in the field, suggesting that they are not indigenous. We have included in our list the species that Lienhard (1994) mentions as exclusively or essentially domestic in Switzerland, keeping in mind that some of them might be indigenous but poorly known in their natural habitat.

Three species of the genus *Dorypteryx* are most likely of exotic origin. Their spread in Europe is illustrated in Lienhard (1994). *D. domestica,* described from Zimbabwe in 1958, was first found in Switzerland in 1973. From there, it has spread rapidly to most European countries where it has become one of the most frequent domestic species. *D. longipennis*, a species of unknown origin, was first found in Luxembourg in 1988. It reached Switzerland in 1992 and is now spreading very rapidly. *D. pallida* is an older introduction. It was first described from North America, and found in Germany in 1890. Its spread seems to be slower than that of the other two species. Other species that are most probably exotic include *Liposcelis mendax, Ectopsocus pumilis* and *E. richardsi*, which have been found associated with an importation of dry mushrooms from Asia. Whether these rare species are established in Switzerland is unclear. Other species are found outdoors in the Mediterranean regions but only indoors in Switzerland, e.g. *Trogium pulsatorium* and *Ectopsocus vachoni*.

4.12 Ectoparasites

Ectoparasitic insects of vertebrates include mainly Siphonaptera (fleas – on birds and mammals), Anoplura (sucking lice – on mammals) and Mallophaga (biting lice – on birds and mammals). Undoubtedly, several of the ectoparasites present in Switzerland are allochtonous, having arrived in the region with their hosts. However, these insects are rather poorly studied, particularly in Switzerland, and their origin is often unclear. In their work on the Siphonaptera of France and the western Mediterranean region, Beaucournu and Launay (1990) provided data for Switzerland. At least two fleas appear to be definitely exotic in the country. The cat flea, *Ctenocephalides felis felis*, has a cosmopolitan distribution but is probably not of European origin (Beaucournu and Launay, 1990). The rabbit flea, *Spilopsylus cuniculi*, is a vector of myxomatosis and probably originates, like its host, from the Iberian Peninsula, while the disease was introduced into Europe from South America. Some other fleas present in Switzerland are of doubtful origin and are not included in the list. For example, the human flea *Pulex irritans* L., which feeds on many carnivores, is now cosmopolitan but belongs to a Nearctic genus. However, its arrival in Europe was probably in the distant past. Büttiker and Mahnert (1978) listed 25 Anoplura for Switzerland. Only one, *Haemodipsus ventricosus*, is very likely to be of exotic origin because it seems to be restricted to rabbits. Sucking lice of doubtful origin include the cosmopolitan rat louse, *Polyplax spinulosa* (Burmeister), and the dog sucking louse, *Linognathus setosus* (v. Olfers). There is no recent list of Mallophaga for Switzerland. Mey (1988) provides a list of mammalian Mallophaga in Europe, but data for Switzerland are scarce. Three South American species, *Gyropus ovalis* Burmeister, *Gliricola porcelli* (Schrank) and *Trimenopon hispidum* (Burmeister), are found on guinea pigs in neighbouring countries and, thus, are probably present in Switzerland. Similarly, it is possible that the Nearctic *Trichodectes octomaculatus* Paine and *Pitrufquenia coypus* Marelli, parasites on raccoons and coypus, respectively, in Central Europe, are present in Switzerland with their host.

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Tab. 4.1 > Established alien Insects in Switzerland: Coleoptera.

Species	Habitat – life traits	Origin	Reference for Switzerland
COLEOPTERA			
Anobiidae			
Lasioderma serricorne (F.)	Stored products, especially tobacco	Tropics and subtropics	C.Besuchet, pers. comm.
Stegobium paniceum (L.)	Stored products, very polyphagous	Cosmopolitan	Lucht, 1987
Oligomerus ptilinoides (Wollaston)	Feeds on wood products	Mediterranean region, possibly native	C. Besuchet, pers. comm.
Anthicidae			
Stricticomus tobias Marseul	Feeds on rotten plant tissue	Asia Minor, Central Asia, India	C. Besuchet, pers. comm.
Apionidae			
Alocentron curvirostre (Gyllenhal)	In stems of *Alcea rosea* L.	Asia, Middle East	C. Besuchet, pers. comm.
Aspidapion validum (Germar)	In fruits of *Alcea rosea*	Asia, Middle East	C. Besuchet, pers. comm.
Rhopalapion longirostre (Olivier)	In seeds of *Alcea rosea*	Asia, Middle East	C. Besuchet, pers. comm.
Bostrichidae			
Rhyzoperta dominica (F.)	Stored products, mainly cereals	Tropics and subtropics	C. Besuchet, pers. comm.
Bruchidae			
Acanthoscelides obtectus (Say)	In leguminous seeds, mainly beans	South and Central America	Lucht, 1987
Acanthoscelides pallidipennis (Motschulsky)	In seeds of *Amorpha fruticosa*	North America	C. Besuchet, pers. comm.
Bruchus pisorum (L.)	In peas	North America or Near East	Lucht, 1987
Callosobruchus chinensis (L.)	In leguminous seeds	East Asia	C. Besuchet, pers. comm.
Buprestidae			
Agrilus guerini Lacordaire	Xylophagous, on *Salix*	Eastern Europe, Russia?	Barbalat and Wermelinger, 1996
Carabidae			
Perigona nigriceps (Dejean)	Predator, in various environments	South Asia	Lucht, 1987
Cerambycidae			
Gracilia minuta (F.)	Xylophagous, polyphagous, often found in wicker	Mediterranean region	Lucht, 1987
Nathrius brevipennis (Mulsant)	Xylophagous, polyphagous, often found in wicker	Mediterranean region	Lucht, 1987
Neoclytus acuminatus (F)	Xylophagous, on *Fraxinus*, Ticino	North America	C. Besuchet, pers. comm.
Phymatodes lividus (Rossi)	Xylophagous, on broadleaved trees	Mediterranean region	C. Besuchet, pers. comm.
Xylotrechus stebbingi Gahan	Xylophagous, polyphagous, on aspen in Ticino	Himalayas	C. Besuchet, pers. comm.
Cerylonidae			
Murmidius ovalis (Beck)	Stored products, especially mouldy cereals, hay, etc.	Cosmopolitan	C. Besuchet, pers. comm.
Chrysomelidae			
Diabrotica virgifera virgifera LeConte	Pest on Maize, root feeder, Ticino	Mexico, Central America	Mario et al., 2001
Leptinotarsa decemlineata (Say)	Defoliator, pest on Solanaceae	North America	Lucht, 1987
Cleridae			
Korynetes caeruleus (De Geer)	Predator on anobiids in wood	Cosmopolitan	Lucht, 1987
Necrobia ruficollis (F.)	Domestic, insect predator	Cosmopolitan	Lucht, 1987
Necrobia rufipes (De Geer)	Domestic, in stored products, also predator	Tropics, subtropics	Lucht, 1987
Necrobia violacea (L.)	Mainly domestic, also on cadavers	Cosmopolitan	Lucht, 1987
Tarsostenus univittatus (Rossi)	Predator in wood, found in Genève only	Cosmopolitan	C. Besuchet, pers. comm.

Species	Habitat – life traits	Origin	Reference for Switzerland
Coccinellidae			
Harmonia axyridis (Pallas)	Polyphagous predator (perhaps not yet established)	East Asia	Klausnitzer, 2004
Rodolia cardinalis (Mulsant)	Predator of scale insects, released and established in Ticino	Australia	C. Besuchet, pers. comm.
Colydiidae			
Myrmecoxenus vaporariorum Guerin-Meneville	In greenhouses, manure, compost, etc.	Unclear	Lucht, 1987
Cryptophagidae			
Atomaria lewisi Reitter	In decaying plant material	East Asia	Lucht, 1987
Caenoscelis subdeplanata Brisout de Barneville	In decaying wood and plant material	North America	C. Besuchet, pers. comm.
Cucujidae			
Cryptolestes ferrugineus (Stephens)	Stored products, mainly cereal grains	Cosmopolitan	Lucht, 1987
Cryptolestes spartii (Curtis)	Stored products	Cosmopolitan	C. Besuchet, pers. comm.
Cryptolestes turcicus (Grouvelle)	Domestic, on plant products	Perhaps Turkey	C. Besuchet, pers. comm.
Curculionidae			
Pentarthrum huttoni Wollaston	Decaying wood	South-western Europe (native?)	C. Besuchet, pers. comm.
Sitophilus granarius (L.)	Stored products	India	Lucht, 1987
Sitophilus oryzae (L.)	Stored products	Asia	Lucht, 1987
Sitophilus zeamais Motschulsky	Stored products	Asia	C. Besuchet, pers. comm.
Dermestidae			
Anthrenus festivus Rosenhauer	Domestic	Mediterranean region	C. Besuchet, pers. comm.
Anthrenus flavipes LeConte	Domestic, feeds on furnitures, fabrics, etc.	Cosmopolitan (Mediterranean region?)	C. Besuchet, pers. comm.
Attagenus brunneus Faldermann	Domestic	Cosmopolitan (native?)	C. Besuchet, pers. comm.
Attagenus quadrimaculatus Kraatz	Domestic	Cosmopolitan (native?)	C. Besuchet, pers. comm.
Attagenus rossi Ganglbauer	Domestic	Cosmopolitan (native?)	C. Besuchet, pers. comm.
Attagenus smirnovi Zhantiev	Domestic	Cosmopolitan (native?)	C. Besuchet, pers. comm.
Attagenus unicolor (Brahm)	Domestic, feeds mainly on fabrics	Africa	Lucht, 1987
Dermester ater DeGeer	Domestic, on animal products, fabrics, etc.	Cosmopolitan (southern Europe?)	C. Besuchet, pers. comm.
Dermestes maculatus DeGeer	Domestic, on animal products	Cosmopolitan (North America?)	Lucht, 1987
Dermestes peruvianus La Porte de C.	Domestic, on animal products, fabrics, etc.	Central and South America	C. Besuchet, pers. comm.
Reesa vespulae (Milliron)	Domestic and in museum collections	North America	C. Besuchet, pers. comm.
Trogoderma angustum (Solier)	Domestic and in museum collections	South America	C. Besuchet, pers. comm.
Trogoderma glabrum Herbst	Domestic and in nests of solitary wasps	Cosmopolitan (native?)	Lucht, 1987
Trogoderma granarium Everts	Stored products, especially cereals	India	C. Besuchet, pers. comm.
Trogoderma versicolor (Creutzer)	Domestic and in museum collections	Cosmopolitan	Lucht, 1987
Histeridae			
Carcinops pumilio Erichson	Predator on Diptera	Cosmopolitan	Lucht, 1987
Hydrophilidae			
Cercyon laminatus Sharp	In various humid environments	East Asia	Lucht, 1987
Cryptopleurum subtile Sharp	In various humid environments	East Asia	Lucht, 1987
Languriidae			
Cryptophilus integer (Heer)	On decaying plant material	Cosmopolitan	Lucht, 1987

Species	Habitat – life traits	Origin	Reference for Switzerland
Latridiidae			
Adistemia watsoni (Wollaston)	Feeds on fungus, found in herbarium	Cosmopolitan	Lucht, 1987
Corticaria ferruginea Marsham	On fungus, on decaying plant material	Cosmopolitan	C. Besuchet, pers. comm.
Corticaria fulva (Comolli)	On fungus, on decaying plant material	Cosmopolitan	Lucht, 1987
Corticaria pubescens Gyllenhal	On fungus, on decaying plant material	Cosmopolitan	Lucht, 1987
Corticaria serrata Paykull	On fungus, on decaying plant material	Cosmopolitan	Lucht, 1987
Dienerella filum (Aubé)	On fungus, on decaying plant material	Central America	Lucht, 1987
Lathridius minutus (L.)	On fungus, on decaying plant material	Cosmopolitan	Lucht, 1987
Migneauxia orientalis Reitter	On fungus, on decaying plant material	Mediterranean region	C. Besuchet, pers. comm.
Stephostetus (= *Aridius*) *bifasciatus* (Reitter)	Feeds on fungus in various environments	Australia	C. Besuchet, pers. comm.
Stephostetus nodifer (Westwood)	Feeds on fungus in various environments	New Zealand	Lucht, 1987
Thes bergrothi (Reitter)	On fungus, on decaying plant material	North-eastern Europe	C. Besuchet, pers. comm.
Lyctidae			
Lyctus africanus Lesne	Domestic, in wood	Africa	C. Besuchet, pers. comm.
Lyctus brunneus (Stephens)	Domestic, in tropical wood	South-east Asia	Lucht, 1987
Lyctus cavicollis Le Conte	Domestic, in wood	North America	C. Besuchet, pers. comm.
Merophysiidae			
Holoparamecus caularum (Aubé)	On fungus, on decaying plant material	Cosmopolitan	C. Besuchet, pers. comm.
Mycetophagidae			
Berginus tamarisci Wollaston	Found on pine trees in Switzerland	Canary Islands	C. Besuchet, pers. comm.
Litargus balteatus Le Conte	On fungus, on decaying plants, e.g. cereals	North America	C. Besuchet, pers. comm.
Typhaea stercorea (L.)	On fungus, on decaying plants, e.g. cereals	North America	Lucht, 1987
Nitidulidae			
Carpophilus dimidiatus (F.)	On stored products and cultivated fields, mainly cereals	North America	C. Besuchet, pers. comm.
Carpophilus hemipterus (L.)	Feeds on fruits, dry fruits, cereals	Cosmopolitan	Lucht, 1987
Carpophilus marginellus Motschulsky	Mainly domestic, on cereals	South-east Asia	C. Besuchet, pers. comm.
Carpophilus quadrisignatus Erichson	Feeds on dry fruits	Probably America	C. Besuchet, pers. comm.
Glischrochilus fasciatus (Olivier)	Feeds on vegetables, fruits, etc.	North America	C. Besuchet, pers. comm.
Glischrochilus quadrisignatus (Say)	Feeds on vegetables, fruits, etc.	North and Central America	C. Besuchet, pers. comm.
Urophorus rubripennis (Heer)	Under oak bark and on Apiaceae	Perhaps Mediterranean region	C. Besuchet, pers. comm.
Orthoperidae			
Orthoperus aequalis Sharp	In compost, in Ticino	Hawaii	C. Besuchet, pers. comm.
Ostomidae			
Tenebroides mauritanicus (L.)	On stored products, especially cereals	Africa	Lucht, 1987
Ptiliidae			
Acrotrichis insularis (Maeklin)	In organic matters, from Vaud and Weissenstein	North America	C. Besuchet, pers. comm.
Acrotrichis sanctaehelenae Johnson	In organic matters, Ticino	St Helena, Africa?	C. Besuchet, pers. comm.
Ptilodactylidae			
Ptilodactyla exotica Chapin	Domestic, indoor plants	North America	C. Besuchet, pers. comm.
Ptinidae			
Gibbium psylloides (Czempinski)	Domestic, on stored products	Cosmopolitan	Lucht, 1987
Niptus hololeucus (Faldermann)	Domestic, feeds on fabrics	Asia Minor, southern Russia	Lucht, 1987

Species	Habitat – life traits	Origin	Reference for Switzerland
Ptinus tectus Boieldieu	Domestic, on stored products	Australia, New Zealand	Lucht, 1987
Epauloecus (=Tipnus) unicolor (Piller & Mitt.)	In barns, cowshed, animal burrows, etc	Cosmopolitan	Lucht, 1987
Scolytidae			
Gnathotrichus materiarius (Fitch)	Xylophagous, on conifers	North America	Hirschheydt, 1992
Phloeosinus aubei (Perris)	Xylophagous, on Cupressaceae	Mediterranean region	Lucht, 1987
Tripodendron laeve Eggers	Xylophagous, on *Picea*	East Asia, Scandinavia	C. Besuchet, pers. comm.
Xyleborinus alni (Niisima)	Xylophagous, on broadleaved trees	East Asia	C. Besuchet, pers. comm.
Xyleborus punctulatus Kurentzov	Xylophagous, on broadleaved trees	Siberia	C. Besuchet, pers. comm.
Xylosandrus germanus (Blandford)	Xylophagous, polyphagous	East Asia	Lucht, 1987
Silvanidae			
Ahasverus advena (Waltl)	Feeds on fungus on rotten stored products	South America	Lucht, 1987
Oryzaephilus mercator (Fauvel)	On stored products, polyphagous	Tropics	C. Besuchet, pers. comm.
Oryzaephilus surinamensis (L.)	On stored products, polyphagous	Cosmopolitan	Lucht, 1987
Staphylinidae			
Acrotona pseudotenera (Cameron)	Mouldy hay	East Asia	C. Besuchet, pers. comm.
Carpelimus zealandicus (Sharp)	Sandy banks	New Zealand	C. Besuchet, pers. comm.
Edaphus beszedesi Reitter	Compost, rotting plant material	Pehaps Mediterranean region	Lucht, 1987
Leptoplectus remyi Jeannel	Unclear, found in Ticino	Asia	C. Besuchet, pers. comm.
Lithocharis nigriceps (Kraatz)	Compost, rotting plant material	Asia	Lucht, 1987
Micropeplus marietti Jaquelin Du Val	Waste land, fallow land	Southern Europe, Caucasus	C. Besuchet, pers. comm.
Oligota parva Kraatz	Domestic, in compost	South America	Lucht, 1987
Oxytelus migrator (Fauvel)	In compost, stable litter, etc.	South East Asia	C. Besuchet, pers. comm.
Paraphloeostiba gayndahensis MacLeay	Fermenting plant matters	Australia	C. Besuchet, pers. comm.
Philonthus parcus Sharp	In compost, stable litter, fermenting plant material, etc.	East Asia	C. Besuchet, pers. comm.
Philonthus rectangulus Sharp	In decomposing matters	East Asia	Lucht, 1987
Philonthus spinipes Sharp	In stable litter, cadavers, etc.	East Asia	C. Besuchet, pers. comm.
Thecturota marchii (Dodero)	Waste land, compost	Southern Europe	Lucht, 1987
Trichiusa immigrata Lohse	In compost and manure	North America	C. Besuchet, pers. comm.
Tenebrionidae			
Alphitobius diaperinus (Panzer)	In stored products, polyphagous	Tropics	C. Besuchet, pers. comm.
Alphitophagus bifasciatus (Say)	Mainly domestic, In rotten fruits	Cosmopolitan	C. Besuchet, pers. comm.
Gnatocerus cornutus (F.)	Stored products	Central America	Lucht, 1987
Latheticus oryzae Waterhouse	Stored products, cereals	India	C. Besuchet, pers. comm.
Tenebrio molitor L., polyphagous	Stored products	Cosmopolitan	Lucht, 1987
Tribolium castaneum (Herbst)	Stored products	Cosmopolitan	Lucht, 1987
Tribolium confusum Jacquelin du Val	Stored products	Perhaps America, cosmopolitan	Lucht, 1987
Tribolium destructor Uyttenboogaart	Stored products	South America	C. Besuchet, pers. comm.
Tribolium madens Charpentier	Stored products	Cosmopolitan	C. Besuchet, pers. comm.

Tab. 4.2 > Established alien insects in Switzerland: Lepidoptera.

Species	Habita – Life traits	Origin	References for Switzerland
LEPIDOPTERA			
Arctiidae			
Hyphantria cunea (Drury)	Polyphagous defoliator, in Ticino	North America	Rezbanyai-Reser, 1991; Jermini et al., 1995
Gelechiidae			
Scrobipalpa ocellatella (Boyd)	Defoliator/ borer on Chenopodiaceae, particularly on beet	Southern Europe	Karsholt and Razowski, 1996; CABI, 2001
Sitotroga cerealella (Olivier)	On stored products	North America	CABI, 2001
Geometridae			
Eupithecia sinuosaria Eversmann	On *Chenopodium* (not sure if established in Switzerland)	Eastern Europe	Rezbanyai-Reser et al., 1998
Gracillariidae			
Cameraria ohridella Deschka & Dimic	Leaf miner on *Aesculus*	Unknown	Kenis and Förster, 1998
Caloptilia azaleella (Brants)	Leaf miner on *Rhododendron*, in greenhouses	EastAsia	CSCF, unpublished list
Parectopa robiniella Clemens	Leaf miner on *Robinia*	North America	Sauter, 1983
Phyllonorycter leucographella (Zeller)	Leaf miner on *Pyracantha* and *Crataegus*	East Mediterranean Region	Sauter, 1983
P. platani (Staudinger)	Leaf miner on *Platanus*	Balkans, Asia Minor	M. Kenis, personal observation
P. robiniella (Clemens)	Leaf miner on *Robinia*	North America	M. Kenis, personal observation
Lycaenidae			
Cacyreus marshalli (Butler)	On *Pelargonium*, in Ticino	South Africa	Y. Gonzeth, pers. comm.
Noctuidae			
Caradrina ingrata Staudinger	Defoliator (not sure if established)	East Mediterranean Region	Rezbanyai-Reser L. 1983, Withebread, 1997
Chrysodeixis chalcites Esper	Vegetables, in glasshouses, migrant (not sure if established)	Mediterranean Region?	Hächler et al., 1998
Helicoverpa armigera (Hübner)	Polyphagous defoliator, mainly in glasshouses (not sure if established)	Africa?	Rezbanyai-Reser L. 1984, Hächler et al., 1998
Sedina buettneri (Hering)	Defoliator, mainly on *Carex*	Siberia	Blattner (1959)
Psychidae			
Typhonia beatricis Hättenschwiler	Polyphagous, in particular on mosses	Eastern Mediterranean	Hättenschwiler (2000)
Pyralidae			
Cadra cautella (Walker)	On stored products	Africa	Hoppe (1981)
Ephestia elutella (Hübner)	On stored products	Cosmopolitan	Hoppe (1981)
E. kuehniella (Zeller)	On stored products	North and Central America	Hoppe (1981)
Plodia interpunctella (Hübner)	On stored products	Cosmopolitan	Hoppe (1981)
Sclerocona acutella (Eversmann)	On *Phragmites*	Siberia	Grimm (1986)
Saturniidae			
Samia cynthia walkeri (C. and R. Felder)	Defoliator on *Ailanthus*	East Asia	CSCF, unpublished list
Tineidae			
Monopis crocicapitella (Clemens)	On fabrics	Cosmopolitan	CSCF, unpublished list
Opogona sacchari (Bojer)	Polyphagous pest in glasshouses	Africa	CABI, 2001
Tortricidae			
Cydia molesta (Busck)	Orchard pest, on Rosaceae	East Asia	CABI, 2001
Yponomeutidae			
Argyresthia thuiella (Packard)	Leaf miner on Cupressaceae	North America	Fischer (1993)

Tab. 4.3 > Established alien insects in Switzerland: Hymenoptera.

Species	Habitat – Life traits	Origin	References for Switzerland
HYMENOPTERA			
Symphyta			
Siricidae			
Sirex cyaneus Fabricius	Feeds on conifer trunks (mainly *Abies*)	North America	Pschorn-Walcher and Taeger, 1995
Tenthredinidae			
Nematus tibialis Newman	Defoliator on *Robinia*	North America	Liston, 1981, Pschorn-Walcher and Taeger, 1995
Apocrita			
Aphelinidae			
Aphelinus mali (Haldeman)	Parasitoid of *Eriosoma lanigerum* (Hausmann), introduced in Switzerland	North America	Greathead, 1976; Noyes, 2002
Aphytis proclia (Walker)	Parasitoid of scale insects, introduced in Italy	Asia	Greathead, 1976; Noyes, 2002
Encarsia berlesei (Howard)	Parasitoid of *Pseudaulacaspis pentagona* (Targioni-Tozzetti), introduced in Italy	East Asia	Mani et al., 1997
Encarsia formosa Gahan	Biocontrol agent against whiteflies. Only in greenhouses	South and Central America	Greathead, 1976; Noyes, 2002
Encarsia lounshuryi (Berlese & Paoli)	Parasitoid of *Chrysomphalus dictyospermi* (Morgan), introduced in Italy	Madeira	Greathead, 1976; Noyes, 2002
Encarsia perniciosi (Tower)	Parasitoid of San José scale, introduced in Switzerland	Probably Asia	Mani and Baroffio, 1997
Braconidea			
Aphidius colemani Viereck	Biocontrol agent against aphids in greenhouses	India	
Dryinidae			
Neodryinus typhlocybae (Ashmead)	Parasitoid of *Metcalfa pruinosa* Say, introduced in Ticino	North America	Jermini et al., 2000
Encyrtidae			
Metaphycus helvolus (Compere)	Biocontrol agent against scale insects. Only in greenhouses	South Africa	Noyes, 2002
Ooencyrtus kuvanae (Howard)	Parasitoid of *Lymantria dispar* L., introduced in Europe. Not reported from Switzerland but from all adjacent countries	East Asia	Greathead, 1976; Noyes, 2002
Formicidae			
Hypoponera schauinslandi (Emery)	Antropophilic, in greenhouses or other heated buildings.	Unclear, tropics	Neumeyer & Seifert, 2005
Linepithema humile (Mayr)	Various habitats indoors and outdoors, perhaps not established in Switzerland	South America	Kutter, 1981
Monomorium pharaonis (L.)	On stored products, antropophilic, mainly indoors	South Asia	Freitag et al., 2000
Paratrechina longicornis (Latreille)	Omnivorous, antropophilic, found in Zürich airport in 1999, perhaps not established	Old world tropics	Freitag et al., 2000
Tapinoma melanocephalum (F.)	On stored products, antropophilic, indoors only	Cosmopolitan, tropics	Dorn et. al., 1997
Sphecidae			
Isodontia mexicana (Saussure)	Predatory wasp, feeds on criquets, In Ticino and Lemanic region	North America	Vernier, 1995, 2000
Sceliphron curvatum (F. Smith)	Predatory wasp, anthropophilic	Asia	Gonseth & al. 2001
Torymidae			
Megastigmus spermotrophus Wachtl	Feeds on seeds of *Pseudotsuga*	North America	Roques and Skrzypczynska, 2003
Trichogrammatidae			
Trichogramma brassicae Bezdenko	Biocontrol agent against Lepidoptera	Eastern Europe	Noyes, 2002

Tab. 4.4 > Established alien insects in Switzerland: Diptera.

Species	Habitat – Life traits	Origin	References for Switzerland
DIPTERA			
Agromyzidae			
Liriomyza huidobrensis (Blanchard)	Polyphagous leaf miner, pest in glasshouses	Central and South America	CABI, 2001
Liriomyza trifolii (Burgess)	Polyphagous leaf miner, pest in glasshouses in Europe, particularly on *Chrysanthemum*	North America	CABI, 2001
Napomyza gymnostoma (Loew)	Leaf miner on *Allium* spp., especially onion and leek.	Unclear, perhaps indigenous	Eder and Baur (2003)
Calliphoridae			
Chrysomya albiceps (Wiedemann)	On cadavers	Cosmopolitan	Rognes, 1997
Cecidomyiidae			
Rhopalomyia chrysanthemi (Ahlberg)	Pest on *Chrysanthemum*	North America	Skuhrava and Skuhravi 1997
Culicidae			
Aedes albopictus (Skuse)	Human nuisance through its bites, and potential vector of various diseases	South-east Asia	Unpublished information
Drosophilidae			
Chymomyza amoena (Loew)	Fruits of various broadleaved trees (apple, walnut, plum, etc.)	North America	Burla and Bächli, 1992
Drosophila curvispina Watabe & Toda	Fruits	East Asia	Bächli et al., 2002
Milichiidae			
Desmometopa varipalpis Malloch	Saprophagous/coprophagous	Probably Cosmopolitan	Merz et al., 2001
Muscidae			
Hydrotaea aenescens (Wiedemann)	On human or animal cadavers	North America	Merz et al., 2001
Phoridae			
Dohrniphora cornuta (Bigot)	Saprophagous, sometimes carnivorous	Tropical, Cosmopolitan	Prescher et al., 2002
Stratiomyidae			
Hermetia illucens (L.)	Saprophagous, very abundant in Ticino.	North and South America , Africa	Sauter, 1989
Tephritidae			
Bactrocera oleae (Gmel.)	Fruit fly, on olive, in Ticino	Mediterranean region	Neuenschwander, 1984
Ceratitis capitata (Wiedemann)	On various fruits, e.g. peach, apricot, peer, etc.	Africa	CABI, 2001
Rhagoletis cingulata Curran	Fruit fly, on cherry. First determined as *R. indifferens* Curran (B. Merz, pers. comm.)	North America	Merz 1991, Mani et al., 1994
Rhagoletis completa Cresson	Fruit fly, on walnut	North America	Merz 1991, Mani et al, 1994
Ulidiidae			
Euxesta pechumani Curran	In carrion and dung, in Ticino	North America	B. Merz., pers. comm.

Tab. 4.5 > Established alien insects in Switzerland: Hemiptera.

Species	Host plant	Origin	Reference for Switzerland
HEMIPTERA			
Sternorrhyncha			
APHIDINA			
Adelgidae			
Dreyfusia nordmannianae (Eckstein)	On *Abies*	Caucasus	Eichhorn, 1967
Dreyfusia prelli Grosmann	On *Abies*	Caucasus	Eichhorn, 1967
Eopineus strobus (Hartig)	On *Pinus strobus* L., *Picea* spp. Not recorded but probably in Switzerland	North America	Schwenke, 1972
Gilletteella cooleyi (Gillette)	On *Picea* and *Pseudotsuga*	North America	Forster, 2002
Aphididae			
Acyrthosiphon caraganae (Choldokovsky)	On *Caragana* and other Fabaceae	Siberia	CSCF/Lampel, unpublished list
Aphis forbesi Weed	On strawberry	North America	Meier, 1975
Aphis gossypii Glover	Polyphagous, mainly Cucurbitaceae and Malva-ceae, in greenhouses in Central Europe	Cosmopolitan, tropical regions	CABI, 2001
Aphis spiraecola Patch	Polyphagous, e.g. *Citrus*, apple	East Asia	Hohn et al., 2003
Aphis spiraephaga F.P. Müller	On *Spiraea*	Central Asia	Stary, 1995
Appendiseta robiniae (Gillette)	On *Robinia*	North America	Lethmayer and Rabitsch, 2002
Aulacorthum circumflexum (Buckton)	Polyphagous, in greenhouses	South East Asia	CSCF/Lampel, unpublished list
Elatobium abietinum (Walker)	On *Picea*	North America	CABI, 2001
Idiopterus nephrelepidis Davis	On ferns, mostly indoors	Neotropics	CSCF/Lampel, unpublished list
Illinoia azaleae (Mason)	On *Rhododendron* and other Ericaceae	North America	CSCF/Lampel, unpublished list
Illinoia lambersi (Mac Gillivray)	On *Rhododendron* and *Kalmia*	North America	CSCF/Lampel, unpublished list
Impatientinum asiaticum Nevsky	On *Impatiens*	Central Asia	CSCF/Lampel, unpublished list
Macrosiphoniella sanborni (Gillette)	On *Chrysanthemum*	East Asia	Meier, 1972
Macrosiphum albifrons Essig	On *Lupinus*	North America	CSCF/Lampel, unpublished list
Macrosiphum euphorbiae (Thomas)	Polypgagous, on vegetables	North America	Derron and Goy, 1995
Megoura lespedezae (Essig & Kuwana)	On *Lespedeza*, Japanese clover	East Asia	Giacalone & Lampel, 1996
Microlophium primulae (Theobald)	On *Primula*	Asia	CSCF/Lampel, unpublished list
Myzus ascalonicus Doncaster	On *Allium* spp.	Near East	CSCF/Lampel, unpublished list
Myzus cymbalariae Stroyan (=cymbalariellus Str.)	Polyphagous	Not clear. In UK, South Africa, New Zealand and Australia	Meier, 1972
Myzus ornatus Laing	On *Prunus cornuta* (Wallich ex Royle) (primary host) and many herbaceous plants (secondary hosts	Himalaya	CSCF/Lampel, unpublished list
Myzus persicae (Sulzer)	Polyphagous	Cosmopolitan, probably from Asia	CABI, 2001
Myzus varians Davidson	On *Clematis*	East Asia	Giacalone & Lampel, 1996
Nearctaphis bakeri (Cowen)	Maloideae (primary hosts) and Fabaceae (secon-dary hosts)	North America	CSCF/Lampel, unpublished list
Pentatrichopus fragaefolii (Cockerell)	On strawberry	North America	CSCF/Lampel, unpublished list
Rhodobium porosum (Sanderson)	On *Rosa*, in greenhouses in Central Europe	Tropics and subtropics	Meier, 1972
Rhopalosiphoninus latysiphon (Davidson)	Polyphagous	North America	CSCF/Lampel, unpublished list
Rhopalosiphum maidis (Fitch)	On Maize, Sorghum, sugar cane and other Poaceae	Probably Asia	Meier, 1975

Species	Host plant	Origin	Reference for Switzerland
Toxoptera aurantii (Boyer de Fonscolombe)	Polyphagous, in Europe mainly on *Citrus*	Cosmopolitan, tropics and subtropics	CSCF/Lampel, unpublished list
Uroleucon erigeronense (Thomas)	On Asteraceae (*Erigeron*, *Coniza*, etc.)	North America	CSCF/Lampel, unpublished list
Callaphididae			
Myzocallis (=*Lineomyzocallis*) *walshii* (Monell)	On *Quercus*	North America	Giacalone and Lampel (1996)
Takecallis arundicolens (Clarke)	On bamboo	South East Asia	Lampel and Meier (2003)
Takecallis arundinariae (Essig)	On bamboo	South East Asia	Giacalone and Lampel (1996)
Takecallis taiwanus (Takahashi)	On bamboo	South East Asia	Giacalone and Lampel (1996)
Tinocallis nevskyi Remaudière, Quednau & Heie	On *Ulmus*	Western Asia	Giacalone and Lampel (1996)
Chaitophoridae			
Periphyllus californiensis (Shinji)	On *Acer*	East Asia	Lampel and Meier (2003)
Pemphigidae			
Eriosoma lanigerum (Hausmann)	On orchard trees	North America	CPC
Lachnidae			
Cinara cupressi (Buckton)	On Cupressaceae	North America? Taxonomy confusing	Lampel, 1974. Watson et al., 1999
Phylloxeridae			
Viteus vitifoliae (Fitch)	On grapevine	North America	CPC
PSYLLINA			
Psyllidae			
Acizzia jamatonica (Kuwayama)	On *Albizia julibrissin* Durazz	East Asia	D. Burckhardt, pers. comm.
Bactericera trigonica Hodkinson	On *Daucus carota* L.	Mediterranean region	Burckhardt and Freuler, 2000
Cacopsylla fulguralis (Kuwayama)	On *Elaeagnus*	East Asia	D. Burckhardt, pers. comm.
Cacopsylla pulchella (Löw)	On *Cercis siliquastrum* L.	Mediterranean region	Burckhardt and Freuler, 2000
Camarotoscena speciosa (Flor)	On *Populus*. Maybe natural spread	Probably Mediterranean region, or Asia	Burckhardt and Freuler, 2000
Ctenarytaina eucalypti (Maskell)	On *Eucalyptus*	Australia	D. Burckhardt, pers. comm.
Homotoma ficus (L.)	On *Ficus carica* L.	Mediterranean region and Middle East	Burckhardt and Freuler, 2000
Livilla spectabilis (Flor)	On *Spartium junceum* L.	Mediterranean region	Schaefer, 1949
Livilla variegata (Löw)	On *Laburnum*	Southern Europe	Schaefer, 1949
Phyllopecta trisignata (Löw)	On *Rubus fruticosus* L. Maybe natural spread	Southern Europe, Near East	Schaefer, 1949
Spanioneura fonscolombii Foerster	On *Buxus sempervirens* L. Maybe natural spread	Mediterranean region	Schaefer, 1949
Triozidae			
Trioza alacris Flor	On *Laurus nobilis* L.	Mediterranean region to Caucasus	Schaefer, 1949
Trioza centranthi (Vallot)	On *Centranthus rubber* (L.)	Mediterranean region	Schaefer, 1949
ALEYRODINA			
Aleyrodidae			
Bemisia tabaci (Gennadius)	Polyphagous, in greenhouse	Cosmopolitan, probably Asia	CABI, 2001
Trialeurodes vaporariorum Westwood	Polyphagous, in greenhouse	Central America	CABI, 2001
COCCINA			
Diaspididae			
Aonidia lauri (Bouché)	Polyphagous, on ornamentals	Mediterranean region	Kozar et al., 1994

Species	Host plant	Origin	Reference for Switzerland
Diaspidiotus distinctus (Leonardi)	On *Corylus*, *Matricaria* and *Quercus*	Mediterranean region. Maybe indigenous	Kosztarab and Kozar, 1988
Diaspidiotus osborni (Newell & Cockerell)	On *Platanus*, *Corylus* and *Gleditsia*	North America	Kozar et al., 1994
Dynaspidiotus britannicus (Newstead)	Polyphagous, indoors and outdoors	Unclear	Kozar et al., 1994
Pseudaulacaspis pentagona (Targioni-Tozzetti)	Polyphagous, on ornamental and orchard trees	East Asia	Mani et al., 1997
Quadraspidiotus labiatarum (Marshal)	Polyphagous	Mediterranean region. Maybe indigenous	Kozar et al., 1994
Quadraspidiotus lenticularis (Lindinger)	Polyphagous on broadleaved trees	Mediterranean region. Maybe indigenous	Kozar et al., 1994
Quadraspidiotus perniciosus (Comstock)	Polyphagous, pest in orchards	East Asia	Mani and Baroffio, 1997
Quadraspidiotus pyri (Lichtenstein)	Polyphagous, pest of fruit trees	Mediterranean region. Maybe indigenous	Kozar et al., 1994
<u>Ortheziidae</u>			
Orthezia insignis Browne	Polyphagous, in greenhouses	Neotropics	Kozar et al., 1994
<u>Pseudococcidae</u>			
Peliococcus multispinus (Siraiwa)	On *Thymus*	East Asia, Caucasus?	Kozar et. al, 1994
Planococcus citri (Risso)	Polyphagous, in greehouses and on indoor plants	Tropics and subtropics	Kozar et. al, 1994
Trionymus penium (Williams)	On *Pseudosasa*	South-east Asia	Kozar et. al, 1994
<u>Coccidae</u>			
Chloropulvinaria floccifera (Westwood)	Polyphagous	Mediterranean region or East Asia?	Kozar et al., 1994
Coccus hesperidum L.	Polyphagous, indoors and outdoors	Cosmopolitan, but prob. not from Europe	Kozar et al., 1994
Eupulvinaria hydrangeae (Steinweden)	Polyphagous on broadleaved trees	Perhaps East Asia	Kozar et al., 1994
Pulvinaria regalis Canard	Polyphagous on broadleaved trees	Perhaps East Asia	Kozar et al., 1994
<u>Margarodidae</u>			
Icerya purchasi Maskell	Polyphagous, indoors and outdoors in Switzerland	Australia	Kozar et al., 1994
Auchenorrhyncha			
<u>Cicadellidae</u>			
Edwardsiana platanicola (Vidano)	On *Platanus*	Unknown. Introduced from Northen Italy	Günthart, 1987
Eupteryx decemnotata Rey	On *Salvia*	Southern Europe	Günthart, 1987
Graphocephala fennahi Young	On *Rhododendron*	North America	Günthart, 1987
Orientus ishidae (Matsumura)	On *Salix* and *Betula*	East Asia	Günthart et al., 2004
Scaphoideus titanus Ball	On vine, vector of 'flavescence dorée'	North America	Günthart, 1987
<u>Flatidae</u>			
Metcalfa pruinosa Say	Polyphagous	North America	Bonavia and Jermini, 1998
<u>Membracidae</u>			
Stictocephala bisonia Kopp & Yonke	Polyphagous	North America	Günthart, 1987
Heteroptera			
<u>Lygaeidae</u>			
Arocatus longiceps Stal	On *Platanus*	Mediterranean region, perhaps expanding naturally	Giacalone et al., 2002
Orsillus depressus Dallas	On Cupressaceae	Mediterranean region, perhaps expanding naturally	R. Heckmann, pers. comm.

Species	Host plant	Origin	Reference for Switzerland
Oxycarenus lavaterae (F.)	On Malvaceae and Tiliaceae	Mediterranean region, perhaps expanding naturally	R. Heckmann, pers. comm.
Miridae			
Deraeocoris flavilinea (A. Costa)	Predator on aphids on broead-leaved trees	Mediterranean Region, perhaps expanding naturally	Rabitsch, 2002
Tingidae			
Corythucha arcuata (Say)	On *Quercus*	North America	Meier et al., 2004
Corythucha ciliata (Say)	On *Platanus*	North America	Barbey, 1996

Tab. 4.6 > Established alien insects in Switzerland: Orthoptera, Dictyoptera, Thysanoptera, Psocoptera, Syphonaptera and Anoplura.

Species	Habitat – Life traits	Origin	References for Switzerland
ORTHOPTERA			
Gryllidae			
Acheta domesticus (L.)	Omnivorous, synanthropic, also ouside in the Valais	North Africa, Cosmopolitan	Thorens and Nadig, 1997
Rhaphidophoridae			
Tachycines asynamorus Adelung	Omnivorous, greenhouses and botanical gardens	Cosmopolitan, probably from East Asia	Thorens and Nadig, 1997
DICTYOPTERA			
Blattellidae			
Blattella germanica (L.)	Omnivorous, synanthropic	Cosmopolitan	Landau et al., 1999
Supella longipalpa (F.)	Omnivorous, synanthropic	Africa	Landau et al., 1999
Blattidae			
Blatta orientalis L.	Omnivorous, synanthropic	Cosmopolitan, possibly indigenous	Landau et al., 1999
Periplaneta americana (L.)	Omnivorous, synanthropic	Africa, cosmopolitan,	Landau et al., 1999
Periplaneta australasiae (F.)	Omnivorous, synanthropic	Cosmopolitan, tropics and subtropics	Landau et al., 1999
THYSANOPTERA			
Thripidae			
Frankliniella intonsa (Trybom)	Polyphagous, mainly in greenhouses	East Asia	CABI, 2001, Linder et al., 1998
Frankliniella occidentalis (Pergande)	Polyphagous, mainly in greenhouses	North America. Now cosmo-politan	CABI, 2001, Ebener et al., 1989
Heliothrips haemorrhoidalis (Bouché)	Polyphagous, in greenhouses	Probably tropical America. Now cosmopolitan	CABI, 2001
Thrips simplex (Morison)	Develops on *Gladiolus*, but found also on many other plants, in greenhouses	Probably South Africa	CABI, 2001
PSOCOPTERA			
Trogiomorpha			
Trogiidae			
Cerobasis annulata (Hagen)	Domestic	Unclear (see text)	Lienhard, 1994
Lepinotus inquilinus von Heyden	Domestic, rarely outdoors	Unclear (see text)	Lienhard, 1994

Species	Habitat – Life traits	Origin	References for Switzerland
Lepinotus patruelis Pearman	Domestic, rarely outdoors	Unclear (see text)	Lienhard, 1994
Lepinotus reticulatus Enderlein	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Trogium pulsatorium (L.)	Domestic	Unclear, perhaps Mediterranean region (see text)	Lienhard, 1994
Psyllipsocidae			
Dorypteryx domestica (Smithers)	Domestic	Unclear, perhaps Africa (see text)	Lienhard, 1994
Dorypteryx longipennis Smithers	Domestic	Unclear (see text)	Lienhard, 1994
Dorypteryx pallida Aaron	Domestic	Unclear, perhaps North America (see text)	Lienhard, 1994
Psyllipsocus ramburii Sélys-Longchamps	Domestic and in caves	Unclear (see text)	Lienhard, 1994
Troctomorpha			
Liposcelididae			
Liposcelis bostrychophila Badonnel	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Liposcelis brunnea Motschulsky	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Liposcelis corrodens (Heymons)	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Liposcelis decolor (Pearman)	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Liposcelis entomophila (Enderlein)	Domestic	Unclear (see text)	Lienhard, 1994
Liposcelis mendax Pearman	Domestic	Unclear, perhaps Asia (see text)	Lienhard, 1994
Liposcelis pearmani Lienhard	Domestic, occasionally outdoors	Unclear (see text)	Lienhard, 1994
Liposcelis pubescens Broadhead	Domestic	Unclear (see text)	Lienhard, 1994
Sphaeropsocidae			
Badonnelia titei Pearman	Domestic	Unclear (see text)	Lienhard, 1994
Psocomorpha			
Ectopsocidae			
Ectopsocus pumilis (Banks)	Domestic	Unclear, perhaps Asia (see text)	Lienhard, 1994
Ectopsocus richardsi (Pearman)	Domestic	Unclear, perhaps Asia (see text)	Lienhard, 1994
Ectopsocus vachoni Badonnel	Domestic	Unclear, perhaps Mediterranean region (see text)	Lienhard, 1994
SIPHONAPTERA			
Pulicidae			
Ctenocephalides felis felis (Bouché)	Ectoparasite on cat and, occasionally, other carnivores	Cosmopolitan, probably not Europe	Beaucournu and Launay (1990)
Spilopsylus cuniculi (Dale)	Ectoparasite on rabbit and, occasionally, other mammals	Probably Iberian Peninsula	Beaucournu and Launay (1990)
ANOPLURA			
Hoplopleuridae			
Haemodipsus ventricosus (Denny)	Ectoparasite on rabbit	Probably Iberian Peninsula	Büttiker and Mahnert (1978)

5 > Spiders and Allies – Arachnida

Prepared by Theo Blick, Ambros Haenggi and Rüdiger Wittenberg

5.1 Introduction

This chapter summarizes the available information on Arachnida, except Acari, covering species' distribution, biology, and potential harm to the environment and economy. Since knowledge of the natural distribution, origins and movement for the Arachnida is very limited, it was decided to use specific definitions for the terms described below, so that coverage of invasive species is expanded to include native species which are spreading, thereby not discriminating between natural spread and human-mediated expansion. The following definitions characterize the framework for this chapter, and explain which species are covered and which are not.

> **Neozoa** (Geiter et al., 2002): A neozoan animal has been introduced, by direct or indirect human mediation, to a region to which it is not native and has established a population there.
> **Invasive Species** (Geiter et al., 2002): This term does not discriminate between natural and human-mediated colonization of a new territory and focuses on species causing problems.

The spiders discussed in this report are categorized mainly by habitat and biology, as follows:

> **Species of natural habitats:** spiders and their relatives which live in natural, near-natural or human-influenced habitats (e.g. crop fields), but not in close proximity to human buildings. The report focuses on species which have changed their distribution, mainly during the last two decades because of a lack of older data. It is based on pitfall trap results, since continuous and standardized information on orb web species is not available.
> **Species inside, and in close proximity, to human buildings:** spiders and their relatives which typically inhabit walls of buildings or live in direct contact with humans, and which have expanded their distribution range into Central Europe during recent decades.
> **House-dwelling species:** spiders and their relatives which exclusively occur in buildings, and no populations in natural habitats are known.
> **Greenhouse-inhabiting species:** spiders and their relatives which, in Central Europe, exclusively inhabit greenhouses and other similarly warm buildings. They have established populations in these warm environments, but cannot survive out-

side due to their climatic requirements. They can also be introduced into houses, e.g. with flowers (e.g. *Eperigone eschatological* (Crosby)).

> **'Banana spiders':** spiders which are introduced with fruit commodities, especially bananas. They are often rather spectacular individuals, but they are not able to establish in our climate.
> **Terrarium species:** spiders, mostly tarantulas/theraphosids (so-called 'bird-eating spiders') from warm regions, which escape captivity, but cannot breed in the Central European climate and at the most survive until the following winter.

The orders Araneae (spiders), Opiliones (harvestmen) and Pseudoscorpiones (false scorpions) within the class Arachnida are covered in this report. Acari (ticks and mites), although very important for the agricultural and the health sectors, are not included in this review, because of the difficulties of preparing comprehensive lists and their minor relevance for the environmental sector. Species which were introduced to Switzerland more than a few decades ago are not included, because of their largely unresolved status. Thus, the wasp spider *(Argiope bruennichi* (Scopoli)) is not included in the list. Additionally, species which besides inhabiting houses and basements also live in caves, rock screes, walls in vineyards or quarries, as for example the genus *Pholcus* or the jumping spider *Salticus scenicus* (Clerck), are not discussed here.

The main general literature sources for the report are Thaler and Knoflach (1995), Geiter et al. (2002) and Komposch (2002).

Knowledge about synanthropic spiders and their relatives in Switzerland is extremely limited. Therefore many observations discussed in the report are based on knowledge, although likewise rudimentary, accumulated in other Central European countries, and extrapolated to Switzerland. The situation in these countries will be similar to that in Switzerland and including the information gives a more comprehensive picture of the alien spider fauna of Central Europe.

Generally, synanthropic spiders seem to attract less attention than species inhabiting natural habitats even among arachnologists or, rather, little is published about them. The spitting spider *Scytodes thoracica* (Latr.) is an example of a spider almost exclusively found in houses in Central Europe; its distribution is fairly well-known by arachnologists, but there are few publications about it. The same is true for species of the genus *Araneus,* which frequently occur in houses and gardens.

5.2 List of species

Table 5.1 introduces the species mentioned in this report.

Tab. 5.1 > Species mentioned in this report, named after Platnick (2004).

Species name	Author, Year	Family	Habitat
Achaearanea tabulata *	Levi, 1980	Theridiidae	In houses
Artema atlanta *	Walckenaer, 1837	Pholcidae	In houses
Astrobunus laevipes *	(Canestrini, 1872)	Phalangiidae	Natural
Chelifer cancroides	(L., 1758)	Cheliferidae	In houses
Cicurina japonica	(Simon, 1886)	Dictynidae	Natural
Coleosoma floridanum	Banks, 1900	Theridiidae	Greenhouses
Collinsia inerrans	(O. P.-Cambridge, 1885)	Linyphiidae	Natural
Dasylobus graniferus	(Canestrini, 1871)	Phalangiidae	Natural
Dictyna civica	(Lucas, 1850)	Dictynidae	On buildings
Diplocephalus graecus *	(O. P.-Cambridge, 1872)	Linyphiidae	Natural
Eperigone eschatologica	(Crosby, 1924)	Linyphiidae	Greenhouses
Eperigone trilobata	(Emerton, 1882)	Linyphiidae	Natural
Erigone autumnalis	Emerton, 1882	Linyphiidae	Natural
Harpactea rubicunda	(C.L. Koch, 1838)	Dysderidae	In houses, but also natural
Hasarius adansoni	(Audouin, 1826)	Salticidae	Greenhouses
Heteropoda venatoria	(L., 1767)	Sparassidae	Greenhouses
Holocnemus pluchei	(Scopoli, 1763)	Pholcidae	In houses
Micropholcus fauroti *	(Simon, 1887)	Pholcidae	In houses
Nesticus eremita	Simon, 1879	Nesticidae	Natural
Oecobius maculatus	Simon, 1870	Oecobiidae	Natural
Opilio canestrinii	(Thorell, 1876)	Phalangiidae	On buildings
Ostearius melanopygius	(O. P.-Cambridge, 1879)	Linyphiidae	Natural
Pseudeuophrys lanigera	(Simon, 1871)	Salticidae	On buildings
Psilochorus simoni	(Berland, 1911)	Pholcidae	In houses
Thanatus vulgaris *	Simon, 1870	Philodromidae	Greenhouses
Uloborus plumipes	Lucas, 1846	Uloboridae	Greenhouses
Zodarion italicum	(Canestrini, 1868)	Zodariidae	Natural
Zodarion rubidum	Simon, 1914	Zodariidae	Natural
Zoropsis spinimana	(Dufour, 1820)	Zoropsidae	In houses

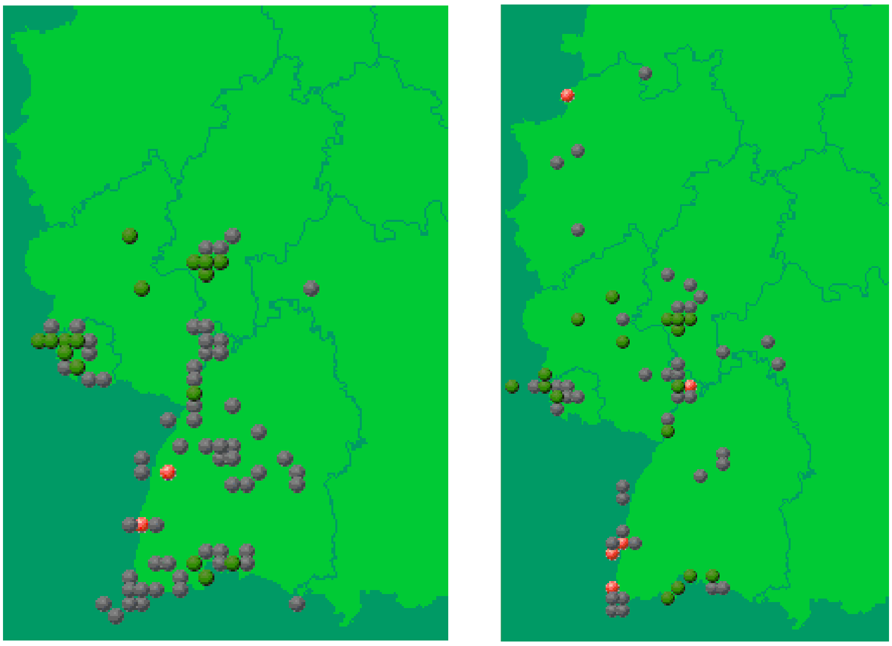
*Species not yet recorded from Switzerland.

5.3 Species of natural habitats

Eperigone trilobata (Emerton)

This spider has a wide distribution range in North America (Millidge, 1987) and was first recorded from Europe in the 1980s at Karlsruhe, Germany. A catalogue of Swiss spiders (Maurer and Hänggi, 1990) noted several records from the Swiss cantons Jura and Ticino. This species is a common member of the spider fauna in all open habitats (e.g. Blick et al., 2000) and was first recorded in the Jura in 1999 at about 800 m above sea level (T. Blick, unpubl.).

Fig. 5.1 > Records of Eperigone trilobata (left) and Zodarion italicum (right) in Germany and north-west Switzerland.



After Staudt (2004). (green dots: since 2000, grey dots: 1990–1999, red dots: 1980–1989)

In Germany, this species has spread from Baden-Württemberg, where it was first found, to Hessen and Rheinland-Pfalz and into north-western Bayern (Staudt, 2004: see Fig. 5.1). There are also records from outside this area, i.e. in the east of Bayern and the south of Niedersachsen (T. Blick, unpubl.; pers. comm. of various arachnologists – these data are not included in Fig. 5.1). The data presented above indicate that this species will colonize Central Europe in the foreseeable future. However, it is unclear what the altitude limit will be or whether its frequency in samples will increase. During past years, there has been no indication that the frequency of the species is increasing – to the contrary, investigations on the same field site in 1994 and 1999 showed a decrease in numbers of the species (Baur et al., 1996; Hänggi and Baur, 1998; Blick, unpubl.). In most samples the frequency of the species reached only about 5% – the maximum was 30% at Basel railway station in 2002 (Hänggi and Heer, unpubl.).

Displacement of native spider species has not been recorded and would be very difficult to prove. Such studies would involve standardized experiments at the same field site over decades, with year-round sampling and also Swiss-wide sites for comparative work. Funding for this kind of research seems unlikely, although the samples could be used for other arthropod research.

Zodarion italicum (Canestrini)

The origin of the aptly named *Zodarion italicum* is the south of Europe. It has expanded its distribution since the publication of the catalogue of Swiss spiders (Maurer and Hänggi, 1990 – cited as sub *Z. gallicum),* and has since reached the south of Switzerland. It is possible that it is even native to that region (see, e.g., Lessert, 1910). This spider is a highly specialized predator of ants (Pekar and Kral, 2002) and occurs mainly in open habitats. The rapid expansion of its range is probably attributable to human-mediated transport to new areas and to global warming, which allows species of southern origin to survive north of the Alps. However, this probable relationship would be difficult to demonstrate. The species is also expanding its range in Germany, as is its sister species *Z. rubidium* Simon (see Bosmans, 1997; Staudt, 2004; also see Figure 5.1).

Other species found in natural habitats

Besides the two species mentioned above, a number of other species are spreading in Central Europe, or their spread is likely within the next few years. A selection of these species is discussed below.

> ***Collinsia inerrans*** (O.P.-Cambridge) (syn. *Milleriana inerrans, C. submissa)* has been found locally in Switzerland during the last 50 years. Currently, the species is expanding its range in western Germany (Klapkarek and Riecken, 1995), and has reached the north-east of Bayern (Blick, 1999). However, it has not yet reached the abundance of *Eperigone trilobata,* despite their similarities in size and ecological niche. The future expansion of this species in Switzerland should be monitored.
> ***Ostearius melanopygius*** (O.P.-Cambridge): Ruzicka (1995) portrays the spread of this cosmopolitan species of unknown origin (cryptogenic) in Europe. In Switzerland, a similar pattern as for *C. inerrans* has been observed. However, occasionally the species exhibits mass outbreaks, which can be a nuisance to humans although it does no actual harm (Sacher, 1978); for cases in Switzerland see, e.g., Benz et al. (1983). The normal sampling techniques using traps at ground level are not effective under these circumstances and generally catch only single individuals. The reasons for the mass outbreaks are not yet understood.
> The distribution of ***Harpactea rubicunda*** (C.L. Koch) described by Wiehle (1953) was restricted to the eastern part of Germany at that time. Since then, the species has expanded its range considerably westwards, most probably by human-mediated transport. It occurs in houses as well as in other synanthropic habitats. In Switzerland, the species was found near Zurlinden (Hänggi, 1988) and in a disused railway area at Basel (Hänggi and Weiss, 2003).
> ***Erigone autumnalis*** Emerton, like *Eperigone trilobata,* originates in North America. The species has been found at several locations in Switzerland (Maurer and Hänggi, 1990; Hänggi, unpubl.). However, it seems to be less abundant and covers a smaller range than *E. trilobata*.
> ***Nesticus eremita*** Simon can be found outdoors around Basel (Hänggi and Weiss, 2003; Hänggi, unpubl.), whereas further north the species is restricted to underground canals and artificial caves (Jäger, 1995, 1998; Blick, unpubl.). It is very

likely that this southern European species will expand its range further in the near future.

- ***Cicurina japonica*** (Simon): this spider of Japanese–Chinese origin was not accepted as an established spider species in Germany by Platen et al. (1995), since the introduction of the species near Kehl am Rhein was thought to be temporary. Since then, fairly large populations have been found in the area around the railway at Basel (Hänggi and Heer, unpubl.). This indicates that the species is able to establish in Europe and the further development of its populations should be monitored.
- ***Diplocephalus graecus*** (O.P.-Cambridge): Blick et al. (2000) presents a record of this species of Mediterranean origin from agricultural areas near Paris, France. Today the species has reached Belgium (Bonte et al., 2002), so it is very likely that it will expand its range into most of Central Europe, including Switzerland, in the near future.
- ***Dasylobus graniferus*** (Canestrini) (syn. *Eudasylobus nicaeensis):* Martens (1978) mentions records of this harvestman species from southern Switzerland. However, in 1997 more than 100 individuals were collected near Liestal (canton Baselland) (I. Weiss, unpubl.). Thus, an expansion into Central Europe of this southern European species is expected, but will probably be difficult to document, since almost no research on harvestmen distribution is being carried out in Switzerland or in adjacent areas of Germany.
- Another harvestman, ***Astrobunus laevipes*** (Canestrini), is already in an expansion phase in Central Europe (see Höfer and Spelda, 2001), especially along rivers. It reached the Netherlands recently (Wijnhoven, 2003). There are no records for Switzerland yet. However, its taxonomic differentiation from *A. bernardinus* Simon, known from the Jura, would merit attention (see Höfer and Spelda, 2001).

Any estimation of potential impacts of the species discussed above would only be guesswork. Economic damage can reasonably be excluded, but it is possible that native species would be replaced or at least populations reduced due to the invaders. However, testing this hypothesis would necessitate long-term monitoring studies in the field on established plots. These investigations are not being carried out to the knowledge of the authors.

5.4 Species in, and in close proximity to, human buildings

Only a few members of the Arachnida are restricted to the outside of houses and other human-made structures, although there are native species naturally occurring on rocks and tree bark. The species which have expanded their range in recent decades are discussed below:

- ***Dictyna civica*** (Lucas) inhabits walls of houses particularly in warm climates (Braun, 1952; Billaudelle, 1957; van Keer and van Keer, 1987). The species is considered to be a nuisance by owners of houses in the lowland parts of Switzerland as well as in the Rhine valley in Baden-Württemberg (Stächele, 2002).

- ***Pseudeuophrys lanigera*** (Simon) (syn. *Euophrys lanigera)* is a good example of a spider which has been continuously expanding its range in Central Europe in recent decades (Braun, 1960; Wijnhoven, 1997; Staudt 2004). Although Maurer and Hänggi (1990) listed only a few sites for this species in Switzerland, it is likely to expand its range in the near future. It is not known whether the species is replacing or influencing the population of native jumping spiders with similar ecological niches on house walls, e.g. *Salticus scenicus*.
- The harvestman ***Opilio canestrinii*** (Thorell) has established populations on walls of houses in Central Europe (Enghoff, 1987; Bliss, 1990; Gruber, 1988; Malten, 1991; van der Weele, 1993). However, records of natural populations, i.e. on bark of trees, have been documented since then (e.g. Staudt, 2004). As the monitoring of harvestmen distribution and ecology in Switzerland is minimal, there are almost no data available from Switzerland on this species (Martens, 1978: sub *O. ravennae).*

House-dwelling species

Spiders living in residential houses have either adapted from native natural habitats such as tree bark, caves and cliffs, or have been introduced from southern Europe and become established. Sacher (1983) gives an overview of spiders living in houses. Some additional house-dwelling species are occasionally observed (Hänggi, 2003), e.g. *Achaearanea tabulata* Levi in Austria and Germany (see Knoflach, 1991; Thaler and Knoflach, 1995), and therefore this species is likely to be found in Switzerland in the future. However, with the exception of *Zoropsis spinimana* (Dufour), which is discussed below, no house-dwelling species is showing signs of being invasive.

Zoropsis spinimana (Dufour)

The first record of *Z. spinimana* was an individual caught in 1994 in a residential house in Basel (Hänggi, 2003). Since then other records have been reported from houses in the south of Switzerland (Ticino). Observations in Austria (Thaler and Knoflach, 1998) suggest this species could cause problems, as it is one of the very few spiders in Central Europe which can penetrate the human skin with its cheliceres and produce a painful bite (Hansen, 1996). This species has not (yet) been recorded from Germany (Blick et al., 2002).

Other species of house-dwelling spiders and their relatives

Some other spider species living in houses are currently found more regularly in Central Europe, e.g. *Psilochorus simoni* (Berland). These species do expand their range, but are found only in small numbers or as individuals. More invaders can be expected, in particular in the family Pholcidae (daddy long legs spiders). This is indicated by observations in the harbour at Antwerpen, Belgium (van Keer and van Keer, 2001), where the introduced *Artema atlanta* Walckenaer and *Micropholcus fauroti* (Simon) have become established, and from German cities, where stable populations of *Holocnemus pluchei* (Scopoli) have been found (Jäger, 1995, 2000).

Interestingly, in contrast to the expanding nature of many house-dwelling species, the false scorpion *Chelifer cancroides* (L.) seems to be decreasing in abundance, although the distribution and population sizes of this group are very poorly investigated in Switzerland, especially in synanthropic areas. Apparently, the increased hygiene and the changed climate in houses caused by central heating affects this species. The considerable alteration in temperature, and changes in daily temperature and humidity, might favour some species, especially species adapted to a warm environment, and negatively affect others.

5.5 Greenhouse-inhabiting species

> ***Hasarius adansoni*** (Audouin) is a cosmopolitan species, which is widespread in European greenhouses (Simon, 1901; Holzapfel, 1932; König and Pieper, 2003). Records from Switzerland are summarized by Hänggi (2003). Information on synanthropic spiders in general, and this species in particular, is too limited to come to any conclusion about the status of species, e.g. whether populations are increasing.
> ***Uloborus plumipes*** Lucas is another greenhouse species, but is much more common than the species above (Jonsson, 1993, 1998; Thaler and Knoflach, 1995). However, misidentifications in some records arising from confusion with the congeneric *U. glomosus* (Walckenaer) cannot be ruled out.
> The first record of ***Coleosoma floridanum*** Banks in Switzerland was reported by Knoflach (1999) from the tropical greenhouse of the Old Botanical Garden at Basel. This pantropical species is occasionally reported from greenhouses in Europe (Hillyard, 1981; Broen et al., 1998; Knoflach, 1999). However, its status cannot be evaluated yet.
> ***Eperigone eschatologica*** (Crosby) was first recorded in Europe from Germany and Belgium (see Klein et al., 1995; Bosmans and Vanuytven, 1998) but very recently it was found in Switzerland in a private flat, most probably carried on a plant from a German garden centre (Hänggi, unpubl.). It remains to be seen whether it will become established in greenhouses in Switzerland.
> ***Heteropoda venatoria*** (L.), a member of the family Thomisidae (crab spiders) of South-east Asian origin, was repeatedly reported from heated buildings, e.g. in zoos (Jäger, 2000). Surveys and research on the spider faunas of heated buildings and greenhouses would be a useful exercise, since this species is also able to penetrate human skin (c.f. *Zoropsis spinimana).*
> ***Thanatus vulgaris*** Simon, a Mediterranean sister species of the native *T. atratus* Simon, would most probably be found in Swiss greenhouses if an intensive survey were undertaken (see Jones, 1997; Jäger, 2002).

5.6 «Banana spiders» and terrarium species

Since the species introduced by trade in bananas and other tropical fruits (see e.g. Schmidt, 1971) cannot establish populations in our climate, they are only of medical interest, because they include some dangerous members of the family Ctenidae from South America. Pesticides used before or during transport will often lead to the death of spiders en route or shortly afterwards (pers. obs. by T. Blick of a ctenid which arrived in Bayreuth, Germany in a consignment of bananas from Brazil).

However, some of the many stable populations of spider species in greenhouses are probably the result of such introductions with trade. Thus, it is possible that poisonous species, especially small ones, including some dangerous for humans could be accidentally introduced and established in greenhouses (see, e.g., Huhta, 1972).

Spiders appropriately kept in terrariums are of no concern, but escaped specimens should be handled with care, since the bite of some species (although not many) can be dangerous for humans. If they escape into the wild they will die when temperatures drop, since all species are of tropical or subtropical origin.

5.7 Discussion and recommendations

Monitoring spider species currently expanding their range after introduction, and surveys at places prone to introductions, are recommended as elements of an early warning system. This would allow the spread of the alien species to be followed and document any displacement of native species. Some species are invading, but there is no way of evaluating their potential threat to native biodiversity. The data collected on synanthropic spiders in Switzerland, as well as other Central European countries, are too limited to allow any conclusions to be drawn. Some cases of established tropical species and increasing trade indicate the possibility of venomous spider species arriving in Switzerland. If a venomous spider becomes established, the public would need to be well-informed about how to handle the situation and anti-venom kits should be made available.

Furthermore, to document threats to native species in natural habitats, the establishment of long-term surveys in specific habitats is recommended. Without further studies on alien spider species, potential impacts are only guesswork.

Surveys for synanthropic alien spiders and their relatives are of lesser importance, as long as no dangerous spiders are introduced and the species that do arrive cannot become established outside. Thus, the costs of conducting surveys for these would probably not be justified. However, monitoring of some selected species (e.g. *Oecobius maculatus* Simon and *Zoropsis spinimana)* to document their spread would be both worthwhile and manageable.

In particular, we recommend an assessment of alien spiders in greenhouses and other heated buildings. Greenhouses in nurseries and garden centres are the most likely to be colonized by alien spider species, and from there these can be spread to households on plant material (e.g. *Eperigone eschatologica)*. Research and monitoring are needed, because of the potential economic impact of some species. The first encounter with *Uloborus plumipes* is an example: a nursery started an inquiry to find out what species had infested their property after this spider had covered all plants with webs, so that plants became difficult to sell. Moreover, the possibility of accidental introductions of poisonous spiders should not be underrated. Nurseries would be the main targets for these monitoring programmes, but other heated buildings in botanical gardens and zoos should be included.

The following are considered to have the greatest potential for economic impacts:

> Mass outbreaks of nuisance species (see *Ostearius melanopygius),* but without causing real damage.
> A dramatic increase in the population of the wall-inhabiting spider *Dictyna civica*.
> The potential medical costs for treatments of bites of introduced poisonous spiders, see ‘banana spiders’, and escaped terrarium species.

Having noted the potential threats to humans, it has to be stressed that broad use of pesticides against spiders is not a reasonable reaction, because of the non-target effects of these chemicals and the fact that publicity of such measures will exaggerate arachnophobia, already well-grounded in the human population.

In conclusion, only a very small number of spiders and their relatives are considered as problem species on a global scale, including Central Europe (e.g. Welch et al., 2001 do not list any alien spiders for Scotland). A reasonable explanation could be that many phytophagous insects live in closer association with their host plants, e.g. eggs, larvae and pupae are firmly attached to host plants or inside them. This would facilitate their transport with plant material. Another factor is that spiders with their predatory behaviour are less obvious than phytophagous insects that damage their host plants. Moreover, as pointed out earlier, the group is rather neglected and many information gaps still exist. However, after successful introduction into a new area, many spiders are highly capable of a rapid expansion in range either by natural means such as ballooning or by hitching a ride on vehicles.

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6 > Molluscs – Mollusca

Prepared by Rüdiger Wittenberg

The molluscs are a very large successful group of about 130,000 described species, making them second in number of species only to the arthropods (Remane et al., 1981). However, of the molluscs' seven classes only two occur in Switzerland, since the others are strictly marine species.

In the text below, gastropod and bivalve species are discussed separately. For ease of reference, in Table 6.2 the species are divided into terrestrial snails (including slugs), freshwater snails and bivalves, while the Fact Sheets are in alphabetical order of species.

A total of 16 gastropods and three bivalves are regarded as established alien species.

6.1 Snails and slugs (Gastropoda)

Gastropods make up 70% of all molluscs and are well represented in marine, freshwater and terrestrial habitats. About 196 terrestrial and 50 aquatic species occur in Switzerland (Turner et al., 1998).

The exact natural distribution of the gastropod species in Switzerland is not well known, and many current populations may be early relocations (introductions within Switzerland). Snails are very successful at hitching a ride, so that many former barriers have been easily bridged through human-mediated transport. Snails arrived on plant material as early as during Roman times. The aquatic snail *Viviparus ater* (Molina) is an example of relocation in Switzerland. Its native range is believed to be south of the Alps, including the Ticino, but today its range north of the Alps encompasses the lower regions between Lac de Genève and Bodensee. It was released into Lac de Genève before 1900.

Snails found in greenhouses are not covered by this report if they do not occur outside as well. Turner et al. (1998) provide a discussion of greenhouse snails and species that have been recorded only temporarily, and which are therefore not considered to be established in the wild.

The snail ***Solatopupa similis*** (Bruguière) (Chondrinidae) was introduced to a location close to Locarno in the 19^{th} century for unknown reasons. This population thrives, but the species' impact is considered minimal because of its very localized distribution.

The family Milacidae with two native species, has been supplemented in Switzerland with two more, i.e. ***Milax gagates*** (Draparnaud) and ***Tandonia budapestensis*** (Hazay), both from other parts of Europe. *M. gagates* has been found only in gardens, where it probably arrived with plant material, so it is not known whether it is established in Switzerland. *T. budapestensis* is an anthropochorous (disperses as a result of human activity) species that is widely distributed within Europe. It is regarded as a pest, especially in winter crops (Fischer and Reischütz, 1998), but is rather difficult to observe because of its cryptic, nocturnal habits.

Another synanthropic species (in addition to members of the Milacidae) is ***Limacus flavus*** (L.) (Limacidae), which is only rarely encountered in Switzerland. It is likely that this species will be introduced with plant material in the future, but it is probably not adapted to the Swiss environment, so that it is less likely to become established.

The slugs ***Deroceras sturanyi*** (Simroth) and ***D. panormitanum*** (Lessona & Pollonera) belong to the Agriolimacidae. This family is taxonomically challenging and new species have recently been described (Kerney et al., 1983). These slugs prefer fresh green plant material and therefore some are recognized as pests. The former species has been considered a pest in gardens, while the latter species is only rarely found in Switzerland. However, *D. panormitanum* is expanding its range in Europe and is increasingly reported as damaging plants of economic importance. This is a species that should be monitored, since it is likely to establish populations in agricultural areas, with the potential to cause economic damage in the near future.

The origin of the slug ***Boettgerilla pallens*** Simroth (Boettgerillidae) is assumed to be the Caucasus, although Jungbluth (1996) argued that it might be a native species in Central Europe which had not been reported earlier. Most collections of slugs are fairly recent and the lack of a shell makes it difficult to find species as subfossils. This species is a predator of slug eggs and young slugs (Reischütz, 2002), so it is a beneficial organism in agricultural settings rather than a pest, as sometimes stated. However, in natural localities, it may have a negative impact on native slugs through predation.

Arion lusitanicus Mabille (Arionidae) (see Fact Sheet) is rapidly expanding its range, and is the most serious invader amongst the snails and slugs. It is not only a pest in agriculture and gardens, but also displaces a native congeneric species in the lowland parts of Switzerland (Turner et al., 1998).

The snail ***Hygromia cinctella*** (Draparnaud) (Hygromiidae) has been accidentally introduced into the northern parts of Switzerland, but could be native around Genève or in the Ticino. It was introduced prior to the start of malacological recording and is mostly found in gardens and other anthropogenic settings (Kerney et al., 1983).

The only introduced species of Helicidae is ***Cryptomphalus aspersus*** (O.F. Müller), which was introduced prior to the start of malacological recording. It is mostly found in gardens and other anthropogenic habitats, although it is recorded from natural habitats, e.g. in the Valais. Its environmental impact is not known, but it is regarded as a pest in gardens.

The freshwater snail ***Potamopyrgus antipodarum*** (Gray) (Hydrobiidae) (see Fact Sheet) is one of the few long-distance invaders in this group. It is native to New Zealand and has been spread around the world probably with ballast water between freshwater systems and on ornamental aquatic plants. Haynes et al. (1985) have suggested another pathway as they have shown that *P. antipodarum* can survive a six-hour passage through the gut of a trout and produce live young shortly afterwards. It is very likely to induce ecosystem changes because of its enormous numbers in some places.

Two *Physella* species, ***Physella acuta*** (Draparnaud) and ***P. heterostropha*** (Say) (Physidae), have been introduced into Switzerland. The latter species is of North American origin, but the origin of the former species is disputed, although it probably originates in south-western Europe. Since *P. heterostropha* is cold-tolerant, the expansion of its range could lead to competition with native snails. While Turner et al. (1998) state that the two species are morphologically distinct and occur together in some parts of Switzerland, Anderson (2003) records the two species as synonyms.

Two alien species of Planorbidae, ***Gyraulus parvus*** (Say) and ***Planorbarius corneus*** (L.), probably cause no concern, because the former is a rare species of North American origin and the latter is a native species in Europe. It is likely that *P. corneus* cannot establish populations in Switzerland, because of unsuitable climatic conditions. However, it is found frequently, probably released from aquariums or transported by birds from garden ponds.

6.2 Bivalves (Bivalvia)

There are only three introduced and established bivalves, but they are of concern, because of their high abundance and feeding behaviour.

The two *Corbicula* species (***Corbicula fluminea*** (O.F. Müller) and ***C. fluminalis*** (O.F. Müller)) are very similar, so that they are discussed together (see Fact Sheet). Hakenkamp and Palmer (1999) have demonstrated the strong influence *Corbicula* spp. have on ecosystem functioning by linking pelagic and benthic processes as a result of their intense filter feeding activity.

The zebra mussel ***Dreissena polymorpha*** (Pallas) (Dreissenidae) (see Fact Sheet) is one of the most widely cited case studies of a freshwater invader. Whereas the species is often considered to be beneficial in Europe, especially as a food source for diving ducks, it is inflicting huge costs to the USA and Canada in the Great Lakes area. The transformation of freshwater ecosystems by *D. polymorpha* is documented by Strayer et al. (1999) and Karateyev et al. (2002).

The 19 established alien mollusc species belong to very different groups, i.e. 14 families, with only one or two species per family. However, the species can be considered as belonging to a number of major groups. Seven species from four families of slugs (Milacidae, Limacidae, Agriolimacidae and Arionidae) have been introduced into

Switzerland. The total number of species in these families found in Switzerland is 33, so about 21% are introduced. This is a rather high percentage, as will be seen below. It seems that slugs are very good at hiding in plant material, decaying material and other commodities and are widely transported. Today there are three established introduced bivalves, which is about 11% of the total of 28 species found in Switzerland. Probably six out of the 50 freshwater snail species are alien (12%). Finally, the large group of terrestrial snails (terrestrial molluscs excluding the four families of slugs mentioned above) comprise approximately 160 species, of which a mere three species (2%) are introduced. With the exception of the slugs, the pattern that emerges might be a random phenomenon due to small sample sizes; whereby a few introductions of species in smaller groups form a higher percentage of the total fauna. The extreme would be a randomly introduced species from a group comprising one species, which would form 100% of the fauna of that particular group. The total percentage of established molluscs is about 6.9% (19 of 274 species).

A comparison of the established mollusc species in Switzerland and Austria shows a very similar picture; the percentage of introduced mollusc species is 6.9% in Switzerland and 7.6% in Austria (Essl and Rabitsch, 2002). Of course, the total number of species differs because Austria is about twice the size of Switzerland (83,855 km^2 compared to 41,285 km^2). About 435 mollusc species occur in Austria, including 33 aliens. Even more established alien mollusc species are recorded in Germany, about 40, but five of those are marine (Geiter et al., 2002). There is a remarkable overlap of the alien species in the three countries, emphasizing the regular introduction of some species (in some cases using the same frequent pathways).

Most of the established alien mollusc species originate within Europe (Tab. 5.1), although the exact origin of some Ponto–Caspian species is not known, so whether these species originate in Europe or Asia may be disputable. Only five (about a quarter) of the species travelled a long distance to Switzerland. The majority have apparently profited from short-distance transport of commodities between European countries.

Tab. 6.1 > Origin of alien molluscs established in Switzerland.

Origin	No. species
Europe	13
Asia	2
North America	2
Switzerland	1
New Zealand	1
Total	19

This leads to an evaluation of the pathways by which these 19 species arrived in Switzerland. It is possible that at least some species could have arrived by several pathways, and for some species the pathways by which they were introduced are speculative rather than proven. The most likely pathways for each species are listed in Table 6.2. About 74% (14 species) were accidentally introduced, while the others were released for unknown reasons and from aquariums (often with the good intention of 'freeing' surplus animals). Five of the eight aquatic species were probably transported by boats and ships, either in ballast water or attached to hulls. The accidental terrestrial introductions were most likely made with imported vegetables and other plant material.

The impacts of the established alien molluscs are discussed in some detail and further references are given in the Fact Sheets and in the text above. Only five out of 19 species can be regarded as harmless, based on present knowledge. The terrestrial slugs (and to a certain extent snails) are mainly economic pests of agriculture and in gardens. However, research on environmental impacts is largely lacking, with the exception of *Arion lusitanicus* displacing the native *A. rufus* (L.). The situation is different in freshwater ecosystems, with demonstrated dramatic impacts of the introduced bivalves on native biodiversity and ecosystem functioning. The introduced bivalves are a novel life form in their new range, because of their densities and intense filter-feeding activities, which alter the correlation between benthic and pelagic communities. They may also have some economic impact because of their colonization of pipes and other artificial structures.

In general, alien species should be treated separately from the native fauna and should not appear on a Red List of endangered species, when they are beyond doubt introduced. This is especially true for the intercontinental invader, since some European species could also expand their range into Switzerland and distinguishing between the two categories (aliens of European and extra-continental origin) is often challenging. However, species such as *Physella heterostropha*, a Nearctic invader, should not appear on the Red List as potentially vulnerable ('potentiell gefährdet'), as it does. Thus, the concept of the Red List of Switzerland should be re-addressed, with alien species being excluded.

Prevention of new mollusc invasions is dependent on identification of the pathways of introduction. Plant health inspection has improved recently and should be vigilant for new arrivals of slugs and snails, as well as insects and other invertebrates. The ballast water issue is currently being addressed for sea-going ships by the International Maritime Organization (IMO) whereby methods are evolving to treat ballast water. Some of these measures can also be used for ships on inland waterways. Another crucial topic is public education and awareness; when using a boat, boots or fishing gear, people should take care not to transport potential hitchhikers. Aquarium owners and pet store merchants need to be made aware of potential problems arising from the release of pets.

Several slug species are major pests in crops, and management strategies to reduce harvest losses have been implemented. Slug pellets, a bait that contains slug attractants and a molluscicide (e.g. metaldehyde), are frequently used. Alternative methods include the use of nematodes and runner ducks (a special breed of the mallard) as biological control agents, as well as hand-picking. The latter approach, although very laborious, was successfully used to eradicate the giant African snail *(Achatina fulica* Bowdich) in Florida, USA (Simberloff, 1996). This was a remarkable achievement. Slug fences and beer traps are often used in gardens. However, these methods are usually used to protect plants at a specific location and are not designed to reduce numbers of snails and slugs of environmental concern on a large scale.

In conclusion, the freshwater ecosystems need to receive more attention and the potential impacts of alien invaders should not be underrated. It is generally very difficult to give conclusive proof of the impacts of invasive species on native biodiversity. However, many of the freshwater invaders reach remarkable densities and will have impacts on natural ecosystems. These invaders are not only molluscs, but often crustaceans and fish (see respective chapters). The boom-and-bust phenomenon (Williamson, 1996) that is frequently observed with many invading species seems often to be caused in European freshwater systems by the arrival of yet another invader. Thus, this does not solve the problem, but simply shifts it to another invader and its impacts. In a terrestrial context, the slug *Arion lusitanicus* is probably of greatest concern in Switzerland (and Central Europe).

Tab. 6.2 > Established alien molluscs in Switzerland.

Scientific name	Family	Year	Origin	Pathway	Impact	Note
Terrestrial snails						
Solatopupa similis (Bruguière)	Chondrinidae	19th century	Genoa, Italy	Released to enrich fauna	Probably harmless	Only one location near Locarno, Ticino
Milax gagates (Draparnaud)	Milacidae	1968	Western and southern Europe	Accidental with vegetables shipment?	Pest in crops and gardens	Not clear whether established or only repeatedly introduced
Tandonia budapestensis (Hazay)	Milacidae	1935	South-eastern Europe	Accidental with vegetables shipment?	Pest, in particular in winter crops, when abundant	Anthropochorous – introduced widely by human-mediated transport
Limacus flavus (L.)	Limacidae	1927	Mediterranean	Accidental	Harmless	Very rare in Switzerland, mostly synanthropic
Deroceras sturanyi (Simroth)	Agriolimacidae	1963	South-eastern Europe	Accidental	Damage to plants in gardens	Mostly secondary habitats
Deroceras panormitanum (Lessona & Pollonera)	Agriolimacidae	1982	South-western Europe	Accidental	Future damage anticipated	Very rare in Switzerland, only in gardens and parks
Boettgerilla pallens Simroth	Boetgerillidae	1960	Caucasus?	Accidental	Predator of native slugs?	Impact not known, but a predator of slugs
Arion lusitanicus Mabille	Arionidae	1950s	Western Europe	Accidental	Most serious pest in gardens and agriculture Displaces native *Arion rufus* (L.)	Most problematic terrestrial snail

Scientific name	Family	Year	Origin	Pathway	Impact	Note
Hygromia cinctella (Draparnaud)	Hygromiidae	1824?	Mediterranean	Accidental	Harmless	Perhaps native in southern and south-western Switzerland, but introduced to the northern parts
Cryptomphalus asperus (O.F. Müller)	Helicidae	Before 1789	South-western Europe	Released	Garden pest	Mainly synanthropic, but also found in natural habitats
Freshwater snails						
Viviparus ater (Molina)	Viviparidae	Before 1900	South Switzer-land	Accidental introduction with boat traffic	Probably harmless	Native in southern Switzerland
Potamopyrgus antipodarum (Gray)	Hydrobiidae	1972	New Zealand	Accidental introduction with boat traffic and birds	Can drastically alter primary production	Rapid expansion throughout Europe
Physella acuta (Draparnaud)	Physidae	1848	South-western Europe	Accidental release from aquariums?	Not known	Maybe of North American origin
Physella heterostropha (Say)	Physidae	Before 1991	North America	Accidental	Competition with native snails?	Expanding in Europe
Gyraulus parvus (Say)	Planorbidae	1994	North America	Accidental with aquatic plants	Not known	Rare in Switzerland
Planorbarius corneus (L.)	Planorbidae	1840	Europe	Releases from aquari-ums	Probably harmless	Perhaps not established
Bivalves						
Corbicula fluminalis (O.F. Müller)	Corbiculidae	1997	Asia, intro-duced via North America	Probably ballast water	Competition with native bivalves	The two *Corbicula* species are very similar
Corbicula fluminea (O.F. Müller)	Corbiculidae	1997	Asia, intro-duced via North America	Probably ballast water	Competition with native bivalves	The two *Corbicula* species are very similar
Dreissena polymorpha (Pallas)	Dreissenidae	1850	Ponto–Caspian region	Probably ballast water and/or hull fouling	Ecosystem engineer. Overgrows native mussel species .Costs to prevent them clogging pipes, etc. are fairly small compared with North America	Species of high concern

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7 > Other selected invertebrate groups

Prepared by Rüdiger Wittenberg and Marc Kenis

This chapter gives only a few examples of alien species from groups which can cause problems for the environment not dealt with in other chapters of this report. It is not possible to give comprehensive lists of most of these invertebrate groups. Therefore, the objective is to give a brief overview of potential problematic species for biodiversity and ecosystems in Switzerland. As mentioned before, there is a great need for more taxonomic work on these groups, not only the alien species, but the native species as well. Based on future work, more comprehensive lists of some groups may be added in the future to complete the knowledge of established alien species in Switzerland.

7.1 Nematodes – Nemathelminthes

Nematodes are a large but little-known group of tiny worms. There is no comprehensive checklist of species in this group for Switzerland, but many species are of great economic importance as pests in agriculture and forestry. Species exclusively causing economic damage are not part of the report, since they are the best-known species in this group; the Swiss Federal Research Stations are actively working on them, and there are other sources dealing with them, e.g. CABI (2001) lists the following 11 problematic nematodes for Switzerland: *Globodera pallida* (Stone) Behrens, *G. rostochiensis* (Wollenweber) Behrens, *Heterodera avenae* Wollenweber, *H. schachtii* A.Schmidt, *Longidorus elongatus* (de Man) Micoletzky, *Meloidogyne arenaria* (neal) Chitwood, *M. hapla* Chitwood, *Pratylenchus penetrans* (Cobb) Filipjev & Schuurmans, *Punctodera punctata* (Thorne) Mulvey & Stone, *Xiphinema diversicaudatum* (Micoletzky) Thorne, and *X. index* Thorne & Allen.

The **pine wood nematode** *(Bursaphelenchus xylophilus* (Steiner & Buhrer) Nickle) (see Fact Sheet) is an example of a species that has recently been found in Europe and is considered to be a potential threat to *Pinus* spp. here. Thus, its wider spread within Europe should be prevented.

The nematode ***Anguillicola crassus*** Kuwahara, Niimi & Itagaki (Anguillicolidae) is an example of a nematode that is having an extensive impact by attacking a fish species. This nematode is a parasite of eel species. In Europe the native *Anguilla anguilla* L. is under threat following the invasion of the nematode. The nematode was accidentally introduced with imports of live Asian eels to Europe in 1982 (Konecny et al., 2002). Besides the negative impact on natural populations of the European eel, it affects Europe's important fishing industries. The European eel is native in the river systems emptying into the Atlantic, as its life history involves spawning grounds in the Sargasso Sea. It has itself been introduced to some parts of Europe, e.g. the Danube basin. The construction of the Rhine–Danube Canal opened the way from the Rhine, where it is native, to the Danube basin.

Another nematode was accidentally introduced into Europe together with its North American host, i.e. ***Baylisascaris procyonis*** (Stefanski & Zarnowski) with the raccoon, Procyon lotor (L.) (see mammal chapter). This species is of concern for human health.

7.2 Flatworms – Turbellaria, Plathelminthes

In the group Turbellaria (part of the Plathelminthes), one species is an abundant alien inhabitant of lakes and rivers, including the Rhine in Switzerland. The predatory aquatic flatworm ***Dugesia tigrina*** (Gerard) is abundant and widespread in standing and slow-moving water bodies in Europe (Pöckl and Rabitsch, 2002). It was probably introduced on aquarium plants or fish from North America around 1900. Although this species is found in high densities, a negative impact has not (yet) been shown.

Other flatworms of environmental concern are terrestrial. The **New Zealand flatworm** *(Artioposthia triangulate* (Dendy)) (see Fact Sheet) serves as an example of several predatory flatworm species introduced into Europe from New Zealand and Australia. Native earthworms are a major prey for these flatworms. Earthworms play an important role in nutrient cycling in soil, so that their reduction could lead to ecosystem changes. They are also a significant element of vertebrate prey.

7.3 Segmented worms – Annelida

The Ponto–Caspian invaders in European waters are an interesting group – see the Crustacea Chapter for more information. The annelid polychaete worm ***Hypania invalida*** (Grube) has become very numerous in the sandy sediment of the Rhine, where it burrows its tubes vertically into the mud (Rey and Ortlepp, 2002; Van der Velde et al., 2002). The impact of this abundant species has not been evaluated. It is approximately 1–2 cm long and can reach densities of about 10,000 individuals per square metre. The species reached the Rhine after the opening of the Rhine–Danube canal, probably in the ballast tanks of ships.

Another possibly harmless species in the group Annelida, but an oligochaete worm (Tubificidae), is the large (up to 20 cm long) ***Branchiura sowerbyi*** Beddard, which originates in south-eastern Asia. It was probably introduced on tropical aquatic plants at the beginning of the 20^{th} century. At first it occurred only in greenhouses, but it adapted to the colder climate and is now found in many slow-moving rivers (Pöckl and Rabitsch, 2002). It lives in self-made tubes in muddy soil and feeds on detritus.

A member of a third group of the Annelida is the leech ***Caspiobdella fadejewi*** (Epshtein) (Hirundinea; Piscicolidae), which can be found in low densities in the Rhine between Basel and the Bodensee. This species, also from the Ponto–Caspian system, is an ectoparasite of various fish species.

7.4 Centipedes and millipedes – Myriapoda

A neglected group in this report is the **Myriapoda**, including the Diplopoda and the Chilopoda. It is impossible to give a comprehensive list. In particular the former group, as plant and detritus feeders, are probably regularly introduced with plant and soil material. Some tropical or subtropical species might be restricted to greenhouses. However, the number of established species in the wild is likely to be small (probably less than ten species) and none is of particular threat to native biodiversity and ecosystems.

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8 > Lichens (Lichen-forming fungi)

Prepared by Rüdiger Wittenberg

There are no lichens known to be introduced and established in Switzerland (C. Scheidegger, pers. comm.). Lichens, with their extremely slow growth, seem ill-adapted to human-mediated transport and the colonization of new regions. There is no doubt that species must be introduced with timber, etc., but the step from introduction to establishment has apparently not been achieved. Breuss (2002) mentions *Anisomeridium polypori* (Ellis & Everh.) M.E. Barr as a neomycete for Austria. However, recently described new species are not necessarily introduced. They could also have been overlooked in the past, in particular as floristic research in microlichens does not have a long history and is rather incomplete. Changes in the environment can also favour some previously rare species, so that they become more abundant and widespread, feigning a new arrival. Aptroot (1999) doubts the neomycete character of *A. polypori*, instead assuming a wide natural distribution.

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9 > Fungi and a selected bacterium

Prepared by Rüdiger Wittenberg and Marc Kenis

Fungi are an often-neglected group and it is not possible to compile a list of neomycetes for Switzerland, let alone to list the fungi occurring in Switzerland. It is a group where the percentage of undescribed species is exceptionally high. In this report, species which are of concern for native biodiversity and economics alike are summarized. Species exclusively causing economic damage are not part of the report, since they are the best-known species; the Swiss Federal Research Stations are responsible for working on them, and there are also other sources, such as university research departments, dealing with them. Two examples of excellent sources are:

> The Alert List of the European and Mediterranean Plant Protection Organization (EPPO). The purpose of the Alert List is to draw attention to certain pests that may present a risk to member countries, thereby functioning as an early warning system: *http://www.eppo.org/QUARANTINE/Alert_List/alert_list.html*
> The Crop Protection Compendium (CPC) (see e.g. CABI, 2004) lists, for example, 104 fungi for Switzerland and provides Fact Sheets incorporating exhaustive information on the species. It is also available on the Internet at: *http://www.cabi.org/compendia/cpc/index.htm*

These sources give other links as well, so that a wealth of information is available for the species of economic importance.

Six fungal species of immediate threat to the native biodiversity are discussed in this section. There is also one bacterium, which is pathogenic to plants, included in the text and a Fact Sheet.

Chestnut blight *(Cryphonectria parasitica* (Murrill) Barr) (see Fact Sheet) was introduced into North America and Europe. In North America chestnut blight has been an ecological disaster. It changed the tree composition of the eastern forests completely by removing one of the dominant trees, *Castanea dentata* (Marshall). Fortunately, it seems that the European congeneric is less susceptible to the disease, although it has suffered and tree composition is altering, in particular in the Ticino.

Another tree-attacking fungus, causing tremendous ecosystem changes in Europe, is **Dutch elm disease** *(Ceratocystis ulmi* (Buisman) C.Moreau and *C. novo-ulmi* (Brassier)) (see Fact Sheet). Mature elm *(Ulmus* spp.) trees have disappeared from the landscape in many regions. *C. novo-ulmi* seems to have arrived decades after *C. ulmi* and is replacing it in many parts of Europe, e.g. Austria (Kirisits et al., 2001). Reinhardt et al.

(2003) estimate that Germany incurs annual costs of about €5 million for the removal and replacement of trees, the lost value of dead trees, and additional expenditure of planting resistant varieties.

While ***Phytophthora quercina*** Jung et al. (see Fact Sheet) is a rather recent invader (or at least attention has been drawn to it by its recent impact), *P. ramorum* Werres, de Cock & Man in't Veld **(sudden oak death)** (see Fact Sheet) is already well-known from its devastating effect in North America. In Europe it is still only a problem in nurseries, but it can be expected to infest native forests in the not-too-distant future. Many woody hosts have been shown to be susceptible to sudden oak death and it has been recorded from Switzerland (Heiniger and Stadler, 2003).

The **crayfish plague** *(Aphanomyces astaci* (Schikora)) (see Fact Sheet) is one of the most devastating fungi attacking European wildlife. The fungus was introduced with North American crayfish species, which are asymptomatic carriers of the disease, into Europe. The European crayfish species are highly susceptible and almost 100% die within two weeks of infection. There are regular outbreaks in European populations resulting in total collapse (Voglmayr and Krisai-Greilhuber, 2002).

The bacterium *Erwinia amylovora* (Burrill) Winslow et al. (see Fact Sheet) is the causal agent of **fire blight**, which was first found on *Cotoneaster* species and is now widely distributed in Switzerland (Hasler et al., 2002).

An interesting case of a mutual relationship between two invaders may be the association between mycorrhizal fungi and plant species. There is some evidence that alien mycorrhiza can help their alien host plant to become a weed in the introduced range (e.g. Crawley, 1993; Harrington et al., 1998). In that way, an introduced mycorrhiza might have an indirect detrimental effect on native biodiversity.

In can be concluded that although quarantine measures are successfully implemented in Switzerland, non-crop plants need to get more attention, e.g. plants in the nursery industry. The few examples described here indicate the enormous impacts diseases can have. Some introduced diseases are completely changing entire ecosystems by eliminating important key species. Moreover, there are human diseases not mentioned in this report with global impact, such as AIDS (a viral disease).

The Fact Sheets are presented after the references, in alphabetical order for ease of location of specific sheets.

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10 > Plants – Planta

Prepared by André Gassmann and Ewald Weber

10.1 Introduction and terminology

The expansion of alien plants within Central Europe began with the introduction of agriculture about 7,000 years ago and the subsequent spread of weeds. In Europe, as in most regions of the world, the number of alien plant species has increased considerably in the past 200 years as a result of increasing trade, tourism and disturbance. The increasing number of naturalized alien plant species with negative impacts on plant communities is viewed as a major component of global change. Successful invaders can affect the invaded communities in various ways, e.g. reducing the local diversity, driving rare native species to extinction (e.g. by competition or hybridization), changing habitat structures and ecosystem functioning, or increasing erosion. Plants are particularly notorious invaders, since they are capable of changing the food web at the base, which can ripple through the entire ecosystem. In Switzerland, with the exception of the Alps, wildlife and areas of conservation value are usually restricted to small areas, surrounded by heavily disturbed habitats or urban areas. In such small areas, invasive plant species pose additional threats to the native plant and animal diversity. Moreover, new plant invaders in Switzerland and in Europe can also affect human health (e.g. *Ambrosia artemisiifolia* L. and *Heracleum mantegazzianum* Sommier et Levier) or are a potential threat to the agro-economy (e.g. *Senecio inaequidens* DC.). This report gives an overview of alien and invasive plant species with regard to the Swiss flora. Some of the ecological and biological characteristics of alien plants in Switzerland are discussed and a list of plant invaders or potential invaders is provided.

In this context, it is important to note that different original sources may cite different numbers of alien plant species. For example, Moser et al. (2002) list 350 neophytes. A number of these species are given a different status in Lauber and Wagner (1998). In addition, the species lists are not identical. For example, Moser et al. (2002) list two ferns as neophytes *(Cyrtomium falcatum* K. Presl, *C. fortunei* J. Sm.) which are not included in Lauber and Wagner (1998). The same holds for *Crataegus lindmanii* Hrabetova and *C. rhipidophylla* Gand. In contrast, species like *Cotoneaster bullata* Bois, *C. dammeri* Schneider, *Helianthus rigidus* (Cassini) and *Paspalum dilatatum* Poiret are not included in Moser et al. (2002). Excluding cultivated species that occur rarely as subspontaneous species (‘C’ plants in Moser et al. (2002)), we found in total over 70 alien species which are included in either one of the two lists but not in the other. Most of the variation originates from whether cultivated species are considered to be subspontaneous or not. In addition, another 60 species of European origin are controversial with regard to their alien status in Switzerland. Thus, different authors have different approaches to the treatment of species, and there is no ultimately correct source. However, either source can be used to seek general patterns in geographic origins, life form distribution, or the numbers of neophytes present. Because Moser et al. (2002) do not provide standardized information on plant status and plant origin, we used the information provided by Lauber and Wagner (1998) to seek these general patterns.

There is much variation in the definition of some of the terms presented below. In particular, there is controversy about the definition of 'invasive species' in the literature. The term 'invasive species' often refers exclusively to species penetrating into natural and semi-natural habitats although it is often difficult to clearly separate semi-natural from human-made habitats. The terms 'weeds' and 'weedy species' are consequently devoted to plants causing problems in managed areas. Some authors call any alien plant species that spreads spontaneously in the introduced range an invasive species, irrespective of whether the species has harmful effects or not. For practical reasons, such a broad definition is not useful.

In this chapter, the term 'invasive species' always refers to plants of alien origin, while the term 'weed' implies an indigenous species. Alien species may become invasive primarily in human-made habitats or agricultural land and thus have economic rather than ecological effects (e.g. *Ambrosia artemisiifolia* and *Cyperus esculentus* L.). It must be stressed however that most invasive plants are of greater concern in natural or semi-natural areas. It should be pointed out also that the spread of many naturalized species is primarily in highly disturbed areas of low ecological (or economic) value but this situation may change for many plant species in the future. In contrast, native species can pose problems by becoming abundant in conservation areas influenced by human activities, e.g. *Phragmites australis* (Cavanilles) or *Rubus* spp. This report does not consider native species that are weeds in agricultural land or may be of concern in natural or semi-natural areas.

The terminology presented below has been adapted from Richardson et al. (2000) and Weber (1999a).

> **Alien** (**non-native**, **non-indigenous**, **introduced**) **plants**: plant taxa (species, subspecies or lower taxon) in a given area whose presence there is due to intentional or accidental introduction as a result of human activity. Unless specified, cultivated plants that have not escaped from cultivation are not treated as alien species.
> **Native** (**indigenous**) **plants**: plant taxa occurring within their natural range and dispersal potential (i.e. within the range they occupy naturally or could occupy without direct or indirect introduction or care by humans).
> **Neophyte plants** (or **neophytes**): *alien* plants introduced during modern times (after 1500 A.D.) and which have become naturalized. **Archeophyte plants** (or **archeophytes**) are those that were introduced before 1500 A.D. This report does not treat the two groups separately.
> **Casual** (**transient**, **ephemeral**) **plants**: *alien* plants that may flourish and even reproduce occasionally in an area, but which do not form self-replacing populations, and which rely on repeated introductions or habitat disturbance for their persistence.

- **Adventive plants**: *casual alien* plants that have been accidentally introduced as a result of human activity.
- **Subspontaneous plants**: *casual alien* plants escaped from cultures.
- **Naturalized plants**: *Alien* plants that reproduce consistently and sustain populations over many life cycles without direct intervention by humans, (or in spite of human intervention); they often recruit offspring freely, usually close to adult plants, and do not necessarily invade their habitat.
- **Invasive plants** (**plant invaders**): *Naturalized* plants that produce reproductive offspring, often in very large numbers, at considerable distances from parent plants, and thus have the potential to spread over a considerable area. Invasive plants can affect the invaded natural or semi-natural communities in various ways. Invasive plants can also affect human-made habitats and have direct economic effects. The term environmental weeds is sometimes used for those *invasive plants* having an impact in natural areas and semi-natural areas; and the term alien weeds is sometimes used for those *alien plants* that are weedy in managed habitats, such as agriculture.
- **Weeds**: *native* plants that grow in sites where they are not wanted and which have detectable economic or environmental effects.

10.2 The native and alien flora of Switzerland

The list of alien species present in Switzerland (Table 10.6) includes both archaeophytes and neophytes. However, in this list, the neophytes of *Flora Helvetica* (Lauber and Wagner, 1998) are marked as such. A few species that have become naturalized recently (e.g. *Ludwigia grandiflora* (Michaux) and *Lysichiton americanus* Hultén & St. John) have been added to the alien species amongst the 3000 plant taxa listed in *Flora Helvetica*. The plant status and life form for each species have been extracted from the information provided by Lauber and Wagner (1998).

The Swiss flora of vascular plants includes some 162 families and over 3000 taxa (species, subspecies and lower taxa). Of these, 20 plant families and 84 plant taxa belong to the ferns and fern allies (Pteridophyta) while the other families and taxa belong to the flowering plants (Spermatophyta).

The Swiss flora comprises 2505 native species belonging to 136 families (Table 10.1; excluding subspecies and lower taxa). From the 470 taxa of alien origin recorded in Switzerland, over 100 species are cultivated species that are not, or rarely, found in the environment. The 362 remaining alien species have become subspontaneous, adventive or naturalized. These alien species, which represent about 12.6% of the flora of Switzerland, are discussed below.

This percentage is similar to that observed in neighbouring countries, e.g. 9.1% in Austria, 10.2% in France, but much less than in countries in North America, e.g. 28% in Canada, or on islands, e.g. 47% in New Zealand (Heywood, 1989). The density of alien species in Switzerland (i.e. the number of alien species per log country size in square kilometres) is 78.4 and slightly higher than in several other European countries. This may be due to the topography and diversity of climates encountered in Switzerland which allow plant species as different as *Agave americana* L. and *Reynoutria japonica* Houttuyn to become naturalized (see also Weber, 1999a, b). France, which offers an even wider range of habitats and climates, has a density of alien species of 87.1 (Heywood, 1989), whereas in Austria, the density of alien species is 60.9.

According to Lauber and Wagner (1998), the group containing ferns and its allies does not include any alien species (Table 10.1). There is a high proportion of alien gymnosperm species (28.6%), i.e. four alien gymnosperm species out of 14 recorded. The frequency of alien species in the dicotyledons and monocotyledons is quite similar, i.e. 13.5% and 11.0%, respectively.

Tab. 10.1 > Synopsis of the native and alien flora of Switzerland: number of species (% of total).

	Pteridophyta	Spermatophyta			Total
		Gymnosperms	Dicotyledons	Monocotyledons	
Native species*	84 (3.4)	10 (0.4)	1879 (75.0)	532 (21.2)	**2505 (100)**
Families	20 (14.7)	4 (2.9)	93 (68.4)	19 (14.0)	**136 (100)**
Alien species**	0	4 (1.1)	292 (80.7)	66 (18.2)	**362 (100)**
Families which include alien spp.	0	2 (2.5)	64 (80.0)	14 (17.5)	**80 (100)**
TOTAL no. species	**84 (2.9)**	**14 (0.5)**	**2171 (75.7)**	**598 (20.9)**	**2867 (100)**
% alien species / total no. species	0	28.6	13.5	11.0	12.6

* Excluding subspecies and varieties

** Excluding cultivated species which are not, or only rarely, found in the environment

10.3 The geographic origin of alien and naturalized species

About one-fifth of all alien plant species in Switzerland have been introduced from each of the following areas: North America, Asia and the Mediterranean (Fig. 10.1; Table 10.2). Some 15% have been introduced from the rest of Europe and Eurasia/the Caucasus. The distribution of the so-called Eurasian species usually extends from eastern and south-eastern Europe to Asia Minor. Approximately one-fifth of the species of Asian origin were restricted to western Asia and the other four-fifths to Central Asia, China and east Asia. Only three species originate from Africa, three from Central America and 14 from South America (Table 10.6). One species is native to Australia. Seven per cent of all alien species in Switzerland are of unknown origin.

One hundred and two alien species have become naturalized. Although 71 alien plant species in Switzerland have been introduced from North America and 76 from the Mediterranean region, only 18.4% from the Mediterranean region have become naturalized whereas 43.7% of those of North American origin have done so. Also, 31.1% of the alien species of European origin have become naturalized but only 25.8% of those of Asian/Eurasian origin. It should be noted that three out of five species introduced from the Caucasus have become naturalized and two of them are considered to be invasive (*Heracleum mantegazzianum* and *Rubus armeniacus* Focke).

Tab. 10.2 > The origin of the alien flora of Switzerland: number of species (%).

	North America	South America	Asia	Eurasia/Caucasus	Europe	Mediterranean.	Others	Unknown	Total
Alien	71 (19.6)	14 (3.9)	68 (18.8)	56 (15.5)	45 (12.4)	76 (21.0)	7 (1.9)	25 (6.9)	362 (100)
Naturalized	31 (30.4)	3 (2.9)	17 (16.7)	15 (14.7)	14 (13.7)	14 (13.7)	3 (2.9)	5 (4.9)	102 (100)
Invasive	8 (40.0)	1 (5.0)	8 (40.0)	2 (10.0)	0	0	1 (5.0)	0	20 (100)

Fig. 10.1 > The origin of alien plants in Switzerland.

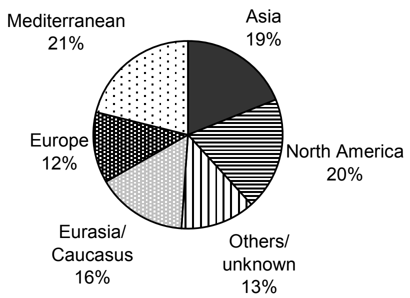
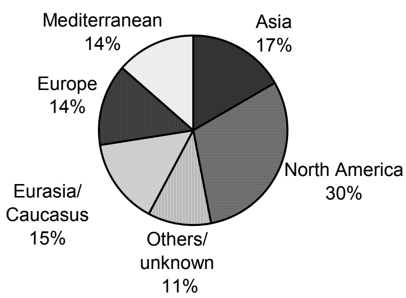


Fig. 10.2 > The origin of naturalized species in Switzerland.



In total, 30.4% of the naturalized flora originates from North America and 31.4% from Eurasia and the Caucasus (Fig. 10.2; Table 10.2).

Of the 20 species that are considered to be invasive in Switzerland *(http://www.cps-skew.ch/)*, 40% originate each from North America and Asia (Table 10.2). With the exception of the Caucasian species, no Eurasian or Mediterranean species have become invasive. One might argue that Eurasian and Mediterranean species capable of being invasive in Switzerland will have arrived already. Thus, not surprisingly, the majority of naturalized and invasive species in Switzerland originate from temperate North America and Asia. Europe and the Mediterranean are a major source of alien species, but interestingly not of naturalized or invasive plants.

Pathways of introduction

From the 20 species on the Black List of invasive species *(http://www.cps-skew.ch/)*, 15 (75%) have been deliberately introduced, usually as ornamentals. The pathway of introduction of the two aquatic species, *Elodea canadensis* Michaux and *E. nuttallii* (Planchon), is unknown but they might well have escaped from garden ponds or been released from aquariums and thus are likely to be deliberate introductions as well. Kowarik (2003) separates the pathways of the 25 problematic species in Germany into 21 deliberate (84%) and four accidental (16%) introductions. These figures are summarized in Table 10.3 together with the corresponding numbers of the total neophytes in Austria and the Czech Republic.

These two sets of data each give a similar picture for the Central European flora. The total numbers of neophytes in Austria and the Czech Republic are around 1,000 species and the numbers of problematic species in Germany and Switzerland are 25 and 27, respectively. It should be noted that the figure of 1,000 neophytes given by Essl and Rabitsch (2002) for Austria is much higher than the 300 introduced species given by Heywood (1989) for the same country.

The percentage of deliberate introductions that have become problematic is between 75% and 84%, while it is lower for all neophytes, i.e. between 55% and 59%. The comparison indicates that species selected for introduction are more likely to become problematic species than those arriving accidentally. These differences may be attributed to human dimensions in the success of invasions, in particular propagule pressure.

Tab. 10.3 > Pathways of introductions into four European countries.

The numbers for Switzerland and Germany are based on problematic plants (authors' data and Kowarik, 2003), while the numbers for Austria (Essl and Rabitsch, 2002) and Czech Republic (Pysek et al., 2002) are neophytes.

	Switzerland	Germany	Austria	Czech Republic
Total number	20	25	1110	924
Deliberate	15	21	652	504
Accidental	4	4	372	420
Unknown	1	-	86	-
Deliberate/Accidental as percentage of total	75 / 25	84 / 16	59 / 33	55 / 45

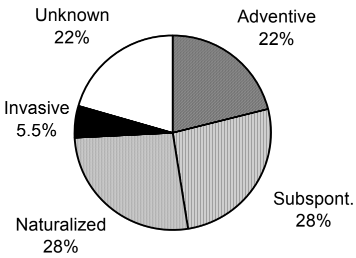
10.4 Status of the alien species of Switzerland

Of the 362 alien species recorded in Switzerland, 102 species (28.2%) have become naturalized and 20 species have become invasive (5.5%) (Fig. 10.3), which also means that a quarter of all naturalized species have become invasive. The remaining species are either adventive or subspontaneous, or of unknown status. Thus, 3.6% of the Swiss flora consists of naturalized species.

The 362 alien species belong to 80 plant families, i.e. about half of all plant families present in Switzerland (Table 10.1). The percentage of alien species per family ranges from 2.8% (Juncaceae) to 100% for 20 plant families which are represented by alien species only, usually by one or two species (Table 10.7). The percentage of alien species in the large families (>30 species) ranges from 2.8 (Juncaceae) to 25.6% (Polygonaceae). The largest family, Asteraceae, comprises 340 species of which some 12.4% are alien species. Thirty percent of all alien species belong to the Asteraceae, Brassicaceae and Poaceae.

Some 50 plant families in Switzerland include no alien species. Most of these are small or very small families. Exceptions are the Orchidaceae (62 species), Gentianaceae (34 species), Potamogetonaceae (21 species) and Orobanchaceae (20 species).

Fig. 10.2 > Status of alien species in Switzerland.

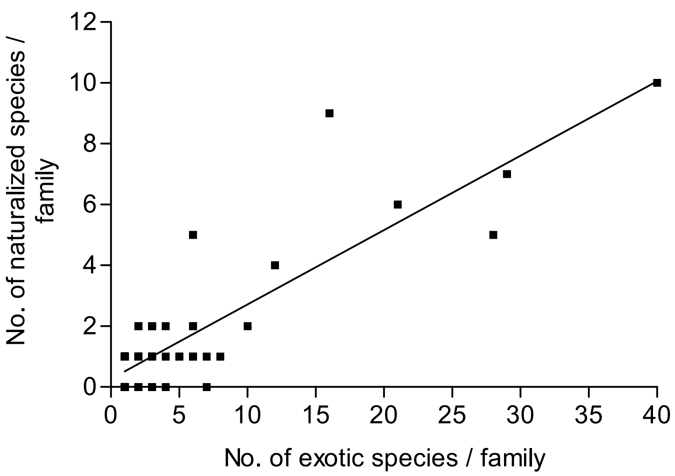


10.5 Naturalized species of Switzerland

Naturalized species are represented by 102 species belonging to 49 plant families, i.e. less than one-third of the total number of families in Switzerland (Table 10.7). The majority (30 families) include only one naturalized species. Eleven families include two naturalized species, and only eight families have more than two naturalized species. The Asteraceae alone includes ten naturalized species followed by the Rosaceae (nine), the Brassicaceae (seven) and the Fabaceae (six). Almost one-third of all naturalized species belong to one of these four families.

The percentage of naturalized species per family ranges from 0.8% (Caryophyllaceae) to 100% for eight families that are represented exclusively by their naturalized species (usually one species – with the exception of the Phytolaccaceae which is represented by two species) (Table 10.7). The percentage of naturalized species in the large families (>30 species) ranges from 0.8% (Caryophyllaceae) to 7.7% (Polygonaceae). The largest family, Asteraceae, comprises 2.9% naturalized species. The aquatic plant family Hydrocharitaceae comprises 71.4% naturalized species.

Fig. 10.3 > Number of established species as a function of the number of alien species (r^2=0.8).



In total, 28.2% of all alien species have become naturalized. No naturalization at all is observed in 31 families (comprising 55 alien species). The highest rate of failure is in the Amaranthaceae with nine alien but no naturalized species. In contrast, 100% naturalization is observed in 17 families accounting for 20 alien species. The number of naturalized species is correlated to the number of species introduced (Fig. 10.4).

10.6 Life form

The 11 life forms that are defined in *Flora Helvetica* (see also Table 10.6) have been pooled into eight different ones. The categories 'trees' and 'shrubs' include both deciduous and evergreen plants. The category 'small shrubs' includes both woody and herbaceous chamaephytic plants. Chamaephytic plants are perennial species with persistent stems and buds overwintering above ground level. Geophytic plants are perennial herbs with tubers, bulbs or rhizomes.

In all, 46.4% of the alien flora of Switzerland consists of annual and biennial species (n=168) but only 21.6% of the naturalized flora is in these groups (n=22) (Table 10.4). In contrast, perennial species form 53.6% of the alien flora but 78.4% of the naturalized flora. Thus, of the alien species present in Switzerland, relatively more aquatic plants (78%), small shrubs (55%) and trees (47%), and indeed perennial plants as a whole (41%) have become naturalised, compared to biennial plants (13%) and annual herbs (13%).

Tab. 10.4 > The life form of vascular plants in Switzerland: number of species (% of total).

Life forms		Alien species	Naturalized species	Invasive species	Native species
Perennials	Trees	30 (8.3)	14 (13.7)	5 (25.0)	68 (2.7)
	Shrubs	25 (6.9)	8 (7.8)	2 (10.0)	103 (4.1)
	Small shrubs	22 (6.1)	12 (11.8)	0	238 (9.6)
	Geophytic plants	48 (13.3)	18 (17.6)	7 (35.0)	383 (15.4)
	Herbs	60 (16.6)	21 (20.6)	1 (5.0)	1120 (44.9)
	Aquatic plants	9 (2.5)	7 (6.9)	2 (10.0)	62 (2.5)
Perennials (total)		194 (53.6)	80 (78.4)	17 (85)	1974 (79.1)
Biennial herbs		54 (14.9)	7 (6.9)	1 (5.0)	239 (9.6)
Annual herbs		114 (31.5)	15 (14.7)	2 (10.0)	279 (11.2)
Total		**362**	**102**	**20**	**2492**

Woody and geophytic plants account for 70% of invasive species in Switzerland (Table 10.4). Perhaps surprisingly, no chamaephytic and only one herbaceous perennial have become invasive. The proportions of shrubs and aquatic plants in the invasive flora are similar, as are the proportions of these two life forms in the naturalized flora, i.e. 7–10%. Thus, there are again a disproportionate number of large woody perennials and geophytic species that have become invasive compared to those that have become naturalized. Only few short-lived species have become invasive.

In total, 85% of the invasive flora in Switzerland consists of perennial species of which more than two-thirds are trees and geophytic plants. The proportion of alien species that are trees is three times the proportion of native species that are trees (Table 10.4), but the proportion of invasive species that are trees is about ten times the figure for native species. For comparison, the proportion of short-lived plants that are alien is about twice the proportion for native species, but the proportions of short-lived species that are invasive and native are similar. In contrast, the proportion of herbaceous perennials that are native is almost three times higher than the figure for alien species and nearly ten times higher than for invasive species (Table 10.4). In summary, the life form composition of the alien flora is different from the native one and it changes during the process of naturalization and invasion. While the highest number of introduced species are annual plants, they do not naturalize well. The relatively small number of introduced trees and geophytic plants are successful in the naturalization process and are aggressive invaders. The introduction, naturalization and invasion of alien plant species results not only in a change in the floristic composition, but also in plant life form changes with probable consequences on habitat structure and ecosystem functioning.

10.7 The habitats of alien plants in Switzerland

The ecological plant groups used here have been taken from Lauber and Wagner (1998) to define plant habitats. Nine ecological groups have been defined:

> F = forest plant
> M = mountain plant
> P = (lowland) pioneer plant
> E = aquatic plant
> H = marsh plant
> S = dry grassland plant
> G = grassland plant
> R = ruderal plant

Tab. 10.5 > The ecological groups of alien plants in Switzerland, excluding cultivated plants: number of species (%).

	Forest	Mountain	Pioneer	Aquatic	Marsh	Dry grassland	Grassland	Ruderal	Total
Alien	34 (11.3)	4 (1.3)	19 (6.3)	12 (4.1)	26 (8.6)	14 (4.7)	4 (1.3)	189 (62.6)	302
Naturalized	23 (23.5)	3 (3.1)	11 (11.2)	8 (8.2)	11 (11.2)	4 (4.1)	0	38 (38.8)	98
Invasive	3 (15.0)	0	7 (35.0)	2 (10.0)	3 (15.5)	0	0	5 (25.0)	20
Native	443 (17.9)	644 (26.0)	126 (5.1)	96 (3.9)	308 (12.4)	347 (14.0)	74 (3.0)	438 (17.7)	2476

The majority of alien species in Switzerland are ruderal plants (62.6%), followed by forest plants (11.3%) and marsh plants (8.6%) (Table 10.5). However, ruderal plants represent only 38.8% of all naturalized species. Forest species increase to 23.5% of all naturalized species, followed by pioneer and marsh species (11.2%), and aquatic species (8.2%). There are very few mountain and grassland species naturalized in Switzerland. Thus, it appears that forest and wetland habitats are more suited to plant naturalization since 42.9% of all naturalized species belong to these ecological groups (F, E, H). It should be noted, however, that three out of four mountain species have become naturalized. Only 20.2% of ruderal species have become naturalized.

Ruderal and pioneer species represent 60% of all invasive species, indicating perhaps less resistance of these habitats to invasion. Wetlands and forests seem to be more resistant to invasion. However, 40% of invasive species in Switzerland belong to either the forest, aquatic or marsh ecological plant groups (F, E, H) and thus are a potential threat to the most valuable ecosystems of Switzerland, i.e. forests and wetland habitats. Mountain and grassland habitats seem to be at less risk based on invasions to date.

About 50% of all naturalized and invasive species are ruderal and lowland pioneer species. These species are often not restricted to waste ground or urban areas, but are known to invade (sometimes after a long period) semi-natural habitats such as meadows, riverbanks, gravel shores, forest margins or clearings. Several of the worst invasive plants in Switzerland such as *Reynoutria japonica, Heracleum manteggazianum, Impatiens glandulifera* Royle*, Buddleja davidii* Franchet and *Solidago canadensis* L. are treated as ruderal or pioneer plants but are known to invade less disturbed places as well. *Solidago* spp. in particular have been recognized for over a decade as a threat to protected areas (Voser-Huber, 1992). *Impatiens parviflora* DC. was introduced from Asia into Central Europe in 1837 and was for many years a typical ruderal plant occurring only in towns, gardens, parks or cemeteries. A few decades ago, however, it started to penetrate into woods, at first only in badly degraded areas, but then becoming firmly established in relatively natural stands of deciduous forests in Central Europe (Kornas, 1990).

Weber (1999a) gives the number of alien plant species recorded in various habitats (s.str.) in Switzerland: 16% are known from forests and related habitats, 15% from lakes and wetland areas, and 8% from grassland habitats. Interestingly, 16% of alien plants are found in rocky sites and on walls. As compared to the 61% of ruderal species, some 35% of alien plants grow only in ruderal sites. The number of alien plants recorded in various habitats is relatively similar to the numbers that can be extrapolated from the ecological groups. The data suggest that many ruderal alien plants are not restricted to ruderal sites but grow mainly in open habitats or less disturbed sites such as rocky areas, walls, or forests subjected to some disturbance.

As shown above, the great majority of naturalized and invasive species in Switzerland are perennial species and most of them are forest, wetland and ruderal species. With very few exceptions (e.g. *Impatiens glandulifera),* naturalized and invasive short-lived species are uncommon in semi-natural or natural habitats.

With respect to plant life form, the composition of the ecological plant groups of the alien flora differs from the native one, and it changes during the process of naturalization and invasion. The proportion of ruderal species in the alien flora is much higher than in the native one but this discrepancy is reduced during the naturalization process. In contrast, the proportion of alien forest plant species is lower than that of native forest plant species but proportions of invasive and native forest plant species are fairly similar.

10.8 Invasive plant species in Europe

Up to 2003, only a few European countries had compiled data on their alien and invasive floras at a national level. However, information from several countries is quite informative about invasive species elsewhere in Europe that could be a threat to Switzerland. Countries usually make explicit distinctions between invasive species, moderately or potentially invasive species, and species for which special attention is needed (usually the so-called 'Watch List'). We had to interpret some data to a certain extent to obtain a more consistent result. Austria includes an assessment of economic impact, which we have reproduced in Table 10.8 (Essl and Rabitsch, 2002). Also, the European and Mediterranean Plant Protection Organization (EPPO) is preparing a list of invasive and potentially invasive alien plants for the EPPO region. This information is still partial and it has not been used for the present review.

Plant species declared invasive or potentially invasive in nine European countries and occurring in Switzerland are presented in Table 10.8. The list includes over 130 alien plant species of concern in Europe. Quite obviously, not all of them are sufficiently pre-adapted to the eco-climatic conditions of Switzerland to present a threat in this part of Europe. On the other hand, some invasive species in northern European countries, for example, which are not listed in Table 10.8, could become a problem in Switzerland. Unfortunately, no detailed list of alien plants in Germany for each of the three categories defined was available at the time of this review. In contrast, the detailed information on the status of alien plants in France is highly relevant to Switzerland (Muller, 2004).

The list of invasive species ('Black List') and 'Watch Species' in Switzerland is taken from the CPS-SKEW working group *(http://www.cps-skew.ch/index.htm)*. A few species in these two categories do not have this status in the other European countries from which information could be collected (Table 10.8). However, they are invasive on other continents, e.g. *Pueraria lobata* (Willd.), and *Lonicera japonica* Thunberg (Cronk and Fuller, 1995; Weber, 2003) or their taxonomy is complex and their invasive status may not yet have been recognized (e.g. *Rubus armeniacus).*

Fact Sheets have been prepared for 48 plant species. They include 19 invasive species and 11 'Watch Species' of the CPS-SKEW working group. In this report, another 18 species to which special attention should be given in the future are also presented in Fact Sheets. These species have been selected according to their status in neighbouring countries and a previous list of potentially invasive species prepared by the CPS-SKEW working group (Table 10.8).

10.9 Discussion

About 362 alien species are established in Switzerland and almost one third of these have become naturalized with certainty. With the exception of aquatic plants in the Hydrocharitaceae, no one plant family appears to be particularly successful in naturalization.

This review stresses the importance of establishing the biological and ecological characteristics of the naturalized flora for determining the potential invasiveness of alien species in Switzerland. The life form composition of the alien flora is different from that of the native one and changes during the process of naturalization from dominance by short-lived to perennial species. The flora of naturalized plants consists of almost 80% perennial species. There is a further shift during the process of invasion towards large woody perennial and geophytic plants. The invasion by herbaceous perennials and short-lived plants has been negligible so far. Invasive species come from geographically distant areas and no European or Mediterranean species is considered to be invasive or potentially invasive in Switzerland.

More than 40% of all naturalized and invasive species consist of either forest or wetland species, thus it appears that these habitats are at a higher risk of invasion. In Europe, over 50% of the naturalized flora occurs in river border communities (Sykora, 1990). This is because rivers are an effective means of transportation for many species, natural riverbank communities have been largely destroyed by human activities, and riverbanks are regularly disturbed by water movement. Alluvial zones and mires are therefore of primary concern with regard to invasive species. The typical vegetation of lowland alluvial zones such as riverine floodplains consists of a mosaic of pioneer communities, shrubs and alluvial forests. Invasion by pioneer or ruderal alien species is likely to occur and expand in such sites due to human activities or colonization from upstream or adjacent fields. Fenlands also are at risk because they are often used for agricultural purposes. In contrast, raised bogs are at a lower risk since only highly specialized plant species can flourish in such habitats, and there is less permanent natural disturbance.

To date, the invasibility of mountain and grassland habitats has been low and few alien species have become naturalized in these habitats. Because meadows and grasslands owe their existence almost exclusively to human management, the threat from alien species will increase with land-use changes and reduced grassland maintenance. In the absence of any management, most meadows and grasslands below the timberline degenerate to scrub and revert to woodland. Alien shrubs and trees may profit from such a situation.

The restoration of biological diversity in intensively used agricultural land has been supported for several years through various agri-environmental schemes. In many areas this involves the conversion of intensively managed arable land to extensive pastures or so-called areas of ecological compensation. The transition period from intensively to extensively managed land or semi-natural habitats is highly favourable to alien species.

Alien plants are a threat to the areas of ecological compensation, the restoration of riverbanks and mires, abandoned grassland and forests, and all previously or currently disturbed natural areas in Switzerland. For example, the rehabilitation of riverbanks can be seriously handicapped by alien species. Many invasive species increase erosion (e.g. *Reynoutria japonica, Buddleja davidii),* which in turn accelerates the establishment of invasive species, thus preventing the restoration of native plant communities.

The problems caused by alien species in cultivated land are still relatively minor but may increase in the future because of newly naturalized species and because changes in land use may favour establishment of alien species in extensive agro-ecosystems. Weber (1999a) recorded 38 alien plants that are known to occur in arable land. For example, *Conyza canadensis* (L.) and *Epilobium ciliatum* Rafinesque are of increasing importance in arable land, gardens, orchards and tree nurseries. *Galinsoga parviflora* Cavanilles is known to be a serious problem in vegetable crops in other countries and *Cyperus esculentus* is considered to be one of the world's worst weeds. *Ambrosia artemisiifolia* is most abundant in sunflower crops owing to the botanical similarity between the weed and the crop itself, and therefore only a limited number of herbicides are available that are effective against *A. artemisiifolia* alone. *Senecio inaequidens* is a potential problem in pastures and meadows. Unlike those in a natural environment, most alien plants in arable land are ruderal species and the majority of them are short lived.

Alien species can also become a public health problem. *Ambrosia artemisiifolia* is a strongly allergenic plant. Exposure to the sap of *Heracleum manteggazianum* sensitizes the skin to sunlight and causes severe irritation and painful blisters. Contact with the sap of *Ailanthus altissima* (Miller) may also cause skin eruptions.

Most of the 20 declared invasive plants in Switzerland are also invasive in neighbouring countries. An analysis of the invasive flora of several European countries shows that over 130 alien plants are of concern in Europe. The status of alien plants in Europe should be one aspect considered in developing a dynamic 'Watch List' of alien plants in Switzerland. In addition to the known invasive species of Switzerland, over 30 alien plants should be monitored over time to predict their invasive potential.

In conclusion, a careful review of invasive and potentially invasive plants in Europe combined with some key biological and ecological traits associated with naturalized species rather than alien plants, as well as field observations, should contribute to assessing the invasiveness of alien plant species in Switzerland. More research is needed to understand the naturalization and invasion process and to evaluate the impact of invasive species on the environment and the agro-ecosystem. More research is also needed to establish long-term and environmentally friendly management tools for invasive plants in Switzerland.

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Tab. 8.6 > Alien species in Switzerland.

Species	Family	Origin	Life form	Status		Ecol. group
Abutilon theophrasti Medic.	Malvaceae	Unknown	t	adventive	N	R
Acalypha virginica L.	Euphorbiaceae	North America	t	naturalized	N	R
Acer negundo L.	Aceraceae	North America	t	subspontaneous		F
Acorus calamus L.	Araceae	Unknown	g	unknown	N	E
Aegilops cylindrica Host	Poaceae	Mediterranean	t	adventive		R
Aegilops ovata L.	Poaceae	Mediterranean	t	adventive		R
Agave americana L.	Agavaceae	Central America	j	naturalized	N	R
Ailanthus altissima (Miller)	Simaroubaceae	Asia	p	naturalized	N	P
Aldrovanda vesiculosa L.	Droseraceae	Unknown	a	unknown	N	E
Allium scorodoprasum L.	Liliaceae	Europa	g	unknown	N	R
Alopecurus rendlei Eig	Poaceae	Mediterranean	t	adventive		H
Althaea officinalis L.	Malvaceae	Asia	h	subspontaneous		C
Amaranthus albus L.	Amaranthaceae	North America	t	unknown	N	R
Amaranthus blitum L.	Amaranthaceae	Unknown	t	unknown	N	R
Amaranthus cruentus L.	Amaranthaceae	North America	t	subspontaneous	N	R
Amaranthus deflexus L.	Amaranthaceae	South America	u	unknown	N	R
Amaranthus graecizans L.	Amaranthaceae	Unknown	t	unknown	N	R
Amaranthus hypochondriacus L.	Amaranthaceae	Unknown	t	unknown	N	R
Amaranthus retroflexus L.	Amaranthaceae	Unknown	t	unknown	N	R
Ambrosia artemisiifolia L.	Asteraceae	North America	t	adventive	N	R
Amorpha fructicosa L.	Fabaceae	North America	n	subspontaneous	N	H
Arabis rosea DC.	Brassicaceae	Europa	h	naturalized	N	P
Arabis caucasica (Willdenow)	Brassicaceae	Eurasia	c	naturalized	N	M
Aremonia agrimonioides (L.)	Rosaceae	Europa	h	naturalized	N	P
Armoracia rusticana P.Gaertn., B. Mey. & Scherb.	Brassicaceae	Eurasia	g	subspontaneous		C
Artemisia annua L.	Asteraceae	Eurasia	t	adventive		R
Artemisia biennis Willdenow	Asteraceae	Eurasia	u	adventive		R
Artemisia verlotiorum Lamotte	Asteraceae	Asia	g	unknown	N	R
Arum italicum Miller	Araceae	Mediterranean	g	naturalized		R
Asarina procumbens Mill.	Scrophulariaceae	Mediterranean	c	naturalized	N	P
Asclepias syriaca L.	Asclepiadaceae	North America	g	subspontaneous	N	CR
Aster novae-angliae L.	Asteraceae	North America	g	subspontaneous	N	H
Aster novi-belgii L.	Asteraceae	North America	c	subspontaneous	N	H
Aster tradescantii L.	Asteraceae	North America	g	subspontaneous		C
Aubrieta deltoidea (L.)	Brassicaceae	Mediterranean	c	naturalized	N	S
Avena barbata Pott	Poaceae	Mediterranean	t	adventive		R
Avena sativa L.	Poaceae	Eurasia	t	subspontaneous		C
Bidens bipinnata L.	Asteraceae	North America	t	naturalized	N	R
Bidens connata Willdenow	Asteraceae	North America	t	naturalized	N	H
Bidens frondosa L.	Asteraceae	North America	t	naturalized	N	R

Species	Family	Origin	Life form	Status		Ecol. group
Bidens subalternans DC.	Asteraceae	South America	t	adventive		R
Brassica juncea (L.)	Brassicaceae	Asia	t	adventive		R
Brassica nigra (L.)	Brassicaceae	Unknown	t	naturalized		R
Brassica rapa L.	Brassicaceae	Europa	u	subspontaneous		C
Bromus diandrus Roth	Poaceae	Europa	t	adventive		R
Bromus inermis Leysser	Poaceae	Eurasia	h	unknown	N	R
Bromus madritensis L.	Poaceae	Mediterranean	t	adventive		R
Bromus rigidus Roth	Poaceae	Mediterranean	t	adventive		R
Buddleja davidii Franchet	Buddlejaceae	Asia	n	naturalized	N	P
Bunias orientalis L.	Brassicaceae	Eurasia	h	unknown	N	R
Calla palustris L.	Araceae	Unknown	g	naturalized	N	E
Cannabis sativa L.	Cannabaceae	Asia	t	subspontaneous		C
Carex vulpinoidea Michaux	Cyperaceae	North America	h	naturalized	N	H
Centaurea diffusa Lamarck	Asteraceae	Mediterranean	t	adventive		R
Centranthus ruber (L.)	Valerianaceae	Mediterranean	h	naturalized	N	P
Cerastium dubium (Bastard)	Caryophyllaceae	Mediterranean	t	adventive		H
Cerastium ligusticum Viviani	Caryophyllaceae	Mediterranean	t	adventive		R
Cerastium tomentosum L.	Caryophyllaceae	Europa	c	subspontaneous		C
Cerinthe major L.	Boraginaceae	Eurasia	t	adventive		R
Cerinthe minor L.	Boraginaceae	Eurasia	u	adventive		R
Chenopodium ambrosioides L.	Chenopodiaceae	South America	t	adventive		R
Chenopodium pratericola Rydberg	Chenopodiaceae	North America	t	adventive		R
Chrysanthemum segetum L.	Asteraceae	Mediterranean	t	unknown	N	R
Commelina communis L.	Commelinaceae	Asia	c	naturalized	N	R
Consolida ajacis (L.)	Ranunculaceae	Eurasia	t	subspontaneous		C
Conyza canadensis (L.)	Asteraceae	North America	u	unknown	N	P
Cornus sericea L.	Cornaceae	North America	n	naturalized	N	F
Coronopus didymus (L.)	Brassicaceae	South America	u	adventive	N	R
Crepis nemauensis Gouan	Asteraceae	Mediterranean	t	naturalized	N	R
Crepis nicaeensis Persoon	Asteraceae	Mediterranean	u	adventive		R
Crepis pulchra L.	Asteraceae	Mediterranean	t	unknown	N	R
Cuscuta campestris Yuncker	Cuscutaceae	North America	t	adventive	N	R
Cuscuta cesatiana Bertoloni	Cuscutaceae	Eurasia	t	unknown	N	R
Cymbalaria muralis P. Gaertn., B. Mey. & Scherb.	Scrophulariaceae	Europa	c	unknown	N	P
Cynodon dactylon (L.)	Poaceae	Mediterranean	g	naturalized	N	R
Cyperus eragrostis Lamarck	Cyperaceae	South America	h	unknown		H
Cyperus esculentus L.	Cyperaceae	Unknown	g	unknown	N	H
Cyperus rotundus L.	Cyperaceae	Eurasia	g	naturalized		H
Datura stramonium L.	Solanaceae	Central America	t	unknown	N	R
Dianthus barbatus L.	Caryophyllaceae	Europa	h	subspontaneous		C
Diplotaxis erucoides (Torner)	Brassicaceae	Mediterranean	u	adventive		R
Dipsacus laciniatus L.	Dipsacaceae	Mediterranean	u	unknown	N	R

Species	Family	Origin	Life form	Status		Ecol. group
Duchesnea indica (Andrews)	Rosaceae	Asia	h	naturalized	N	F
Eleusine indica (L.)	Poaceae	Unknown	t	naturalized	N	R
Elodea canadensis Michaux	Hydrocharitaceae	North America	a	unknown	N	E
Elodea densa (Planchon)	Hydrocharitaceae	South America	a	naturalized	N	E
Elodea nuttallii (Planchon)	Hydrocharitaceae	North America	a	naturalized	N	E
Epilobium ciliatum Rafinesque	Onagraceae	North America	h	unknown	N	R
Epimedium alpinum L.	Berberidaceae	Europa	g	naturalized	N	F
Eragrostis cilianensis (Allioni)	Poaceae	Mediterranean	t	unknown	N	R
Eragrostis multicaulis Steudel	Poaceae	Asia	t	adventive		R
Eranthis hyemalis (L.)	Ranunculaceae	Europa	g	subspontaneous	N	F
Erica tetralix L.	Ericaceae	Europa	z	naturalized	N	H
Erigeron annuus (L.)	Asteraceae	North America	u	naturalized	N	R
Erigeron karvinskianus DC.	Asteraceae	Central America	h	unknown	N	P
Erodium ciconium (L.)	Geraniaceae	Mediterranean	t	adventive		R
Erodium moschatum (L.)	Geraniaceae	Mediterranean	u	unknown	N	R
Erysimum cheiri (L.)	Brassicaceae	Mediterranean	c	naturalized		C
Erysimum hieraciifolium L.	Brassicaceae	Eurasia	u	unknown	N	R
Erysimum repandum L.	Brassicaceae	Europa	t	adventive		R
Euclidium syriacum (L.)	Brassicaceae	Eurasia	t	adventive		R
Euphorbia chamaesyce L.	Euphorbiaceae	Eurasia	t	adventive		R
Euphorbia humifusa Willdenow	Euphorbiaceae	Asia	t	unknown	N	R
Euphorbia lathyris L.	Euphorbiaceae	Eurasia	u	subspontaneous	N	R
Euphorbia maculata L.	Euphorbiaceae	North America	t	unknown	N	R
Euphorbia nutans Lagasca	Euphorbiaceae	North America	t	unknown	N	R
Euphorbia prostrata Aiton	Euphorbiaceae	North America	t	adventive		R
Euphorbia virgata Waldstein et Kitaibel	Euphorbiaceae	Eurasia	h	unknown	N	R
Fagopyrum esculentum Moench	Polygonaceae	Asia	t	subspontaneous		RC
Fagopyrum tataricum (L.)	Polygonaceae	Asia	t	unknown		R
Ficus carica L.	Moraceae	Mediterranean	p	subspontaneous		C
Foeniculum vulgare Miller	Apiaceae	Mediterranean	u	naturalized	N	R
Galega officinalis L.	Fabaceae	Mediterranean	h	subspontaneous	N	G
Galinsoga ciliata (Rafinesque)	Asteraceae	South America	t	unknown	N	R
Galinsoga parviflora Cavanilles	Asteraceae	South America	t	unknown	N	R
Galium saxatile L.	Rubiaceae	Europa	c	unknown	N	H
Galium verrucosum Hudson	Rubiaceae	Mediterranean	t	adventive		S
Geranium sibiricum L.	Geraniaceae	Asia	u	unknown	N	F
Glaucium corniculatum (L.)	Papaveraceae	Mediterranean	t	adventive		P
Glaucium flavum Crantz	Papaveraceae	Europa	u	adventive		P
Glyceria striata (Lamarck)	Poaceae	North America	g	unknown	N	H
Gypsophila paniculata L.	Caryophyllaceae	Eurasia	c	naturalized	N	P
Helianthus annuus L.	Asteraceae	North America	t	subspontaneous		C
Helianthus rigidus (Cassini)	Asteraceae	North America	g	subspontaneous		C

Species	Family	Origin	Life form	Status		Ecol. group
Helianthus tuberosus L.	Asteraceae	North America	g	subspontaneous	N	R
Hemerocallis fulva (L.)	Liliaceae	Asia	g	naturalized	N	R
Heracleum mantegazzianum Sommier & Levier	Apiaceae	Caucasus	h	naturalized	N	R
Hibiscus trionum L.	Malvaceae	Asia	t	subspontaneous		C
Hordeum distichon L.	Poaceae	Western Asia	t	subspontaneous		C
Hordeum vulgare L.	Poaceae	Africa	u	subspontaneous		C
Hypericum calycinum L.	Hypericaceae	Eurasia	z	subspontaneous		C
Iberis umbellata L.	Brassicaceae	Mediterranean	u	subspontaneous		PC
Impatiens balfourii Hooker F.	Balsaminaceae	Asia	t	unknown	N	R
Impatiens glandulifera Royle	Balsaminaceae	Asia	t	naturalized	N	R
Impatiens parviflora DC.	Balsaminaceae	Asia	t	naturalized	N	F
Inula helenium L.	Asteraceae	Europa	h	subspontaneous		C
Iris foetidissima L.	Iridaceae	Europa	g	subspontaneous	N	S
Iris germanica L.	Iridaceae	Mediterranean	g	naturalized		C
Iris lutescens Lamarck	Iridaceae	Eurasia	g	subspontaneous	N	S
Iris sambucina L.	Iridaceae	Unknown	g	unknown	N	S
Iris squalens L.	Iridaceae	Unknown	g	subspontaneous	N	S
Juncus tenuis Willdenow	Juncaceae	North America	h	unknown	N	R
Lagarosiphon major (Ridley)	Hydrocharitaceae	South Africa	a	naturalized	N	E
Laurus nobilis L.	Lauraceae	Mediterranean	i	naturalized	N	F
Legousia hybrida (L.)	Campanulaceae	Mediterranean	t	adventive		R
Lemna minuta Humboldt et al.	Lemnaceae	North America	a	naturalized	N	E
Lepidium densiflorum Schrader	Brassicaceae	North America	u	unknown	N	R
Lepidium neglectum Thellung	Brassicaceae	North America	u	unknown	N	R
Lepidium sativum L.	Brassicaceae	Western Asia	t	subspontaneous		RC
Lepidium virginicum L.	Brassicaceae	North America	u	unknown	N	R
Lepidium latifolium L.	Brassicaceae	Europa	h	subspontaneous		RC
Leucanthemum gaudinii Della Torre	Asteraceae	Unknown	h	unknown	N	R
Ligustrum lucidum Aiton	Oleaceae	Asia	i	subspontaneous		C
Linaria arvensis (L.)	Scrophulariaceae	Europa	t	adventive		R
Linaria repens (L.)	Scrophulariaceae	Europa	h	naturalized	N	R
Linaria simplex (Willdenow)	Scrophulariaceae	Europa	t	adventive		R
Linaria dalmatica (L.)	Scrophulariaceae	Europa	h	naturalized	N	R
Linum bienne Miller	Linaceae	Europa	u	adventive		S
Linum narbonense L.	Linaceae	Mediterranean	h	naturalized	N	S
Lonicera japonica Thunberg	Caprifoliaceae	Asia	i	naturalized	N	F
Lonicera henryi Hemsley	Caprifoliaceae	Asia	i	subspontaneous	N	F
Ludwigia grandiflora (Michaux)	Onagraceae	South America	a	naturalized	N	E
Lunaria annua L.	Brassicaceae	Europa	u	naturalized	N	R
Lupinus polyphyllus Lindley	Fabaceae	North America	h	subspontaneous	N	F
Mahonia aquifolium (Pursh)	Berberidaceae	North America	j	subspontaneous	N	FR
Malus domestica Borkhausen	Rosaceae	Western Asia	p	subspontaneous		C

Species	Family	Origin	Life form	Status		Ecol. group
Matricaria discoidea DC.	Asteraceae	Asia	t	unknown	N	R
Meconopsis cambrica (L.)	Papaveraceae	Europa	h	unknown	N	R
Medicago polymorpha L.	Fabaceae	Mediterranean	u	unknown	N	R
Medicago sativa L.	Fabaceae	Mediterranean	h	subspontaneous		C
Melilotus indicus (L.)	Fabaceae	Eurasia	t	unknown	N	R
Melilotus sulcatus Desfontaines	Fabaceae	Mediterranean	t	unknown	N	R
Mespilus germanica L.	Rosaceae	Eurasia	p	naturalized		C
Mimulus guttatus DC.	Scrophulariaceae	North America	g	naturalized	N	H
Muhlenbergia schreberi Gmelin	Poaceae	North America	h	unknown	N	R
Narcissus incomparabilis Miller	Amaryllidaceae	Europa	g	subspontaneous		C
Narcissus medioluteus Miller	Amaryllidaceae	Unknown	g	naturalized	N	R
Nigella damascena L.	Ranunculaceae	Mediterranean	t	subspontaneous		C
Nonea erecta Bernhardi	Boraginaceae	Asia	h	unknown	N	R
Nonea lutea (Desrousseaux)	Boraginaceae	Eurasia	u	unknown	N	R
Nymphoides peltata (Gmelin)	Menyanthaceae	Eurasia	a	naturalized	N	E
Oenothera biennis L.	Onagraceae	North America	u	unknown	N	R
Oenothera glazioviana Micheli	Onagraceae	Unknown	u	unknown	N	R
Oenothera parviflora L.	Onagraceae	North America	u	unknown	N	R
Oplismenus undulatifolius (Arduino)	Poaceae	Eurasia	c	naturalized		F
Opuntia humifusa (Rafinesque)	Cactaceae	North America	c	unknown	N	S
Opuntia imbricata (Haworth)	Cactaceae	North America	c	unknown	N	S
Ornithogalum nutans L.	Liliaceae	Eurasia	g	unknown	N	R
Oxalis fontana Bunge	Oxalidaceae	Unknown	u	unknown	N	R
Panicum capillare L.	Poaceae	North America	t	naturalized	N	R
Panicum dichotomiflorum Michaux	Poaceae	North America	t	naturalized	N	R
Papaver apulum Tenore	Papaveraceae	Mediterranean	u	adventive		R
Papaver croceum Ledebour	Papaveraceae	Asia	h	naturalized	N	M
Papaver somniferum L.	Papaveraceae	Unknown	t	subspontaneous	N	R
Parthenocissus quinquefolia (L.)	Vitaceae	North America	p	naturalized	N	F
Parthenocissus tricuspidata (Siebold et Zuccarini)	Vitaceae	Western Asia	p	subspontaneous	N	C
Paspalum dilatatum Poiret	Poaceae	South America	g	adventive		H
Paulownia tomentosa (Thunberg)	Bignoniaceae	Asia	p	subspontaneous	N	F
Phacelia tanacetifolia Bentham	Hydrophyllaceae	North America	t	subspontaneous	N	R
Phalaris canariensis L.	Poaceae	Mediterranean	t	adventive		R
Philadelphus coronarius L.	Philadelphaceae	Europa	n	naturalized	N	F
Physalis alkekengi L.	Solanaceae	Eurasia	g	naturalized	N	R
Physocarpus opulifolius (L.)	Rosaceae	North America	n	naturalized	N	F
Phyteuma nigrum F.W. Schmidt	Campanulaceae	Europa	h	adventive		F
Phytolacca americana L.	Phytolaccaceae	North America	h	naturalized	N	R
Phytolacca esculenta Van Houtte	Phytolaccaceae	Western Asia	h	naturalized	N	R
Pimpinella peregrina L.	Apiaceae	Mediterranean	t	adventive		R
Pisum sativum L.	Fabaceae	Eurasia	t	naturalized	N	R

Species	Family	Origin	Life form	Status		Ecol. group
Plantago arenaria Waldstein et Kitaibel	Plantaginaceae	Eurasia	t	unknown	N	R
Polygonum orientale L.	Polygonaceae	Asia	t	subspontaneous		R
Polygonum polystachyum Meissner	Polygonaceae	Asia	g	naturalized	N	R
Polypogon monspeliensis (L.)	Poaceae	Eurasia	t	adventive		R
Pontederia cordata L.	Pontederiaceae	North America	g	adventive		E
Potentilla intermedia L.	Rosaceae	Europa	h	adventive		R
Potentilla recta L.	Rosaceae	Eurasia	h	unknown	N	R
Prunus cerasus L.	Rosaceae	Western Asia	p	naturalized	N	F
Prunus dulcis (Miller)	Rosaceae	Western Asia	p	naturalized	N	F
Prunus laurocerasus L.	Rosaceae	Eurasia	i	naturalized	N	F
Prunus serotina Ehrhart	Rosaceae	North America	p	naturalized	N	F
Pseudotsuga menziesii (Mirbel)	Pinaceae	North America	i	naturalized	N	F
Pueraria hirsuta (Thunberg)	Fabaceae	Western Asia	p	subspontaneous	N	FR
Punica granatum L.	Punicaceae	Western Asia	n	subspontaneous		C
Pyrus pyraster (L.)	Rosaceae	Eurasia	p	subspontaneous		FC
Quercus rubra L.	Fagaceae	North America	p	naturalized	N	F
Ranunculus muricatus L.	Ranunculaceae	Mediterranean	t	adventive		H
Raphanus sativus L.	Brassicaceae	Mediterranean	u	subspontaneous		C
Rapistrum perenne (L.)	Brassicaceae	Europa	h	adventive		R
Reynoutria japonica Houttuyn	Polygonaceae	Asia	g	naturalized	N	R
Reynoutria sachalinensis (F. Schmidt)	Polygonaceae	Asia	g	subspontaneous	N	R
Rhus typhina L.	Anacardiaceae	North America	p	naturalized	N	P
Robinia pseudoacacia L.	Fabaceae	North America	p	naturalized	N	F
Rorippa austriaca (Crantz)	Brassicaceae	Europa	h	adventive		H
Rosa rugosa Thunberg	Rosaceae	Western Asia	n	subspontaneous	N	R
Rostraria cristata (L.)	Poaceae	Mediterranean	h	adventive		R
Rubia tinctorum L.	Rubiaceae	Eurasia	h	naturalized	N	R
Rubus armeniacus Focke	Rosaceae	Caucasus	n	naturalized	N	F
Rudbeckia hirta L.	Asteraceae	North America	u	subspontaneous		C
Rudbeckia laciniata L.	Asteraceae	North America	g	subspontaneous	N	R
Rumex longifolius DC.	Polygonaceae	Eurasia	h	unknown	N	P
Rumex palustris J.E. Smith	Polygonaceae	Eurasia	u	adventive		R
Rumex thyrsiflorus Fingerhuth	Polygonaceae	Eurasia	h	unknown	N	R
Rumex confertus Willdenow	Polygonaceae	Asia	h	naturalized	N	P
Salvia sylvestris L.	Lamiaceae	Eurasia	h	naturalized	N	R
Salvia verbenaca L.	Lamiaceae	Mediterranean	h	adventive		S
Salvia verticillata L.	Lamiaceae	Mediterranean	h	unknown	N	R
Sarracenia purpurea L.	Sarraceniaceae	North America	h	naturalized		H
Saxifraga hirsuta L.	Saxifragaceae	Europa	h	subspontaneous		C
Saxifraga stolonifera Meerburgh	Saxifragaceae	Western Asia	h	naturalized	N	P
Saxifraga umbrosa L.	Saxifragaceae	Europa	c	subspontaneous		C
Scabiosa ochroleuca L.	Dipsacaceae	Europa	h	naturalized	N	S

Species	Family	Origin	Life form	Status		Ecol. group
Scilla non-scripta (L.)	Liliaceae	Europa	g	naturalized	N	F
Scrophularia vernalis L.	Scrophulariaceae	Mediterranean	u	adventive	N	R
Sedum sarmentosum Bunge	Crassulaceae	Asia	c	naturalized		C
Sedum sediforme (Jacquin)	Crassulaceae	Mediterranean	c	adventive		P
Sedum spurium M. Bieberstein	Crassulaceae	Western Asia	c	subspontaneous	N	R
Sedum hispanicum L.	Crassulaceae	Europa	u	unknown		P
Senecio inaequidens DC.	Asteraceae	South Africa	u	naturalized	N	R
Senecio rupestris Waldstein et Kitaibel	Asteraceae	Europa	u	unknown	N	R
Setaria italica (L.)	Poaceae	Unknown	t	subspontaneous		RC
Silene conica L.	Caryophyllaceae	Mediterranean	t	adventive		R
Silene dichotoma Ehrhart	Caryophyllaceae	Europa	u	adventive		R
Sinapis alba L.	Brassicaceae	Mediterranean	t	subspontaneous		RC
Sisymbrium altissimum L.	Brassicaceae	Eurasia	u	unknown	N	R
Sisymbrium irio L.	Brassicaceae	Mediterranean	u	unknown	N	R
Sisymbrium loeselii L.	Brassicaceae	Eurasia	u	unknown	N	R
Sisyrinchium montanum Greene	Iridaceae	North America	h	unknown	N	H
Solanum sublobatum Roemer et Schultes	Solanaceae	South America	t	naturalized	N	R
Solidago canadensis L.	Asteraceae	North America	g	naturalized	N	R
Solidago gigantea Aiton	Asteraceae	North America	g	naturalized	N	H
Solidago graminifolia (L.)	Asteraceae	North America	g	naturalized	N	R
Sorghum halepense (L.)	Poaceae	Unknown	h	unknown	N	R
Sorghum vulgare Persoon	Poaceae	Western Asia	t	adventive		C
Spiraea salicifolia L.	Rosaceae	Eurasia	n	subspontaneous	N	R
Spiraea ulmifolia Scopoli	Rosaceae	Eurasia	n	subspontaneous	N	R
Staphylea pinnata L.	Staphyleaceae	Eurasia	n	subspontaneous		FC
Stratiotes aloides L.	Hydrocharitaceae	Eurasia	a	naturalized	N	H
Symphoricarpos albus (L.)	Caprifoliaceae	North America	n	naturalized	N	F
Symphytum asperum Lepechin	Boraginaceae	Caucasus	h	naturalized	N	R
Tanacetum cinerariifolium (Treviranus)	Asteraceae	Europa	h	naturalized	N	P
Thlaspi alliaceum L.	Brassicaceae	Europa	u	naturalized	N	R
Tolpis barbata (L.)	Asteraceae	Mediterranean	t	adventive		R
Tordylium maximum L.	Apiaceae	Mediterranean	u	adventive		R
Torilis leptophylla (L.)	Apiaceae	Mediterranean	t	adventive		R
Torilis nodosa (L.)	Apiaceae	Europa	t	unknown	N	R
Trachycarpus fortunei (Hooker)	Palmae	Asia	i	subspontaneous	N	F
Tragopogon crocifolius L.	Asteraceae	Mediterranean	u	adventive		S
Tribulus terrestris L.	Zygophyllaceae	Mediterranean	t	adventive		R
Trifolium alexandrinum L.	Fabaceae	Mediterranean	t	subspontaneous	N	R
Trifolium hybridum L.	Fabaceae	Europa	u	naturalized	N	R
Trifolium incarnatum L.	Fabaceae	Europa	u	subspontaneous	N	G
Trifolium resupinatum L.	Fabaceae	Mediterranean	u	naturalized	N	R
Trifolium suaveolens Willdenow	Fabaceae	Mediterranean	t	naturalized	N	R

Species	Family	Origin	Life form	Status		Ecol. group
Tulipa didieri Jordan	Liliaceae	Western Asia	g	unknown	N	R
Tulipa grengiolensis Thommen	Liliaceae	Unknown	g	unknown	N	R
Typha laxmannii Lepechin	Typhaceae	Eurasia	g	adventive		H
Ulex europaeus L.	Fabaceae	Europa	n	naturalized	N	F
Ulmus laevis Pallas	Ulmaceae	Europa	p	subspontaneous		C
Vaccinium macrocarpon Aiton	Ericaceae	North America	z	naturalized	N	H
Valerianella eriocarpa Desvaux	Valerianaceae	Mediterranean	t	adventive		R
Vallisneria spiralis L.	Hydrocharitaceae	Unknown	a	naturalized	N	E
Veronica filiformis Smith	Scrophulariaceae	Eurasia	h	unknown	N	G
Veronica peregrina L.	Scrophulariaceae	North America	t	unknown	N	R
Veronica persica Poiret	Scrophulariaceae	Western Asia	u	unknown	N	R
Vicia hybrida L.	Fabaceae	Europa	u	unknown	N	R
Vicia lutea L.	Fabaceae	Mediterranean	u	adventive	N	R
Vicia pannonica Crantz	Fabaceae	Europa	u	adventive	N	R
Vicia peregrina L.	Fabaceae	Mediterranean	t	adventive		R
Vicia sativa L.	Fabaceae	Mediterranean	u	subspontaneous	N	R
Vinca major L.	Apocynaceae	Eurasia	z	naturalized	N	M
Viola obliqua Hill	Violaceae	North America	g	naturalized	N	F
Vitis vinifera L.	Vitaceae	Europa	p	subspontaneous		C
Vulpia ciliata Dumortier	Poaceae	Mediterranean	t	adventive		R
Xanthium italicum Moretti	Asteraceae	North America	t	subspontaneous	N	G
Xanthium spinosum L.	Asteraceae	South America	t	unknown	N	R
Xeranthemum annuum L.	Asteraceae	Mediterranean	t	adventive		R

* Excluding cultivated plants which have not escaped in the environment

Life form: p, deciduous tree; i, evergreen tree; n, deciduous shrub; j, evergreen shrub; z, woody chamaephytic plant (small shrub); c, herbaceous chamaephytic plant; hhemicryptophytic plant (perennial herb); g, geophytic plant (perennial herb with tubers, bulbs or rhizomes); t, annual plant; u, biennal plant; a, aquatic plant.

Ecological group: R, ruderal plant; P, pioneer plant; F, forest plant; M, mountain plant; E, aquatic plant; H, marsh plant; S, dry meadow plant; G, meadow plant; C, cultivated plant; N, neophyte (according to Lauber and Wagner, 1998).

Tab. 10.7 > Plant families with alien and naturalized species in Switzerland.*

Family	Taxonomy	No. native species	No. alien species	No. naturalized species	Total no. species	% alien species	% naturalized species	% naturalized/ alien
Aceraceae	Dicot	4	1	0	5	20.0	0.0	0.0
Agavaceae	Monoc	0	1	1	1	100.0	100.0	100.0
Aizoaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Alismataceae	Monoc	5	1	1	6	16.7	16.7	100.0
Amarantaceae	Dicot	0	9	0	9	100.0	0.0	0.0
Amaryllidaceae	Monoc	7	2	1	9	22.2	11.1	50.0
Anacardiaceae	Dicot	1	1	1	2	50.0	50.0	100.0
Apiaceae	Dicot	85	7	2	92	7.6	2.2	28.6
Apocynaceae	Dicot	1	1	1	2	50.0	50.0	100.0
Araceae	Monoc	3	3	2	6	50.0	33.3	66.7

Family	Taxonomy	No. native species	No. alien species	No. naturalized species	Total no. species	% alien species	% naturalized species	% naturalized/ alien
Asclepiadaceae	Dicot	1	1	0	2	50.0	0.0	0.0
Asteraceae	Dicot	298	42	10	340	12.4	2.9	23.8
Balsaminaceae	Dicot	1	3	2	4	75.0	50.0	66.7
Berberidaceae	Dicot	1	2	1	3	66.7	33.3	50.0
Bignoniaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Boraginaceae	Dicot	35	6	1	41	14.6	2.4	16.7
Brassicaceae	Dicot	129	35	7	164	21.3	4.3	20.0
Buddlejaceae	Dicot	0	1	1	1	100.0	100.0	100.0
Cactaceae	Dicot	0	2	0	2	100.0	0.0	0.0
Campanulaceae	Dicot	34	2	0	36	5.6	0.0	0.0
Cannabaceae	Dicot	1	1	0	2	50.0	0.0	0.0
Caprifoliaceae	Dicot	12	6	2	18	33.3	11.1	33.3
Caryophyllaceae	Dicot	117	6	1	123	4.9	0.8	16.7
Chenopodiaceae	Dicot	21	6	1	27	22.2	3.7	16.7
Commelinaceae	Monoc	0	1	1	1	100.0	100.0	100.0
Cornaceae	Dicot	2	1	1	3	33.3	33.3	100.0
Crassulaceae	Dicot	26	3	1	29	10.3	3.4	33.3
Cupressaceae	Gymnosperm	2	2	0	4	50.0	0.0	0.0
Cuscutaceae	Dicot	2	2	0	4	50.0	0.0	0.0
Cyperaceae	Monoc	131	4	2	135	3.0	1.5	50.0
Dipsacaceae	Dicot	15	2	1	17	11.8	5.9	50.0
Droseraceae	Dicot	4	1	0	5	20.0	0.0	0.0
Elaeagnaceae	Dicot	1	1	0	2	50.0	0.0	0.0
Ericaceae	Dicot	15	2	2	17	11.8	11.8	100.0
Euphorbiaceae	Dicot	17	8	1	25	32.0	4.0	12.5
Fabaceae	Dicot	135	25	6	160	15.6	3.8	24.0
Fagaceae	Dicot	7	1	1	8	12.5	12.5	100.0
Fumariaceae	Dicot	8	1	0	9	11.1	0.0	0.0
Geraniaceae	Dicot	20	4	0	24	16.7	0.0	0.0
Hydrocharitaceae	Monoc	1	6	5	7	85.7	71.4	83.3
Hydrophyllaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Hypericaceae	Dicot	12	1	0	13	7.7	0.0	0.0
Iridaceae	Monoc	8	6	1	14	42.9	7.1	16.7
Juncaceae	Monoc	35	1	0	36	2.8	0.0	0.0
Lamiaceae	Dicot	82	4	2	86	4.7	2.3	50.0
Lauraceae	Dicot	0	1	1	1	100.0	100.0	100.0
Lemnaceae	Monoc	4	1	1	5	20.0	20.0	100.0
Liliaceae	Monoc	54	9	2	63	14.3	3.2	22.2
Linaceae	Dicot	4	2	1	6	33.3	16.7	50.0
Malvaceae	Dicot	4	4	0	8	50.0	0.0	0.0
Mimosaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Moraceae	Dicot	1	1	0	2	50.0	0.0	0.0

Family	Taxonomy	No. native species	No. alien species	No. naturalized species	Total no. species	% alien species	% naturalized species	% naturalized/ alien
Oleaceae	Dicot	3	2	0	5	40.0	0.0	0.0
Onagraceae	Dicot	21	5	1	26	19.2	3.8	20.0
Oxalidaceae	Dicot	2	1	0	3	33.3	0.0	0.0
Palmae	Monoc	0	1	0	1	100.0	0.0	0.0
Papaveraceae	Dicot	10	5	1	15	33.3	6.7	20.0
Philadelphaceae	Dicot	0	1	1	1	100.0	100.0	100.0
Phytolaccaceae	Dicot	0	2	2	2	100.0	100.0	100.0
Pinaceae	Gymnosperm	7	2	2	9	22.2	22.2	100.0
Plantaginaceae	Dicot	8	2	0	10	20.0	0.0	0.0
Poaceae	Monoc	189	31	5	220	14.1	2.3	16.1
Polygonaceae	Dicot	29	10	3	39	25.6	7.7	30.0
Pontederiaceae	Monoc	0	1	0	1	100.0	0.0	0.0
Punicaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Ranunculaceae	Dicot	93	5	0	98	5.1	0.0	0.0
Rosaceae	Dicot	126	20	9	146	13.7	6.2	45.0
Rubiaceae	Dicot	34	3	1	37	8.1	2.7	33.3
Salicaceae	Dicot	33	1	0	34	2.9	0.0	0.0
Sarraceniaceae	Dicot	0	1	1	1	100.0	100.0	100.0
Saxifragaceae	Dicot	30	4	1	34	11.8	2.9	25.0
Scrophulariaceae	Dicot	106	12	5	118	10.2	4.2	41.7
Simourabaceae	Dicot	0	1	1	1	100.0	100.0	100.0
Solanaceae	Dicot	5	5	2	10	50.0	20.0	40.0
Staphyleaceae	Dicot	0	1	0	1	100.0	0.0	0.0
Ulmaceae	Dicot	3	1	0	4	25.0	0.0	0.0
Valerianaceae	Dicot	18	2	1	20	10.0	5.0	50.0
Violaceae	Dicot	25	1	1	26	3.8	3.8	100.0
Vitaceae	Dicot	0	3	1	3	100.0	33.3	33.3
Zygopphyllaceae	Dicot	0	1	0	1	100.0	0.0	0.0

*Excluding cultivated plants which have not escaped into the environment

Tab. 10.8 > Invasive plant species in Europe.

Fact Sheet	Species	Ecol. group	Life form	Status	CH [1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]
	Abutilon theophrasti Medik.	R	t	adventive		(econ.)	x	xx	xx				x
yes	*Acer negundo* L.	F	p	subspont.		xxx; (econ.)	xxx	x			xxx		
	Aesculus hippocastanum L.	C	p	subspont.						xxx			
	Agave americana L.	R	j	naturalized			+ M	xxx	xx				
yes	*Ailanthus altissima* (Miller)	P	p	naturalized	xxx	xxx	xxx	xxx	xxx		xxx	xxx	
	Allium paradoxum (M. v. Bieberstein)	C	g	subspont.						xx			
	Amaranthus albus L.	R	t	unknown				x	xxx				

Fact Sheet	Species	Ecol. group	Life form	Status	CH[1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]
	Amaranthus blitum L.	R	t	unknown				x	x				
	Amaranthus cruentus L.	R	t	subspont.								xxx	
	Amaranthus deflexus L.	R	u	unknown			x		xxx			xxx	xxx
	Amaranthus retroflexus L.	R	t	unknown		econ.	x		xxx			xxx	xxx
yes	*Ambrosia artemisiifolia* L.	R	t	adventive	xxx	xx; econ.	xxx	x	x		xxx	xxx	
yes	*Amorpha fruticosa* L.	H	n	subspont.	x	xx	++ M				xxx	xxx	
	Artemisia annua L.	R	t	adventive			x						
yes	*Artemisia verlotiorum* Lamotte	R	g	unknown	xxx		xxx	x	x			xxx	
	Arundo donax L.	H	g	subspont.				xxx	xx				
yes	*Asclepias syriaca* L.	C R	g	subspont.		xx	+ M				xxx		
yes	*Aster lanceolatus* Willdenow	C	g	subspont.		xxx	++ M		xx		xxx *Aster* spp.		
	Aster novae-angliae L.	H	g	subspont.									
yes	*Aster novi-belgii* L.	H	c	subspont.		xxx	xxx						
	Aubrieta deltoidea (L.)	S	c	naturalized									
	Avena sativa L.	C	t	subspont.						x			
	Bidens bipinnata L.	R	t	naturalized								xxx	
	Bidens connata Willdenow	H	t	naturalized			+++ A						
yes	*Bidens frondosa* L.	R	t	naturalized		xxx	xxx	xx	xxx			xxx	
	Bidens subalternans DC.	R	t	adventive				xx					
	Brassica napus L.	C	u	subspont.					x	xx			
yes	*Buddleja davidii* Franchet	P	n	naturalized	xxx	xx	xxx	xxx		xx			
yes	*Bunias orientalis* L.	R	h	unknown	x		++ C						xxx
	Cerastium tomentosum L.	C	c	subspont.						xx			
	Chenopodium ambrosioides L.	R	t	adventive			+++ M		x			xxx	
	Chrysanthemum *Segetum* L.	R	t	unknown					xx				
	Cicerbita macrophylla (Willdenow)	C	g	subspont.						xx			
yes	*Conyza canadensis* (L.)	P	u	unknown			+++ C	xxx	xxx		xxx	xxx	xxx
yes	*Cornus sericea* L.	F	n	naturalized	x								
	Coronopus didymus (L.)	R	u	adventive			x		xxx				
	Cotoneaster horizontalis Decne	C	j	subspont.						xx			
	Crepis nemauensis Gouan	R	t	naturalized									
	Cymbalaria muralis P. Gaertn., B. Mey. & Scherb.	P	c	unknown						xx			
yes	*Cyperus eragrostis* Lamarck	H	h	unknown			xxx	xxx	xx				
yes	*Cyperus esculentus* L.	H	g	unknown	x								xxx
	Cyperus rotundus L.	H	g	naturalized									
	Datura stramonium L.	R	t	unknown			x	x	xxx			xxx	xxx
yes	*Duchesnea indica* (Andrews)	F	h	naturalized		xx							
	Eleusine indica (L.)	R	t	naturalized				xx	x			xxx	
yes	*Elodea canadensis* Michaux	E	a	unknown	x	xxx	+++ C	xxx	xx	xx		xxx	
yes	*Elodea nuttallii* (Planchon)	E	a	naturalized	xxx	xx	++ C			xx			
yes	*Epilobium ciliatum* Rafinesque	R	h	unknown		xxx	xxx			x			

Fact Sheet	Species	Ecol. group	Life form	Status	CH[1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]
	Erigeron annuus (L.)	R	u	naturalized			xx				xxx	xxx	
	Erigeron karvinskianus DC.	P	h	unknown			+ A		xx				
	Euphorbia maculata L.	R	t	unknown			x		x				
	Euphorbia prostrata Aiton	R	t	adventive					x				
	Ficus carica L.	C	p	subspont.					x				
	Galega officinalis L.	G	h	subspont.			++ C						
yes	*Galinsoga ciliata* (Rafinesque)	R	t	unknown		econ.	x		x			xxx	xxx
yes	*Galinsoga parviflora* Cavanilles	R	t	unknown		econ.	x		xx			xxx	xxx
	Gleditsia triacanthos L.	C	p	subspont.				xx					
	Glyceria striata (Lamarck)	H	g	unknown		xx							
yes	*Helianthus tuberosus* L.	R	g	subspont.	x	xxx	xxx	xx			xxx	xxx	xxx
yes	*Heracleum mantegazzianum* Sommier & Levier	R	h	naturalized	xxx	xx; econ.	xxx			xxx	xxx		xxx
yes	*Impatiens balfourii* Hooker F.	R	t	unknown			+ C						
yes	*Impatiens glandulifera* Royle	R	t	naturalized	xxx	xxx	xxx			xx	xxx	xxx	xxx
yes	*Impatiens parviflora* DC.	F	t	naturalized			xxx				xxx		xxx
	Juncus tenuis Willdenow	R	h	unknown			++ C						
	Lagarosiphon major (Ridley)	E	a	naturalized			+++ A						
	Lemna minuta Humboldt et al.	E	a	naturalized			xxx						
	Lepidium virginicum L.	R	u	unknown			x		x				
	Ligustrum lucidum Aiton	C	i	subspont.			xx						
yes	*Lonicera henryi* Hemsley	F	i	subspont.	x		xx						
yes	*Lonicera japonica* Thunberg	F	i	naturalized	xxx								
yes	*Ludwigia grandiflora* (Michaux)	E	a	naturalized	xxx		xxx						
yes	*Lupinus polyphyllus* Lindley	F	h	subspont.	x	xx							
	Lycium barbarum L.	C	n	subspont.			++ A						
	Lysichiton americanus Hultén & H. St. John	H	g	naturalized	xxx								
	Lysimachia punctata L.	C H	h	subspont.						xx			
yes	*Mahonia aquifolium* (Pursh)	F R	j	subspont.	x	xx							
	Matricaria discoidea DC.	R	t	unknown			+ C			xx			xxx
	Meconopsis cambrica (L.)	R	h	unknown						xx			
	Medicago sativa L.	C	h	subspont.					x				
	Mimulus guttatus DC.	H	g	naturalized						xx			
	Morus alba L.	C	p	subspont.			++ C						
	Nicandra physalodes (L.)	C R	t	subspont.									xxx
yes	*Oenothera biennis* L.	R	u	unknown			xxx	x		x		xxx	
	Oenothera glazioviana Micheli	R	u	unknown				x		x			
	Opuntia imbricata (Haworth)	S	c	unknown				xxx					
	Oxalis fontana Bunge	R	u	unknown			x						
	Panicum capillare L.	R	t	naturalized			x		x				
	Panicum dichotomiflorum Michaux	R	t	naturalized			x						xxx
	Parthenocissus quinquefolia (L.)	F	p	naturalized									

Fact Sheet	Species	Ecol. group	Life form	Status	CH [1]	Austria[2]	France[3]	Spain[8]	Portugal[7]	Scotland[9]	Hungary[5]	Italy[6]	Germany[4]
	Parthenocissus tricuspidata (Siebold et Zuccarini)	C	p	subspont.			xx				xxx *Parthen.* spp.		
yes	*Paspalum dilatatum* Poiret	H	g	adventive			xxx	xxx	xxx				
	Paulownia tomentosa (Thunberg)	F	p	subspont.									
	Phalaris canariensis L.	R	t	adventive					x				
yes	*Phytolacca americana* L.	R	h	naturalized			x		xx		xxx	xxx	
	Phytolacca esculenta Van Houtte	R	h	naturalized									
	Polygonum orientale L.	R	t	subspont.					x				
yes	*Polygonum polystachyum* Meissner	R	g	naturalized	xxx								
yes	*Prunus laurocerasus* L.	F	i	naturalized	x		xx						
yes	*Prunus serotina* Ehrhart	F	p	naturalized	xxx	xx							xxx
	Pseudotsuga menziesii (Mirbel)	F	i	naturalized						xx			
yes	*Pueraria lobata* (Willdenow)	F R	p	subspont.	x								
yes	*Reynoutria japonica* Houttuyn	R	g	naturalized	xxx	xxx; econ.	xxx	xxx	x	xxx	xxx		xxx
yes	*Reynoutria sachalinensis* (F. Schmidt)	R	g	subspont.	xxx	xx; (econ.)	xxx			xx	xxx		xxx
yes	*Rhus typhina* L.	P	p	naturalized	xxx								
	Ribes rubrum L.	C	n	subspont.						x			
yes	*Robinia pseudoacacia* L.	F	p	naturalized	xxx	xxx; econ.	xxx	xxx	xx		xxx	xxx	
	Rorippa austriaca (Crantz)	H	h	adventive			+ C						
yes	*Rosa rugosa* Thunberg	R	n	subspont.						xxx			
	Rubia tinctorum L.	R	h	naturalized					x				
yes	*Rubus armeniacus* Focke	F	n	naturalized	xxx								
	Rudbeckia hirta L.	C	u	subspont.							xxx		
yes	*Rudbeckia laciniata* L.	C	g	subspont.		xxx					xxx		
	Rumex longifolius DC.	P	h	unknown									
	Rumex patientia L.	C R	h	subspont.			+ C						
	Rumex thyrsiflorus Fingerhuth	R	h	unknown			++ C						
	Rumex confertus Willdenow	P	h	naturalized									
	Sedum spurium M. Bieberstein	R	c	subspont.	x								
	Sedum hispanicum L.	P	u	unknown									
yes	*Senecio inaequidens* DC.	R	u	naturalized	xxx	x	xxx	xxx				xxx	
	Senecio rupestris Waldstein et Kitaibel	R	u	unknown	x								
	Solanum sublobatum Roemer et Schultes	R	t	naturalized			++ M						
yes	*Solidago canadensis* L.	R	g	naturalized	xxx	xxx	+++ C				xxx		xxx
yes	*Solidago gigantea* Aiton	H	g	naturalized	xxx	xxx; (econ)	+++ C			x	xxx	xxx	xxx
	Sorghum halepense (L.)	R	h	unknown			x	xx	x				
	Symphoricarpos albus (L.)	F	n	naturalized						xxx			
	Symphytum asperum Lepechin	R	h	naturalized			+++ C			xx			
	Syringa vulgaris L.	C	n	subspont.		xx							

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	Tanacetum parthenium (L.)	C	h	subspont.					xx				
	Tetragonia tetragonioides (Pallas)	C	t	subspont.			++ M		x				
	Trachycarpus fortunei (Hooker)	F	i	subspont.	x								
	Trifolium incarnatum L.	G	u	subspont.					x				
	Trifolium resupinatum L.	R	u	naturalized					x				
	Ulex europaeus L.	F	n	naturalized			++ A						
	Vaccinium macrocarpon Aiton	H	z	naturalized									
	Veronica filiformis Smith	G	h	unknown						xx			
	Veronica peregrina L.	R	t	unknown			+ C			x			
	Veronica persica Poiret	R	u	unknown			xx		xxx	xx			
	Xanthium spinosum L.	R	t	unknown			+ M	xx	xx				

xxx, invasive species (black list); xx, potentially or moderately invasive species; species in expansion, locally invasive; x, species present; need to be followed up (watch list).
+++ – For France: invasive species in one sector only: M (Mediterranean area); A (Atlantic area); C (continental area);
++ – For France: potentially invasive in one sector only: M, A or C;
+ – For France: species present, which need to be followed up (Watch List), in one sector only: M, A or C.
1 Switzerland: CPS-SKEW (http://www.cps-skew.ch/)
2 Austria: Essl, F. and W. Rabitsch (eds) (2002) Neobiota in Österreich. Federal Environment Agency, 432 pp.
3 France: Muller, S. (2004) Plantes invasives en France. Paris, Muséum National d'Histoire Naturelle. Patrimoines naturels; 62, 176 pp.
4 Germany: From a preliminary EPPO list of invasive alien plants for the EPPO region (plants from Germany include mostly species in the category xxx)
5 Hungary: Invasive alien species in Hungary. National Ecological Network No. 6 (the list includes only invasive plant species in Hungarian protected areas)
6 Italy: Laura Celesti, pers. comm. (2003). The species given for Italy are those most frequent in northern Italy
7 Portugal: De Almeida, J.D. (1999) Flora exotica subespontanea de Portugal continental. Universidade de Coimbra, 151 pp.
8 Spain: Dana, E.D., Sanz-Elorza, M. & E. Sobrino (2001) Plant invaders in Spain, http://www.ual.es/personal/edana/alienplants/checklist.pdf
9 Scotland: Welch, D. et al., (2001) An audit of alien species in Scotland. Scottish Natural Heritage Review No 139, 225 pp.

> Fact sheets

The fact sheets are available at *http://www.environment-switzerland.ch/uw-0629-e*.