3.1 *Ambrosia artemisiifolia* L., Common Ragweed (*Asteraceae*)

Common ragweed is native to Mexico and southern USA (GISD 2009). It is a summer annual plant that blooms from August to October (Brandes and Nitzsche 2007). Spread is due mostly to human activities through soil and seed transport (Bassett and Cromton 1975). Common ragweed has been introduced into Australia, Asia, Europe, New Zealand and South America (GISD 2009). In Europe, it was first recorded in the mid-1800s, but only since the early 1940s has *Ambrosia artemisiifolia* begun to spread (Juhász 1998). Multiple sources of introduction are recorded in the literature: through contamination of seeds (Chauvel et al. 2006), introduced via wool (Brandes and Nitzsche 2007) and during World War I with horse fodder (Chauvel et al. 2006). More recently, the species has also been distributed via bird seeds (Chauvel et al. 2006). Common ragweed is now widespread in Europe and occurs in almost all European countries (GISD 2009). It is commonly found as a ruderal plant growing in waste sites associated with frequent and extensive disturbance regimes resulting from human activities. Roadsides, railways, gravel pits, construction sites, agricultural fields, waterways, urban areas and private gardens are all sites on which this species establishes easily and grows prolifically.

Common ragweed produces highly allergenic pollen and has become the prime cause of hay fever in many European countries. The pollen causes rhinoconjunctivitis, asthma and, more rarely, contact dermatitis and urticaria. As a further consequence, tourism can be affected if visitors avoid areas with high *Ambrosia* occurrence (e.g., the Dalmatian coast). Increasingly, common ragweed has also become a major weed in agriculture, presently ranking as the number one weed in several crops in Croatia and Hungary, including sunflower (references in Brandes and Nitzsche 2007). Owing to the taxonomic closeness to sunflower, herbicide use is greatly limited, which is particularly problematic in countries such as Hungary, where sunflower is a major crop plant.
The insect complex associated with common ragweed in Europe consists mainly of polyphagous species, including some known agricultural pests. About ten species of insects, mites and fungi were recorded in Eurasia by Kováč (1971), several generalist fungal pathogens and six insect species were found in Hungary (Bohar and Vajna 1996; Kiss et al. 2008) and 28 species of insects were recorded in former Yugoslavia (Maceljški and Igrc 1989).

Fungal pathogens associated with *Ambrosia* species in Eurasia are known to have a wide host range and, as observed in the case of *A. artemisiifolia*, most of them have been found to have little impact on the plant in the field (Kiss et al. 2003). Outbreaks of disease epidemics caused by two biotrophic fungal pathogens, *Phyllachora ambrosiae* (Berk. and M.A. Curtis) Saccardo and *Plasmophora halstedii* (Farlow) Berlese and De Toni, did affect *A. artemisiifolia* in Hungary in 1999 and 2002 (Vajna et al. 2000; Vajna 2002); however, for unknown reasons no similar epidemics were noted in other years (Kiss 2007). Overall, European natural antagonists are unlikely to be used to control *A. artemisiifolia* and other exotic *Ambrosia* species in Europe, leaving the classical biological control approach as the most promising option.

### 3.1.1 *Zygogramma suturalis* (Fabricius) (Col., Chrysomelidae)

The leaf-feeding beetle *Zygogramma suturalis* originates from Canada and the USA. Both larvae and adults feed on the leaves and flowers of common ragweed from April to mid-September. The species is generally bivoltine, occasionally univoltine or trivoltine (Igrc et al. 1995). It was first released as a biological control agent in 1978 in the northern Caucasus (Julien and Griffiths 1998).

In 1985, 1988 and again in 1990, *Z. suturalis* was released at three sites in former Yugoslavia, now Croatia (Igrc et al. 1995). Prior to its release in 1985, no-choice host specificity tests were conducted with 128 plant species/varieties, and no feeding was reported on any other plant than common ragweed (Igrc 1987). Insects for the field releases originated from the USA and from Krasnodar, Russia. In total, 2000 adults and 700 larvae were received from the USA between 1984 and 1990, and 6000 adults in 1990 from Russia (Igrc et al. 1995). In 1985, about 1000 larvae were released in a field near Bjelovar. Unusually low temperatures after the release were presumed to have killed most of the larvae and no permanent establishment was recorded at this site. In 1988, 250 adults were released into a field cage near Zagreb and another 250 in the open field near Zadar. At both sites, the species established and was also recorded 2 years after release. In 1990, 190 additional adults originating from the USA were released into the field cage near Zagreb. In the same year, 4000 adults originating from Russia were also released at the Zagreb site, both into field cages and into the open field.

Although *Z. suturalis* has established and has been slowly dispersing from the release sites, densities of the beetles in the field have remained low, and no control of common ragweed has been recorded so far (Igrc et al. 1995).
Chapter 3

3.2 **Reynoutria japonica var. japonica HOUTTUYN**, Japanese Knotweed (Polygonaceae)

**Syn.: Fallopia japonica var. japonica (HOUTTUYN) RONSE DEGRAENE; Polygonum cuspidatum Siebold and Zuccarini**

Japanese knotweed is native to Japan, Taiwan and China. It is a perennial plant, but the whole aboveground biomass dies back with the first autumn frosts. In early spring, annual stems grow from an extensive rhizome system (Beerling *et al.* 1994). A single genotype has been identified for Japanese knotweed in Europe and the species spreads almost exclusively by vegetative propagation (Krebs *et al.* 2010). Japanese knotweed has a high regeneration ability and can regenerate from small rhizome or shoot fragments (Brock and Wade 1992). Dispersal occurs mainly by transportation of soil, horticultural waste or via river systems (Child and Wade 2000). Japanese knotweed was introduced into Australia, Europe, New Zealand and North America (GISD 2009). In Europe, it was first introduced as an ornamental plant from Japan to the UK in 1825 (Seiger 1991). Japanese knotweed tolerates a wide range of habitat conditions; it is, however, particularly abundant along waterways. Naturally occurring disturbances, such as flooding, aid the transportation of rhizome and stem fragments in these habitats.

Japanese knotweed is considered among the most aggressive invasive weeds in temperate Europe and has serious consequences for biodiversity. It forms dense stands, at times even monocultures, leaving literally no space for the native vegetation and associated invertebrates. In addition to the ecological impact, Japanese knotweed can cause substantial economic damage. The stout rhizomes grow through asphalt, building foundations, concrete retaining walls and even drains, causing significant damage to infrastructure. It can add up to 10% to the costs of development and regeneration schemes.

Efforts to control knotweeds are being undertaken throughout Europe, using both mechanical and chemical methods. Control is, however, labour-intensive because the plant benefits from an extensive rhizome system and it takes several years to achieve eradication. Moreover, chemical control is limited because in most European countries the use of pesticides is restricted by law in wetlands and along rivers, i.e. in those areas invaded most heavily by alien knotweeds.

The majority of phytophagous species feeding on Japanese knotweed in Europe are generalist. The chrysomelid *Gastrophysa viridula* (De Geer), a species feeding only on members of the Polygonaceae, in particular on *Rumex* species, has been found feeding on the leaves of Japanese knotweed (Beerling *et al.* 1994); however, it cannot complete its larval development on this species (Krebs 2009). Surveys within the native range of Japanese knotweed in Japan revealed that 186 species of phytophagous arthropods were associated with the plant in its native range (Shaw *et al.* 2009).
3.2.1 *Aphalara itadori* (Shinji) (Hem., Psyllidae)

*Aphalara itadori* is native to Japan, Korea, Russia and the Sakhalin and Kurile Islands. Both nymphs and adults are sap suckers on the leaves and stems of Japanese knotweed from April onwards. *Aphalara itadori* is a multivoltine species. Adults overwinter presumably using tree species as shelter plants.

Prior to its release, host specificity tests were conducted using 87 plant taxa (i.e. species, subspecies and hybrids). The only plant taxa on which *A. itadori* could complete its development were exotic *Reynoutria* taxa (*Reynoutria japonica* var. *compacta*, *Reynoutria sachalinensis* and two hybrids, *Reynoutria × bohemica* and *Reynoutria × conollyana*).

Between 2010 and 2013, *A. itadori* was released in England and Wales at eight sites, with a maximum of 20,000 adults per site and year. Despite the observation of some eggs developing through to adults and small numbers of overwintered adults at some of the sites in some years, there have been no signs of establishment of *A. itadori* in the UK (Richard Shaw, Egham, 2015, personal communication).

3.3 *Cirsium arvense* (L.) Scopoli, Creeping Thistle (Asteraceae)

Creeping thistle is a perennial plant that is probably native to south-eastern Europe and the eastern Mediterranean area but has been resident throughout the rest of Europe and parts of Asia for a long time (CABI 2007). Creeping thistle has also been introduced into Africa, Australia, New Zealand and North and South America. Propagation occurs both by seeds and adventitious shoots arising from perennial roots. Creeping thistle can infest many temperate agricultural crops and is found in both disturbed (tilled) and no-tillage agricultural fields, but also in undisturbed roadides, riverbanks, forest edges and open meadows.

Creeping thistle is a major pest and is considered one of the world's worst weeds. In Europe, it is ranked as the third most important weed and is considered an important weed in the UK, particularly in uplands and other grazing areas (Baker *et al.* 1972; CABI 2007). Creeping thistle tends to form patches when it occurs in crops and can cause substantial crop losses.

Methods for controlling creeping thistle using both non-chemical methods and herbicides have been developed for various crops. Combining herbicides with cultivation, mowing or grazing, and competitive crops has been shown to be more effective for controlling creeping thistle than herbicides alone.

At least 78 species of phytophagous insects feeding on creeping thistle are reported for Europe, including several species with high degrees of specialization on the weed (Zwölfer 1965). In the UK, however, creeping thistle does not carry the full range of phytophagous insects that attack the plant on mainland Europe. Five specialist phytophagous insects have been tested and subsequently introduced.
as biological control agents into Canada, New Zealand and the USA (Julien and Griffiths 1998).

### 3.3.1 *Altica carduorum* (Guérin-Méneville) (Col., Chrysomelidae)

*Altica carduorum* is a univoltine species native to southern Europe (Baker *et al.* 1972). The species is known in the field in Europe mainly from creeping thistle, with a single record of adults on *Carduus pycnocephalus* L. (Zwölfer 1965). Host specificity tests in the laboratory revealed that first-instar larvae completed their development only on *Cirsium*, *Carduus* and *Silybum* species (Harris 1964). Both larvae and adults feed externally on plants. Heavy adult feeding can cause the collapse of plants both in the laboratory and in the field (Karny 1963).

In 1969 and 1970, at least 2300 *A. carduorum* originating from France were released at four sites in the UK, both in field cages and into the environment. Some beetles overwintered successfully in cages, but no permanent establishment occurred. Egg production was low and mortality high, suggesting that *A. carduorum* was not adapted to the climatic conditions in the UK (Baker *et al.* 1972).