1998-08-19

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Paulownia tomentosa (Thunb.) Steud.

A. COMMUNITY

The flora of Paris, like that of the majority of cities, is characterised by the existence of a high proportion of exotic species originating from every corner of the globe. Some of these exotic species were introduced deliberately (Figure 1) (1) to beautify the streets, window boxes, parks and gardens, such as the Butterfly bush, the Giant hogweed or the Canada Goldenrod; (2) for agricultural purposes, e.g. Rape, very widely grown in the Parisian region, which can now be observed growing spontaneously in the streets and wastelands of Paris; (3) for medicinal use, like Lemon balm or Annual wormwood which have gradually escaped from private gardens.

The other exotic species have been introduced accidentally (Figure 1) by means of the major network of paths of communication that exist between and in towns, such as Canadian horseweed, Narrow-leaved Ragwort or Common ragweed; and/or by their spread beyond the northern boundary of their original distribution area due to current climatic warming. This it the case of the Rabbitsfoot grass and the Crested rostraria.

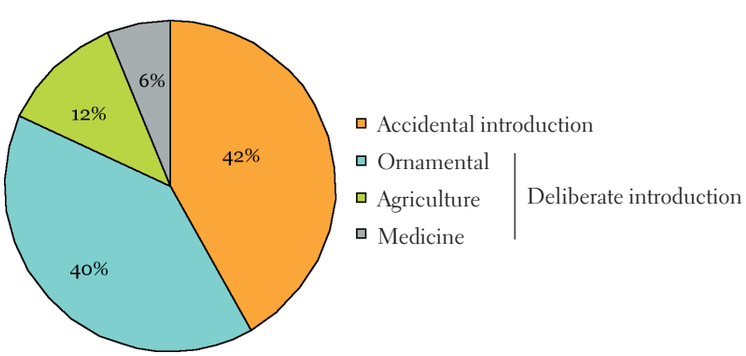

Figure 1: Origin of introduction of exotic species now naturalised in the Hauts-de-Seine department, Île-de-France (Muratet 2006)

The future development of these introduced species is uncertain.

Either the species is not adapted to the climatic, environmental and/or man-made conditions of the area of introduction and does not maintain itself over a long period, when it is described as **casual**.

Or it succeeds in crossing this first environmental barrier, and reproducing or multiplying so as to form viable populations: it then becomes **naturalised** and takes its place in the wild flora, just like species indigenous to the region.

Or finally the species can spread into zones remote from the sites of introduction, so overcoming the dispersal barriers of the new region and becoming **invasive** (Richardson *et al*. 2000).

The likelihood of these exotic species passing each of these barriers is 1:10 at each stage (Williamson and Fitter 1996). Thus one introduced species out of 100 would become naturalised, and one out of 1000 would become invasive.

In urban surroundings, the introduced species which succeed in overcoming all these barriers to the point of becoming naturalised form more than 15% of wild flora (Kowarik 1995; Pygek 1998; Godefroid 2001; Filoche *et al.* 2006; Muratet 2006). They tolerate being trodden on, drought, nitrate deposits, excrement, being clipped, being pulled up and herbicides. They colonise lawns, wasteland, the foots of trees, gaps between paving stones, cracks in tarmac and any other space that is left empty. In order to achieve this they have developed remarkable adaptation mechanisms. Some have adopted a prostrate habit and are resistant to being trodden on, to the compaction of the soil and drought, such as the large-fruit amaranth, the spotted spurge or the procumbent pearlwort... Most adapt to a variety of soils and tolerate high levels of nitrogen and nitrate. They often have very rapid growth, sometimes associated with a very short life cycle. The majority have high dissemination capacities. The perennial species among them are often resistant to mechanical means of eradication and combine several sexual and asexual methods of reproduction to promote their expansion, like the Tree of Heaven and the Black Locust which can reproduce sexually through seeds and spread vegetatively by producing suckers.

B. POPULATION

The species pp. 204, 206, 208, 210, 212, 214, 216, 218, 220 is the Princess tree, *Paulownia tomentosa* (Thunb.) Steud. It is an exotic species that has recently been observed growing spontaneously in Paris in cracks in tarmac, on vacant plots and uncovered ground, and in the gaps on the concreted banks of the Seine, but always close to a planted individual: it is an "escapee". So far it cannot manage to reproduce naturally in such a way as to form viable long-term populations, and it is therefore not yet regarded as being part of our wild flora. In this case, the status of this species is casual: most of the individuals observed have come from planted individuals.

The Princess tree was introduced to Paris to embellish squares, avenues, gardens and streets because of its capacity to adapt to various types of soil, its rapid growth, its ability to withstand pollu-

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tion and pruning, the shade it provides and the beauty of its large flower heads.

It is a species originating from north China and Korea. It was first introduced into Europe along with 12,000 other specimens in the 1830s by Philipp Franz von Siebold, a doctor and naturalist with the Dutch East India Company, returning to the Netherlands after a long stay in Japan (Remaley 2005). It was he and Joseph Gerhard Zuccharini who gave the name Paulownia to this species in honour of Anna Pavlowna, the Queen of the Netherlands at the time. The Princess tree was introduced into the rest of Europe, then taken to the United States a few years after, for ornamental purposes and to cultivate the wood for woodworking (Bergmann 1998).

The high nitrogen content of the leaves and flowers also makes it a good fertiliser and means it is good fodder for animals. The flowers which are rich in nectar can also be used in apiculture (Zhu *et al.* 1986; Ulu *et al.* 2000; Ayan *et al.* 2003). Finally since the mid-nineteenth century the Princess tree's seeds have been used by the Chinese as packing material for delicate porcelain objects intended to travel beyond the Pacific Ocean. The spread of this species in the United States may have been encouraged by this last use.

Unlike in the Paris region where spontaneous populations of this species are still only casual, the Princess tree has gradually become naturalised on the East Coast of the United States, overcoming environmental and reproduction barriers to the point where it is today regarded as an "aggressive" species there (Remaley 2005). Moreover, this species is one of the ten invasive plants declared to be a priority in North America where looking for a biological control is concerned (Table 1).

The drawing up of this list by Ding *et al.* (2006) is based on:

– the scale of the invasion: the Princess tree is regarded as invasive in 26 American states;

– the presence of pathogens or insects specific to the species in its place of origin: this species has nearly 128 natural enemies in China;

– the potential risk the introduction of these pathogens could pose to the ecosystem: in the United States there is no species close to the Princess tree which could suffer from the introduction of its natural enemies.

The Princess tree generally grows on sandy and clayey soil, but it can also develop on soils that are rich in humus or poor and dry. Its tolerance to the pH of the soil varies between 5 and 8.9 (Zhu *et al.* 1986). It can be observed in a variety of habitats: in North America it is found on steep slopes, in open valleys, along roads, railways and steep, rocky waterways. The Princess tree's capacity to survive, develop and reproduce in hostile exposed sites has made it a favourite, for example, for replanting on the outsides of mines (Carpenter 1977).

It is adapted to variable temperatures and resists cold relatively well (down to -20°C in its area of origin, [Zhu *et al.* 1986]). Its ecology is more demanding when it comes to humidity and light. Its large leaf surface (the leaves are up to 30 cm long) associated with a high rate of transpiration and its developed root system require adequate moisture for it to develop well. However it tolerates a minimum annual rainfall as low as 500 mm if the rain comes during its growing period. This species does not like shade, so it cannot cope with competition from other heliophilous trees. The germination of Princess tree seeds and the growth of the young seedlings also require a lot of light (Immel *et al.* 1980; Grubisic *et al.* 1985). So this species can regenerate naturally only in areas exposed to light.

Paulownia tomentosa is in flower for a month, from April to May, and its flowers appear before the leaves. The fruit develops from August to September in the form of capsules (Figure 2) containing between a hundred and several thousand winged seeds. These are scattered by the wind and can travel distances of up to 1 km. They can then remain dormant in the ground for at least three years, and start germinating rapidly as soon as the environmental conditions are favourable.

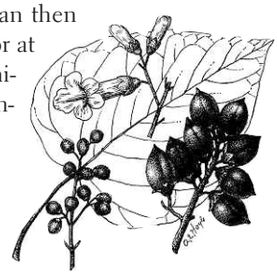

Figure 2: Picture of the leaf, flower buds, flowers and fruit of the Princess tree (Faucon 2005)

Scientific name	Common name	States invaded	Congeneric species	Natural enemies	Potential agents
Ampelopsis brevipedunculata	Porcelainberry	10	2	22	4
Celastrus orbiculatus	Oriental bittersweet	25	1	9	5
Dioscorea oppositifolia	Chinese yam	23	3	41	5
Euonymus alata	Burning bush	21	4	40	13
Euonymus fortunei	Winter creeper	—	—	—	—
Ligustrum sinense	Chinese privet	20	0	106	18
Melia azedarach	Chinaberrytree	21	0	31	7
Paulownia tomentosa	Princess tree	26	0	128	19
Sapium sebiferum	Tallowtree	9	0	113	10
Ulmus pumila	Siberian elm	41	6	>400	40

Table 1: Ten invasive species declared to be a priority in the United States (Ding *et al.* 2006)

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The Princess tree can also be propagated from fragments of stem or via the roots which form suckers. Thus the eradication of this species is made difficult, for after it is cut down, new shoots can quickly reappear on the stump or from the roots (Remaley 2005). Furthermore this species is characterised by extremely rapid growth which translates into an annual height gain of two metres and a gain of about three centimetres in diameter. A Japanese tradition bears witness to this: a Princess tree was planted on the birth of a daughter so that a cupboard could be made from it when the young woman came to marry.

Finally the Princess tree has a large root system extending over a radius of 29 metres from the parent tree, i.e. almost three times the area occupied by the crown of the tree, and it can therefore spread rapidly by vegetative means (Zhu *et al.* 1986).

C. INDIVIDUAL

The individual specimen was photographed at the exit of the underground car park of the Hôtel Mercure on rue de Bercy. It is developing in a concrete crack about 10 sq. cm in area that is hard for the city gardeners' mowers and herbicides to reach, where a minimum of water, nitrogen and nitrates supply it with the resources required for its development.

The appearance and preservation of this Princess tree are probably linked to the earlier existence of individuals planted for ornamental purposes on the rue de Bercy. When those individuals were taken out, they must have left suckers in the ground under the concrete which could have developed and produced a new individual. There is nothing concrete allowing that hypothesis to be reached, other than the exposure. We know that the germination of a Princess tree seed requires considerable exposure to light. Now, the place where this individual was observed receives only weak indirect light, which seems unlikely to have favoured the germination of a seed. Furthermore the presence in the ground of a pre-existing sucker would provide a better explanation of the toughness and rapid growth of this individual. Over the entire duration of observation, the plant was cut down and pulled up many times and at short intervals (July 1998, May 1999, October 1999, November 1999, January 2000, August 2000, September 2000, April 2001), but each time it very quickly recovered, so demonstrating this species' great capacity to adapt to the urban environment. Nonetheless, the last time it was pulled out in December 2002 seems to have proved fatal to it, for this Princess tree has not been seen again in the five years that have followed.

References

AYAN, Sezgin, SAGLAM, Irem and SIVACIOGLU, Ahmet, "Paulownia Sieb. & Zucc: A new exotic genus for multi-purpose uses in Kastamonu-Turkey", in *Decision Support For Multiple Purpose Forestry*, A transdisciplinary conference on the development and application of decision support tools for forest management, Vienna: University of Natural Resources and Applied Life Sciences, April 2003

BERGMANN, Ben A., "Propagation method influences first year field survival and growth of Paulownia", *New Forests*, vol. 16, no. 3, November 1998, pp. 251-264

CARPENTER, Stanley B., "This 'Princess' heals disturbed land", *American Forests*, no. 83, July 1977, pp. 22-23

DING, Jianqing, REARDON, Richard, WU, Yun, ZHENG, Hao and FU, Weidong, "Biological control of invasive plants through collaboration between China and the United States of America: a perspective", *Biological Invasions*, vol. 8, no. 7, October 2006, pp. 1439-1450

FAUCON, Philippe, "Princess tree, Royal Paulownia", 2005, in *www.desert-tropicals.com/Plants/Scrophulariaceae/Paulownia_tomentosa.html*

FILOCHE, Sébastien, ARNAL, Gérard and MORET, Jacques, *La biodiversité du département de la Seine-Saint-Denis – Atlas de la flore sauvage*, Mèze: Biotope; Paris: Muséum national d'Histoire naturelle, 2006

GODEFROID, Sandrine, "Temporal analysis of the Brussels flora as indicator for changing environmental quality", *Landscape and Urban Planning*, vol. 52, no. 4, January 2001, pp. 203-224

GRUBISIC, Dragoljub, NESKOVIC, Mirjana and KONJEVIC, Radomir, "Changes in light sensitivity of Paulownia tomentosa and P. fortunei seeds", *Plant Science*, vol. 39, no. 1, May 1985, pp. 13-16

IMMEL, Mark J., TACKETT, E. M. and CARPENTER, Stanley B., "Paulownia seedlings respond to increased daylength", *Tree Planters Notes*, vol. 31, no. 1, winter 1980, pp. 3-5

KOWARIK, Ingo, "Time lags in biological invasions with regard to the success and failure of alien species", in Petr Pygek, Karel Prach, Marcel Rejmánek and Max Wade (eds.), *Plant Invasions: General Aspects and Special Problems*, Amsterdam: SPB Academic Publishing, 1995, pp. 15-38

MURATET, Audrey, *Diversité végétale en milieu urbain. L'exemple des Hauts-de-Seine*, Doctoral thesis in ecology, Paris: Université Paris VI, 2006

PYGEK, Petr, "Alien and native species in Central European urban floras: A quantitative comparison", *Journal of Biogeography*, vol. 25, no. 1, January 1998, pp. 155-163

REMALEY, Tom, "Plant Conservation Alliance's Alien Plant Working Group: Princess Tree", 2005, in *www.nps.gov/plants/alien/fact/pato1.htm*

RICHARDSON, David, PYGEK, Petr, REJMÁNEK, Marcel, BARBOUR, Michael G., PANETTA, Dane and WEST, Carol, "Naturalization and invasion of alien plants: concepts and definitions", *Diversity & Distributions*, vol. 6, no. 2, March 2000, pp. 93-107

ULU, Fahrettin, ÇETINER, fiaban, EREN, Necmettin and AYAN, Sezgin, "Results of the Field Stage in Third Year of Species and Provenances Trials of Paulownia Sieb. & Zucc.", in *Eastern Black Sea Region*, Proceedings of the IUFRO Meeting on "Management of Fast Growing Plantations", 2002

WILLIAMSON, Mark and FITTER, Alastair, "The Varying Success of Invaders", *Ecology*, vol. 77, no. 6, September 1996, pp. 1661-1666

ZHU, Zhao-Hua, CHAO, Ching-Ju, LU, Xin-Yu and XIONG, Yao Gao, *Paulownia in China: Cultivation and utilization*, Singapore: Asian Network for Biological Sciences, and Canada: International Development Research Centre, 1986