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ORIGINAL PAPER

Patterns of plant invasions in China: Taxonomic, biogeographic, climatic approaches and anthropogenic effects

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Abstract This study was aimed to determine the patterns as well as the effects of biological, anthropogenic, and climatic factors on plant invasions in China. About 270 volumes of national and regional floras were employed to compile a naturalized flora of China. Habit, life form, origin, distribution, and uses of naturalized plants were also analyzed to determine patterns on invasion. Correlations between biological, anthropogenic and climatic parameters were estimated at province and regional scales. Naturalized species represent 1% of the flora of China. Asteraceae, Fabaceae, and Poaceae are the dominant families, but Euphorbiaceae and Cactaceae have the largest ratios of naturalized species to their global numbers. *Oenothera*, *Euphorbia*, and *Crotalaria* were the dominant genera. Around 50% of exotic species were introduced intentionally for medicinal purposes. Most of the naturalized species originated in tropical America, followed by Asia and Europe. Number of naturalized species was significantly correlated to the number of native species/log area. The intensity of plant invasion showed a pattern along climate zones from mesic to xeric, declining with decreasing temperature and precipitation across the nation. Anthropogenic factor, such as distance of transportation, was significantly correlated to plant

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invasions at a regional scale. Although anthropogenic factors were largely responsible for creating opportunities for exotic species to spread and establish, the local biodiversity and climate factors were the major factors shaping the pattern of plant invasions in China. The warm regions, which are the hot spots of local biodiversity, and relatively developed areas of China, furthermore, require immediate attentions.

Keywords Anthropogenic factor · Biodiversity · Biogeographic pattern · China · Climate · Plant invasion · Taxonomic pattern

Introduction

Plant invasions, accelerated and aggravated by international trade and tourism, especially in developing countries (Levin and D'Antonio 2003; Ruiz and Carlton 2003; Valladares-Padua 2006), have been considered to be one of the most important environmental issues of our time. Unfortunately, reports and studies on plant invasions are anecdotal or local in purview. China, the largest country in Asia and one of the most important industrial countries in the world, has been experiencing booming economic and domestic development in recent decades (Ding et al. 2008; Weber and Li 2008a, b). Although recent attention has been paid to the pattern of plant invasion in China, figures for less familiar invasive plants in China, compiled from the literature, number only 1–200 (Liu et al. 2006; Ding et al. 2008; Weber and Li 2008a, b). Compared to the area and diversity of habitats in China, these are not significant numbers. The knowledge of plant invasions and potential invaders is limited and far behind studies in neighboring areas such as Singapore (Corlett 1988), Japan (Enomoto 1999), Korea (Koh et al. 2000), and Taiwan (Wu et al. 2003; Wu et al. 2004a, b).

Datasets that present floristic status, biological attributes, geographical distribution, and usage information on exotic species have been shown to be very effective tools for discerning patterns of plant invasions and species invasiveness (Rejmánek and Richardson 1996; Daehler 2001; Pyšek et al. 2002; Lake and Leishman 2004; Pyšek et al. 2004; Wu et al. 2004a, b; Cadotte et al. 2006). For a region where the status and composition of invasive species are not definite, establishment of a database of naturalized species should be the first step toward approaching local plant invasions.

Albeit that not every naturalized species will become invasive, but all invasive species are naturalized first. Naturalized species can therefore be considered to be potential invaders for characterizing the pattern of plant invasions. A naturalized species is defined as an introduced (non-native, exotic) species, that can consistently reproduce and sustain populations over many generations without (or despite) direct intervention by humans (Richardson et al. 2000; Pyšek et al. 2002).

Habitat characteristics, such as local biodiversity, climate, and anthropogenic activities, as well as the uses of plants, may have a bearing on successful invasions and invasion patterns (Chytrý et al. 2008; Van der Wal et al. 2008). It has been shown that most of successful, established, invasive species were introduced intentionally as ornamentals, or for forage, medicine, and other purposes (Mack and Erneberg 2002; Mack 2003), while unintentional introductions usually occurred through contaminated fodder or crop seeds, footwear, packing materials, and ballast (Kloot 1987). Although contributions from the local economy and from anthropogenic activities have been studied, patterns of plant invasion along climatic gradients have not been documented. In consideration of the pools of species in different climate regions of the world and the length of the growing season, the intensity of plant invasions may vary in accordance with local biodiversity and climates. Comparisons of native and naturalized floras across different climate zones will contribute to generate better understandings of plant invasions.

International and domestic transportation, tourism, and cargo shipments across borders have been considered to be important vectors responsible for species introduction and exchange (Jenkins 1996; Williamson 1996; Shigesada and Kawasaki 1997; Dalmazzone 2000; McNeely 2000). Regardless of China's importance in the world's industrial capacity, the improved economy has accelerated domestic development of the public infrastructure, such as railroads, airports, harbors, and highways (Ding et al. 2008). Although there have been warnings of exponential growth in the invasions by alien species with the booming economy (Ding et al. 2008; Weber and Li 2008a, b), there is no evidence to back up such warnings. Since national statistical information is well assembled and released to the public, the effects of the local economy and anthropogenic activities on the naturalized flora and patterns of plant invasion can be readily assessed.

The main purpose of this study was to reveal patterns of plant invasions in China by identifying and analyzing the naturalized flora. This first list of naturalized species in China will serve as a foundation for future research on plant invasions. Based on this compilation, several basic questions can be addressed regarding naturalized alien species in China: (1) Is there a taxonomic pattern? (2) Are some life forms or habits overrepresented? (3) What is the nativity of the naturalized plants? (4) What are the modes of introduction? Furthermore, we also approximated the effects of local biodiversity, climate and anthropogenic activity on plant invasions. By understanding the patterns of plant naturalization in China, the only missing piece of the puzzle on plant invasions in eastern Asia, we hope to generate insightful perspectives and information for further regional studies.

Materials and methods

Catalogue of naturalized species

To compile a list of the naturalized flora, we reviewed 270 national, regional, and local floras as well as e-floras. Additionally, relevant articles in Chinese and English journals published before September 2008 were reviewed as well. Among these references, 172 books and numerous documents cited the naturalized status of the species compiled in Appendix. We employed the *Flora of China* as the major source of naturalized status. Hundred of volumes were therefore not listed as references. Each species designated as naturalized, escaped or persistent after cultivation, or invasive, was marked for further examination. Species introduced or cultivated without evidence of escaping were not considered. Additional information, such as life form, habit, use, and origin of these species, was carefully extracted from these references. The distribution of each species was presented by province, with the number of provinces used to indicate degree of invasiveness. Species mentioned in the literature as naturalized or escaped without documenting specimens or without further field evaluation were considered to be possibly naturalized and are listed separately.

Analysis

Information on the species nativity, life form (converted to Raunkiaer system (Mueller-Dombois and Ellenberg 1974), habit, year of first available record, mode or purposes of introduction, was used in the analyses. The list was organized by family and genera. The ratio of number of naturalized species per family and genus in China to the total number of species per family and genus worldwide (Mabberley 1997), excluding species of China, was used for comparison. For the purpose of introduction, all uses of a particular species were included. The total percentage therefore exceeded one hundred. Species without information on purpose of introduction were treated as purpose unknown. Because information on the native distribution of species provided in different references was not consistent, we grouped species by broad categories according to their biogeographical origins, such as Africa, America, Asia, Europe, and Eurasia (excl. southern Asia).

Parameters of local biodiversity, human activities and climatic factors in China were obtained to evaluate their effects on plant invasions. Number of native species per provinces was obtained from China biodiversity databases, and the numbers were divided by logarithmic area of respective provinces as the indicator of local biodiversity. Factors of human activities, including demography (population size), amount of freight movement (per 10 million tons/kilometer), freight quantity (billion tons), total length of transportation (kilometers), area used for transportation (km^2), and international tourists (per million people) were obtained from the official website (http://www.stats.gov.cn) of the National Bureau of Statistics of China. Climatic factors, such as annual average temperature (°C), annual lowest temperature (°C), annual highest temperature (°C), and annual average precipitation (mm), were collected from the official website (http://www.cma.gov.cn) of the China Meteorological Administration. Temperature difference (°C) was calculated by subtracting the lowest temperature from the highest temperature. To reveal the relationships between trends in plant invasions and climate, a map of the climatic zones of China on the official website of Ministry of Culture, P. R. China (http://www1.chinaculture.org/index.html) was utilized. Multiple regression analyses (SPSS 15 2006) were applied to evaluate the relationships between plant invasions and parameters of anthropogenic effects and climatic factors in China. Collinearity analysis and adjusted R^2 were applied.

To characterize patterns of plant invasion across the nation, two categories were employed, province and region according to data availability. Data from 26 provinces were compiled to estimate plant invasions at the province scale, the basic administrative unit that usually has comprehensive background information for analyses. However, in consideration of data availability and regional development policy, background information for six regions was collected for further analyses as well. The six regions are: North (Beijing, Tianjin, Hebei, Shanxi, and Nei Mongol), Northeast (Liaoning, Jilin, and Heilongjiang), East (Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, and Shandong), South Central (southeast china; Henan, Hubei, Hunan, Guangdong, Guangxi, and Hainan), Southwest (Chongqing, Sichuan, Guizhou, Yunnan, and Xizang), and Northwest (Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang). These regions are named by their locations in China and are combinations of neighboring provinces that have relatively similar environmental and economic conditions. To standardize the incidences of plant invasion for comparison, an index of number of casual and naturalized species/log (area of a particular region in km^2; Vitousek et al. 1997) was utilized.

Results

Documented naturalized species represent about 1% of the flora of China: 420 species in 273 genera and 84 families (Table 1; Appendix). Among these species, 84% are dicotyledons, 15% are monocotyledons, and two species are ferns. Chamaephytes represents 46.7% of the naturalized flora, followed by therophytes (28.5%), phanerophytes (16%), hemicryptophytes (6%), and cryptophytes (2.4%). Among the families and genera of the naturalized flora, 10% of the families are new to China, while 52% of the genera are new to China. Twenty-one additional species were categorized as status unknown (Appendix (Electronic supplementary information)).

Asteraceae, Poaceae, and Fabaceae have many more naturalized species than other families. Of the remaining families (for example, Euphorbiaceae, Amaranthaceae, Brassicaceae, and Convolvulaceae) all have fewer than 20 naturalized species per family (Fig. 1a). About 50% of the families contribute only one species to the naturalized flora, while 75% of the genera are represented by a single naturalized species. Euphorbiaceae (2.4%) and Cactaceae (2%) have the largest percent of naturalized species in China to the global number of species in the family, followed by Caryophyllaceae (0.57%), Convolvulaceae (0.54%), Agavaceae (0.5%), and Amaranthaceae (0.45%; Fig. 1). Of these families with higher ratios, the Amaranthaceae have the most naturalized species (43), followed by the Euphorbiaceae (18) and Convolvulaceae (16), while Agavaceae has the fewest (8).

Table 1 Numerical summary of the naturalized flora in China

	Pteridophyta	Angiosperm		Total
		Dicotyledons	Monocotyledons	
Family	2	70(7)	12(1)	84(8)
Genus	2	223(117)	48(23)	273(140)
Species	2	355	65	420
Chamaephyte	–	168	31	199
Cryptophyte	–	6	4	10
Hemicryptophyte	–	10	14	24
Phanerophyte	–	65	1	66
Therophyte		104	15	117

Numbers in parentheses indicate families and genera new to China, respectively

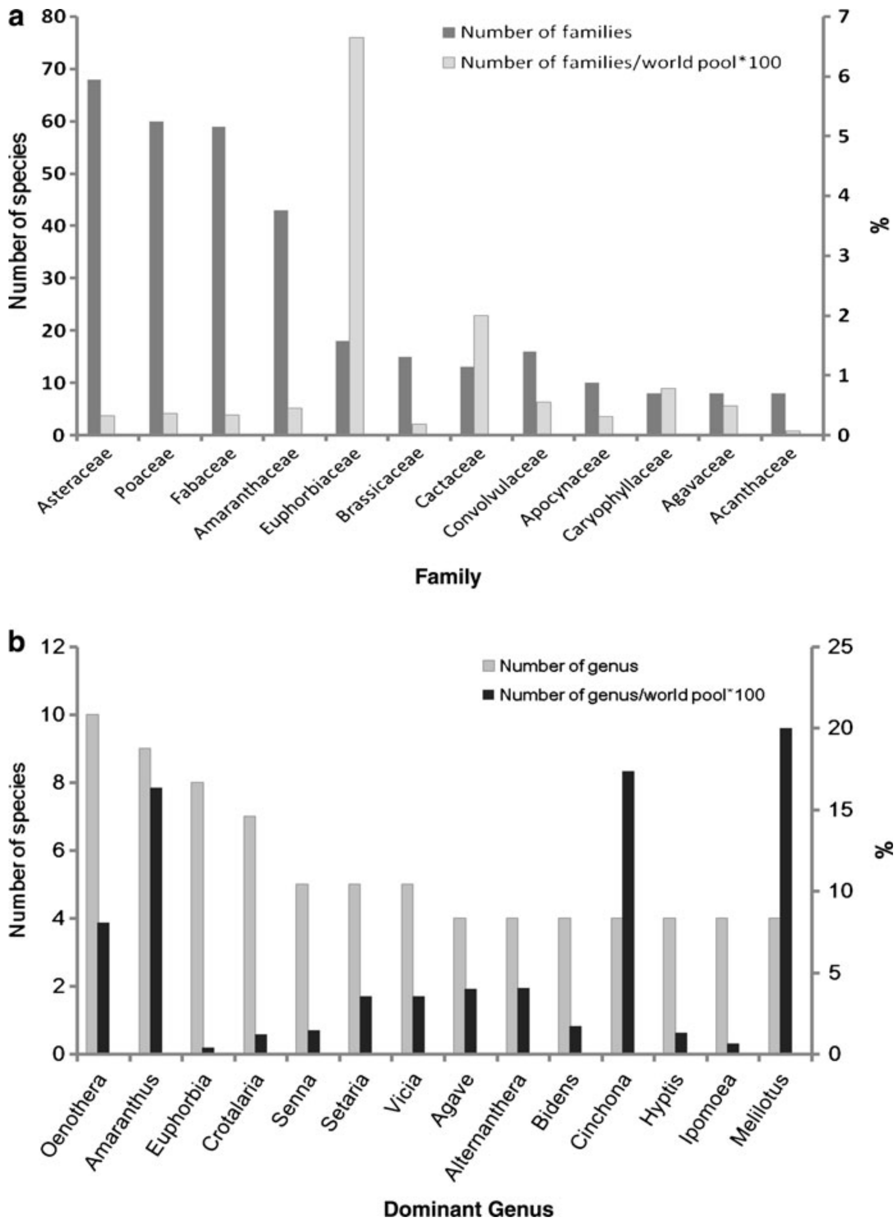

Fig. 1 Taxonomic patterns of naturalized plants in China. **a** Top ten dominant families according to species number and ratio of number of naturalized species in China to global number of species per family. **b** Top ten dominant genera according to species number and ratio of number of naturalized species in China to global number of species per genera

Oenothera (Onagraceae) has the most naturalized species (10), followed by *Amaranthus* (Amaranthaceae) (9), *Euphorbia* (Euphorbiaceae) (8), *Crotalaria* (Fabaceae) (7), and *Senna* (Fabaceae) (5) (Fig. 1b). *Melilotus* has the largest percentage (20%) of naturalized species in China compared with the global number of species in this genus, followed by *Cinchona* (17%), *Amaranthus* (15%), and *Oenothera* (8%). In addition to *Oenothera* and *Amaranthus*, both of *Melilotus* and *Cinchona* have more than five naturalized species in China.

About 11.4% of the naturalized species are distributed nationwide (Table 2). The Asteraceae is the dominant family, with 11 naturalized species occurring in all provinces, followed by Fabaceae (6), Amaranthaceae (5), and Poaceae (4).

Most of the naturalized species have had more than one path of introduction, while the route of introduction of only a small portion of the species is unknown About 51% of the naturalized species were introduced for medicinal purposes, followed by

Table 2 List of 47 nationally distributed species

Apiaceae
Coriandrum sativum L.
Amaranthaceae
Alternanthera pungens Kunth
Alternanthera sessilis (L.) R. Br. ex DC.
Amaranthus albus L.
Celosia argentea L.
Gomphrena globosa L.
Asteraceae
Ageratum houstonianum Mill.
Amberboa moschata (L.) DC.
Ambrosia artemisiifolia L.
Conyza canadensis (L.) Cronq.
Coreopsis grandiflora Hogg. ex Sweet
Coreopsis tinctoria Nutt.
Eupatorium coelestinum L.
Iva xanthifolia Nutt.
Lagascea mollis Cass.
Praxelis clematidea R. M. King & H. Rob.
Sanvitalia procumbens Lam.
Tagetes patula L.
Capparaceae
Cleome burmannii Wight & Arn.
Caryophyllaceae
Saponaria officinalis L.
Convolvulaceae
Calonyction muricatum (L.) G.. Don
Ipomoea alba L.
Ipomoea purpurea (L.) Roth
Cyperaceae
Eleocharis valleculosa Ohwi f. *setosa* (Ohwi) Kitag.
Euphorbiaceae
Phyllanthus amarus Schumach. & Thonn.
Phyllanthus niruri L.
Ricinus communis L.
Fabaceae
Medicago lupulina L.
Medicago sativa L.
Melilotus albus Medik.
Trifolium pratense L.
Trifolium repens L.
Vicia sativa L.
Malvaceae
Hibiscus trionum L.
Onagraceae
Oenothera odorata Jacq.
Oxalidaceae
Oxalis corymbosa DC.
Poaceae
Coix lacryma-jobi L.
Phalaris canariensis L.
Setaria glauca (L.) P. Beauv.
Setaria viridis (L.) P. Beauv.
Polygonaceae
Polygonum aviculare L.
Pontederiaceae
Eichhornia crassipes (Mart.) Solms
Portulacaceae
Talinum paniculatum (Jacq.) Gaertn.
Solanaceae
Capsicum annuum L.
Datura stramonium L.
Nicandra physaloides (L.) Gaertn.
Solanum pseudocapsicum L. var. *diflorum* (Vell.) Bitter

ornamentals (41%), crops (34%), cultivation (18%), and timbering (2%).

As for the origins of the naturalized species, the Americas have been the largest contributors (58%), followed by Europe (15%), Asia (12%), and Africa (9%). Species from Eurasia, Australia, and those with a general notion of origin represent only approximately 6% of the naturalized flora in China. Tropical areas of the Americas, Asia, and Africa were especially important sources (64%). Europe represents the single most important donor of temperate species naturalized in China.

Local biodiversity, anthropogenic and climatic factors are significantly correlated with the index of invasion province-wide and region-wide (Fig. 2; Table 3). The number of naturalized species was significantly exponentially correlated to local biodiversity (Fig. 2). Total length of transportation, which is positively significantly correlated to demography, is the only factor significantly correlated to the index of invasion region-wide. Annual highest temperature and temperature difference are significantly correlated to the index of invasion province-wide and region-wide.

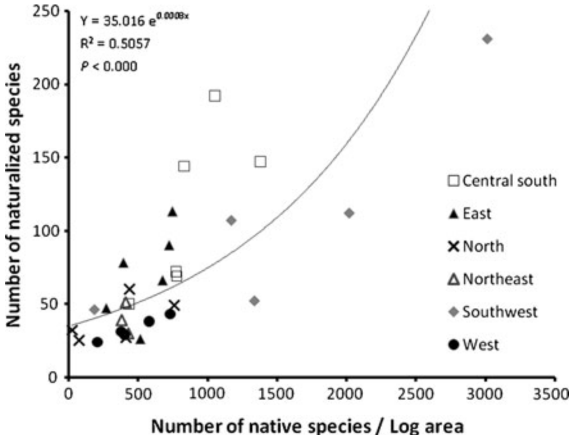

Fig. 2 Regression and curve fitting analysis of naturalized species number to the number of native species per log area. Each point presented a province, and the shapes of data points are designated according to their respective regions

Table 3 Multiple regression analysis of invasion index to anthropogenic and climate factors in regional and provincial scales

Predictor variable	Regional		Provincial	
	Beta	*P*	Beta	*P*
Anthropogenic factors[a]				
Transportation distance	1.171*	0.023	–	–
Log area	−0.059	0.736	–	–
Tourist	−0.279	0.337	–	–
Climate factors[b,c]				
Average temperature	−0.918	0.102	−0.386	0.256
Highest temperature	0.453*	0.052	0.200	0.176
Precipitation	0.855	0.103	0.246	0.385
Temperature difference	−0.838*	0.040	−0.902*	0.000

Beta represents the adjusted correlation coefficients. (* $P < 0.05$)

[a] Anthropogenic factors in regional scale: $F_{(3,2)} = 27.439$, $P = 0.035$, Adjusted $R^2 = 0.94$)

[b] Climate factors in regional scale: ($F_{(4,1)} = 281.202$, $P = 0.045$, Adjusted $R^2 = 0.996$)

[c] Climate factors in provincial scale: ($F_{(4,25)} = 12.59$, $P = 0.000$, Adjusted $R^2 = 0.651$)

Discussion

In consideration of the size of the area and the native flora, our intensive efforts only represented a relatively small fraction of the plant invasions in China (Table 1, Appendix; 420 naturalized species) compared to other areas of the world (Mehrhoff 2000, Enomoto 1999, Wu et al. submitted). The naturalized flora may be as much as five times larger than that compiled in this study according to tens-rules (Williamson and Fitter 1996) and previous estimations of invasive species in China (Liu et al. 2006; Ding et al. 2008; Weber and Li 2008a, b). However, the resolution is not able to be improved due to the quality of taxonomical reports/documents. Although the Flora of China has been comprehensively compiled and the e-flora of China has been under-construction, naturalization status of introduce and cultivated were hardly stated. The naturalized flora may be seriously underestimated due to unclear statements of naturalization status of cultivated/introduced species. However, the general patterns of plant invasions in China could still be accessed by our study since the attentions of plant invasions seem to be even across taxonomic groups and geographical regions.

The composition of the dominant naturalized families and genera implied partially their sizes worldwide (Heywood 1989), and their climatic properties. While naturalized species can be placed in 84 families (Table 1), 45% of them are from only three families, Asteraceae, Poaceae and Fabaceae (Fig. 1a), the major contributors to the alien floras in many regions of Asia (Wu et al. 2004a, b; Zerbe et al. 2004) and of the world (Pyšek 1998). Nevertheless, other important families of the naturalized flora varied slightly in different regions of the world, probably in response to differences of climate in a particular area. Integrated with the fact that a remarkable proportion of naturalized species originated in the tropics, plant invasions in China confirm the assumption that species adapt better to new land where the climate is similar to their homeland (Corlett 1988, 1992). Convolvulaceae, Euphorbiaceae, and Amaranthaceae are considered to be tropical or warm temperate families, and Brassicaceae and Caryophyllaceae are more adapted to cooler climates, such as temperate China, due to similar climates in their home range (Weber 1997; Vilà and Muñoz 1999; Pyšek et al. 2002; Rouget and Richardson 2003). Over representation of Cactaceae species may be the case as well. The xeric environments, such as the extensive deserts in the North (Nei Mongol), in the West (Xinjiang), and in dry, hot valleys of the Southwest (Sichuan, Yunnan) provide suitable habitats for Cactaceae. Based on the ratio of naturalized species to global species per family, the importance of Euphorbiaceae and Cactaceae emerged. Each of these families has around 650–750 species, but the over-representation of these two families suggests that they are especially successful in China (Rejmánek et al. 1991) and deserve further attention.

In contrast, the species numbers of the dominant genera did not completely coincide with the size of their world species pools or the importance of their respective families in the naturalized flora in China. Although *Crotalaria* and *Euphorbia* have hundreds of species worldwide, *Oenothera* and *Amaranthus* are only intermediate in size, with 124 and 60 species respectively (Mabberley 1997). No particular pattern was found between the worldwide size of the species pool and the dominancy of naturalized genera. Overrepresentation of *Cinchona* and *Melilotus*, however, may deserve deliberate investigation due to their high values in the ratio of naturalized versus global species number per genus.

The high percentage (84%) of newly naturalized genera in the flora seems to support Darwin's idea that exotic floras are gaining disproportionately more new genera than new species (Darwin 1859). The idea is that species in exotic genera may be exposed to less competition when they do not have to interact with native congeners. This assumption is also supported by the high percentage (52%) of genera with only one naturalized species. A similar pattern is not shown for naturalized families. Only 16% of the families have less than five naturalized species, and only 10% of the naturalized families are new to China. Darwin's hypothesis has also been supported by data from California (Rejmánek 1998), but not from islands (Daehler 2001; Duncan and Williams 2002). However, we do not know whether this is simply a result of random selection.

Life forms and habits of most naturalized species coincided with the features of the families and genera that have the most naturalized species (Table 1; Fig. 1a, b). For example, Brassicaceae, Fabaceae, Asteraceae and Poaceae are mainly composed of therophytes, phanerophytes, chamaephytes, and hemicryptophytes. The large number of perennial species (phanerophytes, chamaephytes, and hemicryptophytes) in China may be an indicator of serious environmental impact in the future (Huang et al. 2009).

The remarkable percentage of naturalized species with medicinal properties may be the result of China's long history of use of herbal medicines and the definition of medicinal plants. In China, herbal medicines have been used for thousand years, and the application of herbal medicines is highly popular and influential even today. Furthermore, almost every plant can be used to improve or supplement human health more or less according to ancient references (Li 1578; Boym 1656). It appears that the proportion of naturalized species with so-called medicinal properties may be magnified. Although medicinal species are important to human society and have been introduced in many places (Maheshwari and Paul 1975; Klemow et al. 2002), only a relatively small proportion of them are naturalized or invasive (Austin 2000; Weber 2003).

The significant correlations between plant invasions and local biodiversity as well as climates may imply that suitable environment for growth is a key factor determining the biodiversity of native and naturalized floras (Figs. 2, 3). Mesic environment of southern China accommodated most of native species; however, the high biodiversity did not perform as resistance to plant invasions in these areas. Exponentially increased number of naturalized species along native number per log area may be a result of unfulfilled niches and habitat limitation. Disturbances may be responsible as well; however, further information is not currently available for better understandings. Close and significant relationship between invasion index and climatic factors (Table 2), such as annual average temperature, annual lowest temperature, temperature difference, and annual average precipitation, reinforces this descending trend of plant invasion across climatic zones, which symbolize available growth seasons and conditions. This pattern is also very similar to that of altitudinal gradients (Lingua et al. 2008; Mallen-Cooper and Pickering 2008). Habitat limitation seems to be responsible for the diversity of both of naturalized and native species along horizontal climatic gradients of temperature and precipitation. Furthermore, the decrease in sizes of the global species pool from the tropics to the Arctic/Antarctic may indicate the decreasing number of species available for introduction (Barthlott et al. 1996; Kier et al. 2005). We do not, however, have an explanation for why tropical American species were so copiously

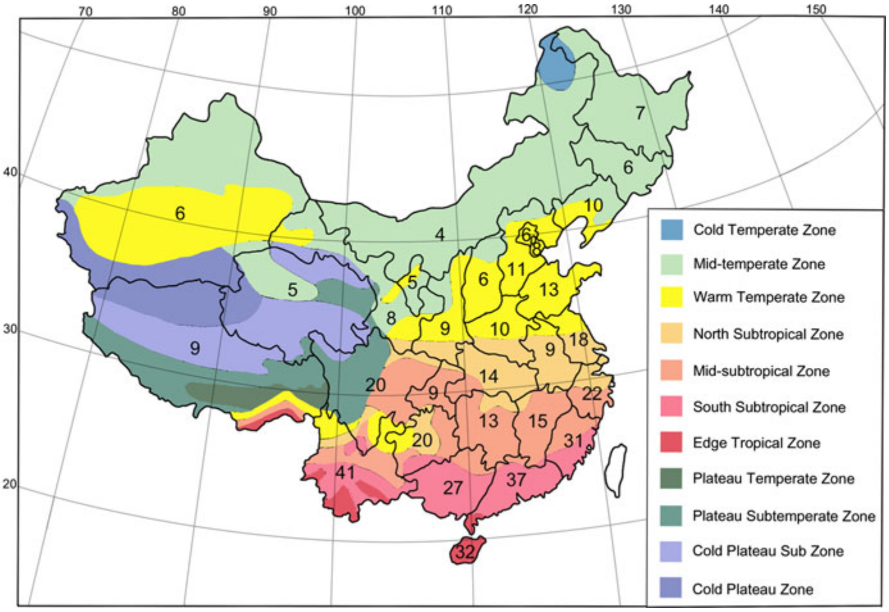

Fig. 3 Climatic zones and intensity of plant invasions in China. *Black lines* indicate provincial boundaries. *Numbers* are an index of number of casual and naturalized species/log (area of a particular region in km^2; Vitousek et al. 1997) in each province. *Colors* designate different climatic zones across China

represented, further studies are urgently needed for a better understanding of plant invasions in China.

Although only few anthropogenic factors are significantly correlated with the index of invasion, the effects of the local economy on plant invasions are indisputable (Table 3). Significant correlations of total length of transportation, which was highly correlated to demography, implies the population size (data not shown) and moving efforts of plant invasions in the regional scale (Gelbard and Belnap 2003; Liu et al. 2005). It was a surprise quantity of freight, extent of freight turnover, and number of international tourists showed no contributions to plant invasions in China. Perhaps latest data were not comprehensive and our analysis did not reflect the impacts of the local economy and development on plant introduction. Nevertheless, with an increase in transportation length facilitated by booming economy, the relationship with plant invasions should be monitored to prevent further impacts (Dong et al. 2008).

Although China's naturalized flora is relatively small, the proportion species occurring nation-wide (11.4%) to the total number of naturalized species coincides with the tens rule. Moreover, the taxonomic and biogeographical patterns of plant invasions in China are very similar to patterns in neighboring regions (Corlett 1988; Enomoto 1999; Koh et al. 2000; Wu et al. 2003; Wu et al. 2004a, b). However, the documentation of naturalized species, potential invaders, and the status of introduced species, is still far from sufficient. It is worrisome that knowledge and study on naturalized species, invasive species, and biological invasions is scanty in China. We recommend that extra attention be paid to certain plant families, such as Euphorbiaceae and Cactaceae, while additional studies are required for a few critical genera, such as *Cinchona* and *Melilotus*. In conclusion, the above-mentioned close relationship between climate and plant invasions may, furthermore, alert people in the warmer parts of China that extreme care should be given to introducing species.

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Appendix

See Table 4.

Table 4 List of naturalized species in China

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Pteridophyta								
Azollaceae								
Azolla filiculoides Lam.	America		H	A	O	+	2	1
Cyatheaceae								
Sphaeropteris lepifera (J. Sm. ex Hook.) Tryon	Philippines		H	P	Cr/Cu/M/O		1	2
Angiosperms								
Dicotyledons								
Acanthaceae								
Adhatoda vasica Nees	Southeast Asia, India and Myanmar	Ph	S	P	O		15	
Andrographis paniculata (Burm. f.) Nees	India and Indochina Peninsula	Th	H	A	Cu	+	1	3
Ruellia brittoniana Leonard	Mexico	Ch	H	P	O	+	14	4
Amaranthaceae								
Alternanthera paronychioides A. St.-Hil.	Tropical America	Ch	H	P	O	+	1	5
Alternanthera philoxeroides (Mart.) Griseb.	Brazil	Ch	H	P	Cr/M	+	25	
Alternanthera pungens Kunth	South America	Th	H	A		+	33	
Alternanthera sessilis (L.) R. Br. ex DC.	America	Ch	H	A/P		+	33	5
Amaranthus albus L.	North America	Th	H	A	M	+	33	
Amaranthus blitoides S. Watson	North America	Th	H	A		+	4	6
Amaranthus caudatus L.	America	Th	H	A	M	+	1	7
Amaranthus hypochondriacus L.	North America	Th	H	A	Cr/O	+	3	
Amaranthus lividus L.	Tropical Africa and Asia	Th	H	A	Cr/M	+	29	8
Amaranthus retroflexus L.	Tropical America	Th	H	A	Cr/M	+	2	9
Amaranthus spinosus L.	Tropical America	Th	H	A	M/O	+	5	10
Amaranthus tricolor L.	India	Th	H	A	Cr/M/O	+	3	11
Amaranthus viridis L.	Tropical Africa	Th	H	A	Cr/M	+	12	12
Celosia argentea L.	India	Th	H	A	Cr/Cu/M	+	33	13
Celosia cristata L.	Tropical Asia	Th	H	A	M/O	+	1	14
Gomphrena celosioides Mart.	Tropical America	He	H	P	M/O	+	4	
Gomphrena globosa L.	Tropical America	Th	H	A	M/O	+	33	
Iresine herbstii Hook. f. ex Lindl.	Brazil	Ch	H	P	O	+	6	15
Annonaceae								
Annona glabra L.	Tropical America	Ph	T	P	Cr/Cu	+	1	3
Annona squamosa L.	Tropical America	Ph	S/T	P	Cr/M	+	6	16

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Apiaceae								
Coriandrum sativum L.	Mediterranean	Ch	H	A/B	Cr/Cu/M	+	33	2
Cyclospermum leptophyllum (Pers.) Sprague ex Britton & P. Wilson	South America	Ch	H	P		+	2	
Daucus carota L. var. *sativa* Hoffm.	Europe, North Africa and Asia	Cr	H	B	Cr/M	+	9	
Eryngium foetidum L.	Tropical America	Ch	H	P	Cr/M	+	5	
Foeniculum vulgare Mill.	Mediterranean	Ch	H	A/B	Cr/M	+	2	42
Apocynaceae								
Asclepias curassavica L.	West Indies	Ch	H	P	M	+	3	17
Catharanthus roseus (L.) G. Don	Madagascar	Ph	H	P	M/O	+	9	
Catharanthus roseus (L.) G. Don 'Albus' Lawrence	Africa	Ph	S/H	P	M/O	+	2	
Plumeria rubra L. 'Acutifolia' Bailey	Mexico	Ph	T	P	M/O	+	2	18
Rauvolfia tetraphylla L.	Tropica America and Tropical Africa	Ph	S	P	Cu/M	+	6	
Thevetia peruviana (Pers.) K. Schum.	Tropical America	Ph	S/T	P	Cu/M/O	+	7	
Asteraceae								
Acanthospermum australe (L.) Kuntze	South America	Th	H	A		+	3	
Achillea millefolium L.	Europe	He	H	P	Cu/M	+	1	19
Ageratina adenophora (Spreng.) King & H. Rob.	Mexico	Ch	H	P		+	3	20
Ageratum conyzoides L.	Central and South America	Th	H	A	M	+	9	
Ageratum houstonianum Mill.	Mexico	Th	H	A	M/O	+	33	
Amberboa moschata (L.) DC.	Turkey and Armenia	Ch	H	A/B	O	+	33	21
Ambrosia artemisiifolia L.	North America	Th	H	A		+	33	22
Ambrosia trifida L.	North America	Th	H	A		+	8	
Anthemis arvensis L.	Europe	Th	H	A		+	8	
Anthemis cotula L.	Europe	Th	H	A		+	2	23
Aster subulatus Michx.	North America	Th	H	A	M	+	15	
Bidens alba (L.) DC.	Tropical America	Th	H	A	Cr/M	+	3	
Bidens bipinnata L.	East Asia	Th	H	A	M	+	29	
Bidens frondosa L.	North America	Th	H	A	M	+	8	13
Bidens pilosa L. var. *radiata* Sch. Bip.	North America	Th	H	A	M	+	1	17
Buphthalmum salicifolium L.	Europe	Ch	H	P	O	+	5	
Carthamus tinctorius L.	Central Asia	Th	H	A	Cu/M	+	8	
Centaurea diffusa Lam.	Southeast Europe	Ch	H	B		+	1	
Chromolaena odorata (L.) King & H. Rob.	America	Ch	H	P	M	+	8	8

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Cichorium intybus L.	Northern Europe	Ch	H	P	Cr/M	+	15	
Conyza bonariensis (L.) Cronq.	South America	Ch	H	A/B	M	+	1	24
Conyza canadensis (L.) Cronq.	North America	Th	H	A	Cr/M	+	33	
Conyza sumatrensis (Retz.) Walker	South America	Ch	H	A/B		+	9	
Coreopsis grandiflora Hogg ex Sweet	North America	Ch	H	P	O	+	33	25
Coreopsis lanceolata L.	North America	Ch	H	P	O	+	1	26
Coreopsis tinctoria Nutt.	North America	Ch	H	P	O	+	33	27
Cosmos bipinnata Cav.	Mexico	Ch	H	A/P	O		3	17
Cosmos sulphureus Cav.	Mexico to Brazil	Th	H	A	Cu/O	+	1	2
Crassocephalum crepidioides (Benth.) S. Moore	Tropical Africa	Ch	H	P	M	+	12	
Dahlia pinnata Cav.	Mexico	Cr	H	P	O	+	3	28
Elephantopus scaber L.	Tropical America	He	H	P	M	+	8	13
Erechtites hieracifolia (L.) Raf. ex DC.	Mexico	Ch	H	P			15	
Erechtites valerianaefolia (Wolf) DC.	Brazil	Th	H	A			5	
Erigeron annuus (L.) Pers.	North America	Ch	H	A/B	M	+	13	
Erigeron karvinskianus DC.	Mexico and Panama	Ch	H	P	O	+	3	29
Eupatorium coelestinum L.	America	Ch	H	P		+	33	
Gaillardia aristata Pursh	North America	Cr	H	P	O	+	1	30
Gaillardia pulchella Foug.	North America	Th	H	A	O	+	1	30
Galinsoga parviflora Cav.	Tropical America	Th	H	A		+	5	
Galinsoga quadriradiata Ruiz & Pav.	Tropical America	Th	H	A		+	2	31
Gnaphalium pensylvanicum Willd.	Warm America	Th	H	A		+	9	
Helenium autumnale L.	North America	Ch	H	P	M	+	1	31
Helianthus tuberosus L.	North America	Cr	H	P	M/O	+	1	
Iva xanthifolia Nutt.	North America	Th	H	A		+	33	
Kleinia radicans (L. f.) Haw. ex DC.	South Africa	Ch	H/S	P			1	30
Lactuca sativa L.	Europe	Ch	H	A/B	Cr/M	+	2	
Lagascea mollis Cass.	Cuba	Ch	H	P	O	+	33	8
Mikania cordata (Burm. f.) B. L. Rob.	Central and South America	Ch	H	P	M	+	2	32
Mikania micrantha Kunth	South America	Ch	V	P		+	8	33
Parthenium hysterophorus L.	Tropical America	Th	H	A	Cu/M	+	5	
Polymnia uvedalia L.	America	Ch	H	P	M	+	7	
Praxelis clematidea R. M. King & H. Rob.	South America	Ch	H	P		+	33	

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Pseudelephantopus spicatus (Juss. ex Aubl.) C. F. Baker	Tropical America and Tropical Africa	Ch	H	P		+	16	
Pyrethrum parthenifolium Willd.	Middle Asia	Ch	H	P	O	+	1	
Sanvitalia procumbens Lam.	Mexico	Th	H	A	M/O	+	33	
Saussurea costus (Falc.) Lipsch.	Kashmir	Ch	H	P	M		14	8
Sclerocarpus africanus Jacq.	Africa	Th	H	A		+	1	34
Senecio vulgaris L.	Europe	Ch	H	A/B	M	+	9	24
Solidago canadensis L.	North America	Ch	H	P	O	+	7	
Soliva anthemifolia (Juss.) R. Br. ex Less.	South America	Th	H	A		+	5	4
Sonchus oleraceus L.	Europe and Middle Asia	Ch	H	A/B	M	+	23	
Synedrella nodiflora (L.) Gaertn.	Tropical America	Th	H	A	M	+	14	4
Tagetes erecta L.	Mexico	Th	H	A	Cr/Cu/M/O	+	10	
Tagetes patula L.	Mexico	Th	H	A	M/O	+	33	35
Tithonia diversifolia A. Gray	Mexico	Ph	H	A/P	Cr/O	+	4	36
Tridax procumbens L.	Tropical America	He	H	P	Cr	+	3	36
Zinnia elegans Jacq.	Mexico	Th	H	A	O	+	1	37
Zinnia peruviana (L.) L.	Mexico	Th	H	A	O	+	6	
Balsaminaceae								
Impatiens walleriana Hook. f.	East Africa	Ch	H	P	O	+	7	
Basellaceae								
Anredera cordifolia (Ten.) Steenis	Tropical South America	Ch	V/H	P	M/O	+	5	
Basella alba L.	Tropical Asia	Ch	V	P	M	+	3	
Begoniaceae								
Begonia semperflorens Link & Otto	Brazil	Ch	H	P	M/O	+	20	
Berberidaceae								
Berberis thunbergii DC.	Japan	Ph	S	P	M	+	6	
Bignoniaceae								
Macfadyena unguis-cati (L.) A. H. Gentry	West Indies, Mexico, Brzil and Argentina	Ch	V	P	O	+	2	6
Bixaceae								
Bixa orellana L.	Tropical America	Ph	S/T	P	Cu/M/O	+	2	
Bombacaceae								
Ochroma lagopus Swartz	Tropical America	Ph	T	P	W	+	1	38

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Boraginaceae								
Heliotropium europaeum L.	Europe	Th	H	A	M	+	2	39
Alyssum alyssoides (L.) L.	Europe	Th	H	A		+	1	40
Brassicaceae								
Brassica juncea (L.) Czern.	Europe	Ch	H	A	Cr	+	N/A	41
Brassica nigra (L.) W.D.J. Koch	Europe	Ch	H	A	Cr	+	5	41
Brassica oleracea L. var. *botrytis* L.	Europe	Ch	H	B	Cr	+	1	2
Brassica oleracea L. var. *capitata* L.	Europe	Ch	H	B	Cr	+	3	
Coronopus integrifolius (DC.) Spreng.	Africa	Ch	H	A/P		+	1	
Coronopus didymus (L.) Smith	South America	Ch	H	B/P		+	11	
Diplotaxis muralis (L.) DC.	Europe	He	H	A/B/P	Cr	+	2	33
Isatis tinctoria L.	Europe	Ch	H	B	M	+	16	43
Lepidium campestre (L.) R. Br.	Europe, Asia Minor	Ch	H	A/B	M	+	8	44
Lepidium densiflorum Schrad.	North America	Ch	H	A/B		+	6	
Lepidium virginicum L.	North America	Ch	H	A/B	M	+	23	31
Lobularia maritima (L.) Desv.	Mediterranean	Ch	H	P		+	8	41
Nasturtium officinale R. Br.	Eurasia	Ch	H	P	Cr/M	+	14	45
Raphanus sativus L.	Mediterranean	Ch	H	A/B	Cr	+	N/A	41
Sisymbrium officinale (L.) Scop.	Eurasia	Ch	H	A		+	5	41
Cactaceae								
Epiphyllum oxypetalum (DC.) Haw.	Mexico and Central America	Ph	S	P	O	+	5	
Hylocereus trigonus (Haw.) Saff.	Caribbean	Ch	V	P	O		3	
Hylocereus undatus (Haw.) Britt. & Rose	Mexico, Central and South America	Ph	H/S	P	Cu/O	+	12	
Opuntia cochinellifera (L.) Mill.	Mexico	Ph	S/T	P	Cr/Cu/O		4	46
Opuntia dillenii (Ker. Gawl.) Haw.	Caribbean	Ph	S	P	Cu/M/O	+	4	3
Opuntia ficus-indica (L.) Mill.	Mexico	Ph	S/T	P	Cr/Cu	+	16	
Opuntia monacantha (Willd.) Haw.	South America	Ph	S/T	P	Cr/Cu/M	+	4	47
Pereskia aculeata Mill.	Central and South America, West Indies	Ch	S	P	Cr/Cu	+	4	
Campanulaceae								
Hippobroma longiflora (L.) G. Don	America	Ch	H	P	M	+	5	
Triodanis biflora (Ruiz & Pav.) Greene	Tropical America	Th	H	A		+	8	

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Cannabaceae								
Cannabis sativa L.	Bhutan, Sikkim, India and Middle Asia	Th	H	A	M	+	12	
Capparaceae								
Cleome burmannii Wight & Arn.	India	Th	H	A			33	
Cleome speciosa Raf.	South America	Th	H	A	O	+	2	
Caprifoliaceae								
Lonicera sempervirens L.	North America	Ch	V	P	O	+	4	
Caryophyllaceae								
Arenaria serpyllifolia L.	Europe	Ch	H	A/B	M	+	8	27
Cerastium tomentosum L.	Italy	Ch	H	P	O	+	1	42
Dianthus sylvestris Wulfen	Europe	Ch	H	P	W	+	1	
Saponaria officinalis L.	Europe	Ch	H	P	O	+	33	48
Silene armeria L.	South Europe	Ch	H	A/B	O	+	14	
Silene pratensis (Raf.) Gren. & Godr.	Europe, Siberia and Middle Asia	Ch	H	A/B		+	6	
Vaccaria segetalis (Neck.) Garcke	Europe	Ch	H	A/B	M	+	28	49
Casuarinaceae								
Casuarina equisetifolia L.	Australia and Pacific islands	Ph	T	P	Cr/Cu/M/W	+	5	28
Chenopodiaceae								
Atriplex hortensis L.	Europe and Southwest Asia	Th	H	A	Cr	+	23	
Chenopodium ambrosioides L.	Mexico	Ch	H	A/P	M	+	10	
Convolvulaceae								
Calonyction muricatum (L.) G. Don	Tropical America and Netherlands	Th	V	A	M/O	+	33	
Ipomoea alba L.	Tropical America	Ch	V	A/P	O	+	33	
Ipomoea cairica (L.) Sweet	Tropical Asia and Africa	Ch	V	P	M/O	+	4	
Ipomoea indica (Burm. f.) Merr.	South America	Ch	V	A/P	O	+	3	
Ipomoea triloba L.	Tropical America	Th	V	A	Cu/O	+	3	13
Jacquemontia tamnifolia (L.) Griseb.	Tropical America	Th	V	A		+	1	32
Ipomoea indica (Burm. f.) Merr	South America	Th	V	A	o	+	4	50
Ipomoea nil (L.) Roth	Tropical America	Th	V	A	M/O	+	4	51
Ipomoea purpurea (L.) Roth	Tropical America	Th	V	A	O	+	33	
Quamoclit pennata (Desr.) Bojer	Tropical America	Th	V	A	O		1	

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Crassulaceae								
Aeonium spathulatum (Hornem.) Praeg.	Canary Islands	Ch	S	P	O		6	
Bryophyllum pinnatum (Lam.) Oken	Africa and Madagascar	Ch	H	P	M/O	+	5	
Cucurbitaceae								
Sechium edule (Jacq.) Swartz	South America	Ch	V	P	Cr	+	7	2
Dioscoreaceae								
Dioscorea arachidna Prain & Burkill	India	Cr	V	P			3	
Equisetaceae								
Equisetum variegatum Schleich. ex F. Weber & D. Mohr ssp. *alaskanum* (A.A. Eaton) Hultén	North America	Ch	H	P		+	7	
Euphorbia neriifolia L.	India	Ph	S/T	P	O	+	6	
Euphorbiaceae								
Chamaesyce prostrata (Aiton) Small	Tropical and Subtropical America	Th	H	A	O	+	7	52
Codiaeum variegatum (L.) A Juss.	Indonesia, Malaysia and Oceania	Ph	S/T	P	M/O	+	2	2
Euphorbia peplus L.	Mediterranean	Th	H	A			5	
Euphorbia helioscopia L.	Europe	Ch	H	A/B	Cu/M	+	26	
Euphorbia heterophylla L.	Mexico	Th	H	A		+	16	24
Euphorbia hirta L.	Central America	Th	H	A	M	+	10	53
Euphorbia lathyris L.	Europe	Th	H	A	Cu/M	+	24	
Euphorbia milii Des Moul.	Madagascar	Ch	S/L	P	M/O	+	27	18
Euphorbia tirucalli L.	Angola	Ph	S/T	P	O	+	12	35
Jatropha curcas L.	Tropical America	Ph	S/T	P	Cu	+	6	
Jatropha gossypiifolia L.	Tropical America	Ph	S	P	M	+	2	
Manihot esculenta Crantz	Brazil	Ph	S	A/P	Cu	+	12	
Phyllanthus amarus Schumach. & Thonn.	America	Ch	H	A/B	M	+	33	
Phyllanthus niruri L.	Tropical America	Th	H	A	M	+	33	42
Ricinus communis L.	Northeast Africa	Th	H/S/T	A	Cr/Cu/M/O/W	+	33	34
Fabaceae								
Acacia catechu (L. f.) Willd.	India, Myanmar, Thailand and Africa	Ph	S/T	P	M	+	6	
Acacia dealbata Link	Australia	Ph	T	P	Cu	+	13	
Acacia farnesiana (L.) Willd.	Tropical America	Ph	S/T	P	Cu/O/W	+	5	2
Amorpha fruticosa L.	North America	Ph	S	P	Cu/M	+	17	

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Arachis hypogaea L.	Brazil	Th	H	A	Cr/Cu/M	+	6	
Caesalpinia pulcherrima (L.) Sw.	West Indies and Tropical America	Ph	S/T	P	M/O	+	3	54
Cassia floribunda Cav.	Tropical America	Ph	S	P	O	+	4	54
Cassia mimosoides L.	Tropical America	Ch	H	A/P	Cr/Cu/M	+	5	
Cassia siamea (Lam.) Irwin & Barneby	India, Sri Lanka and Malaysia.	Ph	T	P	O/W	+	1	55
Centrosema pubescens Benth.	South America	Ch	V	P	Cu	+	2	24
Clitoria ternatea L.	India	Ch	V/H	P	M/O	+	5	
Crotalaria incana L.	Tropical America	Ch	S	P		+	6	
Crotalaria juncea L.	India	Th	H	A	Cr/Cu/M	+	7	
Crotalaria lanceolata E. Mey.	Africa	Ch	H/S	P		+	2	
Crotalaria micans Link	America	Ch	H/S	P	M	+	4	
Crotalaria ochroleuca G. Don	Africa	Ch	H/S	P		+	3	
Crotalaria pallida Aiton	Southern Africa	Ch	S	P	Cu/M	+	8	
Crotalaria trichotoma Bojer	Africa	Ch	H/S	P	M/O	+	7	
Desmanthus virgatus (L.) Willd.	Tropical America	Ch	S	P	Cr	+	1	2
Desmodium scorpiurus (Sw.) Desv.	South America	Ch	H	P		+	1	
Desmodium tortuosum (Sw.) DC.	South America and West Indies	Ch	H	A/P		+	2	
Indigofera suffruticosa Mill.	Tropical America	Ph	S	P	Cu	+	8	
Leucaena leucocephala (Lam.) de Wit	Tropical America	Ph	S/T	P		+	5	
Macrotyloma uniflorum (Lam.) Verdc.	India	Ch	V/H	A/P	Cr/Cu	+	1	4
Medicago lupulina L.	Europe	Th	H	A	Cr	+	33	8
Medicago polymorpha L.	Europe	Th	H	A	Cr	+	18	28
Medicago sativa L.	Europe and West Asia	Ch	H	P	Cr/M	+	33	
Melilotus albus Medik.	Europe	Ch	H	A/B	Cr/Cu	+	33	56
Melilotus indica (L.) All.	India	Th	H	A	Cr/Cu	+	13	
Melilotus indicus (L.) All.	Europe	Ch	H	B	M	+	1	8
Melilotus officinalis (L.) Lam.	Europe	Ch	H	A/B	Cu/M	+	25	6
Mimosa bimucronata (DC.) Kuntze	South America	Ph	S/T	P		+	3	2
Mimosa diplotricha C. Wright	Brazil	Ph	H/S	P	Cr/Cu	+	5	
Mimosa pigra L.	Tropical South America	Ph	S	P	O	+	1	2
Mimosa pudica L.	Tropical America	Ch	H/S	P	M/O	+	6	
Neptunia plena (L.) Benth.	America	Ch	H	P	O	+	1	
Pithecellobium dulce (Roxb.) Benth.	Mexico	Ph	T	P	Cr/Cu	+	2	24

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Senna alata (L.) Roxb.	Tropical America	Ch	S	P	O	+	3	
Senna hirsuta (L.) H. S. Irwin & Barneby	Tropical America	Ch	H/S	P	M	+	4	
Senna occidentalis (L.) Link	South America	Ph	H	P	M	+	10	
Senna sophera (L.) Roxb.	Tropical Asia	Ph	S	P	Cr/M	+	12	
Senna tora (L.) Roxb.	Tropical Asia and America	Th	H	A	Cr/M	+	16	
Sesbania cannabina (Retz.) Pers.	India, Java, Malaysia, Philippines and Tropical Eastern Hemisphere	Th	H	A	Cr/Cu	+	8	
Sesbania grandifloua (L.) Pers.	West Indies and Southeast America	Ph	S/T	P	Cr/Cu/M	+	3	24
Tamarindus indica L.	Tropical Africa	Ph	T	P	Cr/Cu/M/O	+	5	
Tephrosia candida (Roxb.) DC.	East India and Malaysia	Ph	H/S	P	Cu	+	5	
Tephrosia noctiflora Bojer ex Baker	Africa and India	Ph	H/S	A/P		+	2	
Tephrosia vogelii Hook. f.	Tropical Africa	Ch	H/S	P	Cu	+	1	
Trifolium fragiferum L.	Europe and Middle Asia	Ch	H	P	Cr	+	1	
Trifolium hybridum L.	Europe	Ch	H	P	Cr	+	3	
Trifolium pratense L.	Europe	Ch	H	P	Cr/M	+	33	
Trifolium repens L.	Europe and North Africa	Ch	H	P	Cr/Cu/M	+	33	
Trigonella foenum-graecum L.	Eurasia	Th	H	A	Cr/Cu/M	+	10	
Ulex europaeus L.	Europe	Ch	S	P	Cr/O	+	1	
Vicia hirsuta (L.) S. F. Gray	North Hemisphere	Th	V	A	Cr/Cu/M	+	18	8
Vicia sativa L.	South Europe and West Asia	Ch	H	A/B	Cr/Cu	+	33	
Vicia sativa L. ssp. *nigra* (L.) Ehrh.	Europe	Th	H	A	Cr/Cu/M	+	?	8
Vicia tetrasperma (L.) Schreb.	Europe	Ch	H	A/P	Cr/M	+	18	8
Vicia villosa Roth	Europe, Middle Asia and Iran	Th	H	A	Cr/Cu/M	+	22	
Vigna umbellata (Thunb.) Ohwi & H. Ohashi	Subtropical Asia	Th	V	A	M	+	7	
Geraniaceae								
Erodium cicutarium (L.) L'Hér.	Europe and Africa	Ch	H	A/B	M	+	16	8
Geranium carolinianum L.	North America	Ch	H	P	M	+	17	
Juglandaceae								
Juglans regia L.	Eastern Europe	Ph	T	P	Cr/Cu/M	+	28	57
Lamiaceae								
Hyptis brevipes Poit.	Mexico	Th	H	A		+	2	
Hyptis rhomboidea Mart. & Gal.	Tropical America	Ch	H	P		+	3	
Hyptis rhomboides Mart & Gal.	Madagascar	Ch	H	P		+	?	8

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Hyptis suaveolens (L.) Poit.	Tropical America	Th	H	A	M	+	4	
Mentha spicata L.	South Europe, Canary Islands	Ch	H	P	Cu/M	+	9	
Ocimum basilicum L.	Tropical Asia	Th	H	A	Cr/Cu/M	+	12	
Salvia coccinea P.J. Buchoz ex Etlinger	America	Ch	H	A/B/P	M/O	+	9	
Linaceae								
Linum usitatissimum L.	Europe	Th	H	A	Cu/M	+	?	
Lobeliaceae								
Hippobroma longiflora (L.) G. Don	Tropical America	Ch	H	P		+	6	15
Lythraceae								
Cuphea carthagenensis (Jacq.) J. F. Macbr.	Tropical America	Th	H	A	Cr/Cu/M/O	+	1	24
Malvaceae								
Abelmoschus moschatus (L.) Medik.	Indies, Malaysia to the Pacific islands	Ch	H	A/P	Cr/Cu/M/O	+	15	12
Gossypium barbadense L. var. *acuminatum* (Roxb. ex G. Don) Triana & Planch.	South America and West Indies	Ch	H/S	P	Cu	+	1	47
Herissantia crispa (L.) Brizicky	Tropical America	Ch	H	P		+	2	
Hibiscus trionum L.	Middle Africa	Th	H	A	M	+	33	
Malvastrum americanum (L.) Torr.	America	Ch	H/S	P		+	2	
Malvastrum coromandelianum (L.) Garcke	America	Ch	S	P	M	+	6	
Martyniaceae								
Martynia annua L.	Mexico and Central America	Ch	H	A/P		+	1	
Moringaceae								
Moringa oleifera Lam.	India	Ph	T	P	Cr/Cu/O	+	2	
Myrtaceae								
Psidium guajava L.	South America	Ph	T	P	Cr/M	+	8	
Syzygium jambos (L.) Alston	Southeast Asia	Ph	T	P	Cr	+	7	58
Nyctaginaceae								
Bougainvillea glabra Choisy	Brazil	Ch	S/L	P	M/O	+	2	24
Mirabilis jalapa L.	Tropical America	Th	H	A	M/O	+	6	
Oleaceae								
Ligustrum obtusifolium Siebold & Zucc. ssp. *microphyllum* (Nakai) P. S. Green	Japan and Korea	Ph	S	P	O	+	2	

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Jasminum sambac (L.) Aiton	India	Ch	S/L	P	Cu/M/O	+	8	42
Onagraceae								
Clarkia pulchella Pursh	North America	Th	H	A	O	+	1	
Gaura biennis L.	North America	Ch	H	A/B		+	1	
Gaura lindheimeri Engelm. & A. Gray	North America	Ch	H	P		+	6	
Gaura parviflora Douglas ex Lehm.	North America	Ch	H	A/B		+	7	
Oenothera biennis L.	North America	Ch	H	B	M	+	19	
Oenothera drummondii Hook.	East North America	Ch	H	A/B/P	O	+	2	
Oenothera glazioviana Micheli	Europe	Ch	H	B/P	O	+	19	
Oenothera oakesiana (A. Gray) J. W. Robbins ex S. Watson & J. M. Coult.	North America	Ch	H	B		+	1	
Oenothera odorata Jacq.	South America	Ch	H	A/B		+	33	
Oenothera parviflora L.	North America	Ch	H	B		+	1	
Oenothera rosea L'Her. ex Aiton	Tropical America	Ch	H	P	Cu/M	+	5	
Oenothera tetraptera Cav.	Mexico and Central America	Ch	H	A/P	Cu	+	2	
Oenothera villosa Thunb.	North America	Ch	H	B	Cr/M	+	4	
Oenothera laciniata Hill	North America	Ch	H	A/P	O	+	1	63
Oxalidaceae								
Oxalis corymbosa DC.	Tropical South America	Ch	H	P	M/O	+	33	
Oxalis pes-caprae L.	South Africa	Ch	H	P	O	+	1	59
Papaveraceae								
Argemone mexicana L.	West Indies	Th	H	A	M	+	7	
Eschscholtzia californica Cham.	California	Ch	H/S	A/P	O		2	31
Passifloraceae								
Passiflora coerulea L.	Brazil	Ch	V	P	M/O	+	7	
Passiflora edulis Sims	Brazil and Netherlands Antilles	Ch	V	P	Cr/Cu/M	+	3	
Passiflora foetida L.	West Indies, South America and Netherlands Antilles	Ch	V	P	Cr/M	+	5	60
Passiflora gracilis Jacq. ex Link	South America	Th	V	A		+	1	
Phytolaccaceae								
Phytolacca americana L.	North America	Ch	H	P	M	+	12	
Rivina humilis L.	Tropical America	Ch	S	P	O	+	3	

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Piperaceae								
Peperomia pellucida (L.) Kunth	Tropical America	Th	H	A		+	10	9
Plantaginaceae								
Plantago arenaria Waldst. & Kit.	Europe, North Africa and West Asia	He	H	A/B		+	8	
Plantago aristata Michx.	North America	He	H	A/B		+	2	
Plantago lanceolata L.	Britain	He	H	P	M	+	4	8
Plantago virginica L.	North America	He	H	A/B		+	6	
Polygalaceae								
Polygala paniculata L.	Brazil and Mexico	Ch	H/S	A/P		+	1	12
Polygonum aviculare L.	Europe and North Asia	Th	H	A	Cr/M	+	33	8
Rumex acetosella L.	Eurasia	Ch	H	P		+	12	8
Rumex crispus L.	Eurasia	Ch	H	P		+	20	8
Portulacaceae								
Portulaca pilosa L. ssp. *grandiflora* (Hook.) R. Geesink	Tropical America	Ch	H	A/P	M	+	5	12
Talinum paniculatum (Jacq.) Gaertn.	Tropical America	Cr	H	A/P	M	+	33	
Punicaceae								
Punica granatum L.	Balkan Peninsula and Iran	Ph	S/T	P	Cr/M	+	10	
Ranunculaceae								
Ranunculus arvensis L.	West Asia and Europe	Th	H	A	M	+	1	
Resedaceae								
Reseda lutea L.	Southwest Asia and Mediterranean	Ch	H	A/P		+	1	
Rubiaceae								
Carapichea ipecacuanha (Brot.) L. Andersson	Southern America	Ch	H	P	M		1	61
Cinchona calisaya Wedd.	Bolivia and Peru	Ph	T	P	Cr/M		1	61
Cinchona ledgeriana (Howard) Moens ex Trim.	Bolivia and Peru	Ph	T	P	M		1	61
Cinchona officinalis L.	South America	Ph	S/T	P	M	+	1	61
Cinchona succirubra Pav. ex Klotzsch	Ecuador and Peru	Ph	T	P	M	+	1	61
Morinda lucida Benth.	East Africa	Ph	S/T	P	Cu/M		1	61
Mussaenda erythrophylla Schumach. & Thonn.	Tropical West Africa	Ph	S	P	O		1	61
Richardia scabra L.	Tropical America	Th	H	A		+	6	
Rutaceae								
Citrus aurantifolia (Christm.) Swingle	India and Myanmar	Ph	T	P	Cr	+	1	12

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Sapindaceae								
Cardiospermum halicacabum L.	Tropical America, India, and Africa	Ch	H	P	M	+	19	60
Scrophulariaceae								
Digitalis purpurea L.	Europe	Ch	H	A/P	M	+	5	62
Scoparia dulcis L.	Tropical America	Ch	H	P	M	+	6	
Torenia fournieri Linden ex Fourn.	Vietnam	Th	H	A		+	5	
Veronica anagallis-aquatica L.	Europe	Ch	H	A/P	M	+	18	62
Veronica arvensis L.	South Europe and Southwest Asia	Th	H	A	M	+	8	
Veronica peregrina L.	North America	Th	H	A	M	+	19	8
Veronica persica Poir.	West Asia and Europe	Ch	H	A/B		+	12	
Solanaceae								
Brugmansia ×*candida* Pers.	South America	Ph	T	P		+	1	47
Capsicum annuum L.	Mexico and South America	Ch	S/H	A/P	Cr/M	+	33	42
Datura stramonium L.	Mexico and South America	Ph	S/H	P	Cu/O	+	33	63
Datura inoxia Mill.	America	Ch	H	P	O	+	6	63
Datura metel L.	America	Th	H/S	A	M	+	6	28
Hyoscyamus niger L.	Britain	Ch	H	B	Cu/M	+	15	40
Lycopersicon esculeutum Mill.	Tropical America	Ch	H	A/P	Cr		2	42
Nicandra physaloides (L.) Gaertn.	Peru	Th	H	A	Cr/M	+	33	
Petunia ×*hybrida* Vilm.	South America	Th	H	A	O	+	1	47
Physalis angulata L.	South America	Th	H	A	M	+	11	8
Physalis peruviana L.	South America	Ch	H	P	Cr/M	+	5	
Physalis pubescens L.	America	Th	H	A		+	15	
Solanum chrysotrichum Schltdl.	Central and South America	Ch	S	P	Cr	+	1	64
Solanum pseudocapsicum L.	South America	Ch	S	P	M/O	+	8	28
Solanum pseudocapsicum L. var. *diflorum* (Vell.) Bitter	Brazil	Ch	S	P	O	+	33	
Solanum sisymbriifolium Lam.	South America	Th	H	A	Cr/M	+	1	
Tamaricaceae								
Myricaria squamosa Desv.	India, Pakistan and Afghanistan	Ch	S	P	M		5	
Theaceae								
Schima crenata Korth.	Indochina Peninsula, Malaysia and Indonesia	Ph	T	P			1	

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Tiliaceae								
Corchorus capsularis L.	Tropical Asia	Th	S	A	Cu	+	14	
Corchorus olitorius L.	India	Th	H	A	Cu	+	11	39
Tropaeolaceae								
Tropaeolum majus L.	Peru and Brazil	Th	H	A	O	+	3	
Ulmaceae								
Ulmus laevis Pall.	Europe	Ph	T	P	O	+	1	65
Urticaceae								
Pilea microphylla (L.) Liebm.	South America	Th	H	A	M	+	6	
Verbenaceae								
Duranta repens L.	Tropical America	Ph	S	P	M	+	5	
Lantana camara L.	Tropical America	Ch	S/L	P	M/O	+	7	
Phyla nodiflora (L.) Greene	California	Ch	H	P	M	+	11	60
Stachytarpheta jamaicensis (L.) Vahl	Central and South America	Ch	H/S	P	M/O	+	6	
Tectona grandis L. f.	India, Myanmar, Malaysia and Indonesia	Ph	T	P	M/W	+	4	2
Monocotyledons								
Agavaceae								
Agave americana L.	Tropical America and Mexico	He	H	P	Cr/Cu/O	+	14	
Agave americana L. var. *variegata* Hort.	Tropical America	He	H	P	Cr/O	+	2	3
Agave rigida Mill.	America	He	H	P	Cu		14	58
Agave sisalana Perrine	Tropical America	He	H	P	Cu/O	+	1	23
Amaryllidaceae								
Hippeastrum rutilum (Ker Gawl.) Herb.	Peru, Brasil	He	H	P	O		1	66
Narcissus tazetta L. var. *chinensis* Roem.	Middle Europe, Mediterranean and West Asia	He	H	P	M/O	+	4	67
Nothoscordum gracile (Aiton) Stearn	Temperate South America	He	H	P	O	+	1	55
Zephyranthes grandiflora Lindl.	Mexico and Central America	He	H	P	M	+	3	55
Araceae								
Caladium bicolor (Aiton) Vent.	South America	Cr	H	P	O	+	1	
Dieffenbachia picta (Lodd.) Schott	South America	Cr	H	P	O	+	4	
Elaeis guineensis Jacq.	Tropical Africa	Ph	T	P	Cu/M	+	19	18
Commelinaceae								
Zebrina pendula Schnizl.	Mexico	Ch	H	P	M/O	+	1	68

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Cyperaceae								
Cyperus alternifolius L. ssp. *flabelliformis* (Rottb.) Kükenth.	Madagascar	He	H	P	O	+	2	2
Eleocharis valleculosa Ohwi f. *setosa* (Ohwi) Kitag.	Korea and Japan	He	H	P	O	+	33	38
Iridaceae								
Eleutherine plicata Herb.	West Indies	He	H	P	M		3	
Gladiolus ×gandavensis Van Houtte	Mediterranean, Asia Minor, Africa	Cr	H	P	M/O	+	2	
Sisyrinchium rosulatum E.P. Bicknell	North America	Cr	H	A	O	+	14	69
Liliaceae								
Aloe vera (L.) Burm. f. var. *chinensis* (Haw.) Berg.	South Africa, Madagascar, Arab, South Asia and India	He	H	P	Cr/M/O	+	1	
Limnocharitaceae								
Limnocharis flava (L.) Buch.	Tropical America	He	H	P	O	+	3	2
Musaceae								
Musa basjoo Sieb. & Zucc.	Ryukyu Islands	Ch	H	P	Cu/M	+	1	23
Poaceae								
Agrostis canina L. var. *formosana* Hack.	Temperate Asia and Europe	Ch	H	P	O	+	6	
Avena fatua L.	Europe	Th	H	A	Cr/M	+	20	8
Axonopus compressus (Sw.) P. Beauv.	Tropical America	Ch	H	P	Cr/O	+	6	
Bambusa multiplex (Lour.) Raeusch. ex Schult. & Schult. f.	Vietnam	Ch	H	P	O	+	14	
Brachiaria mutica (Forsk.) Stapf	Tropical Africa	Ch	H	P	Cr/O	+	2	8
Briza minor L.	Europe	Th	H	A	O	+	1	
Bromus catharticus Vahl	South America	Ch	H	A/P	Cr	+	1	70
Cenchrus echinatus L.	Tropical America	Th	H	A	Cr	+	1	71
Chloris virgata Sw.	North America	Th	H	Ann	Cr	+	20	
Coix lacryma-jobi L.	Tropical Asia	Th	H	A	Cr/M	+	33	72
Cynosurus cristatus L.	Mediterranean	Ch	H	P	Cr/O	+	1	
Dactylis glomerata L.	Europe	Ch	H	P	Cr/O	+	12	72
Dichanthelium acuminatum (Sw.) Gould & C. A. Clark	North America	Ch	H	P		+	1	
Digitaria sanguinalis (L.) Scop.	Europe	Th	H	A	Cr	+	12	8
Eleusine coracana (Linn.) Gaertn.	Tropical Africa	Th	H	A	Cr/Cu	+	14	71
Festuca arundinacea Schreb.	Europe, Central and North Asia	Ch	H	P	Cr/O	+	1	8
Lolium multiflorum Lam.	South Europe, North Africa and Southwest Asia	Ch	H	A/B/P	Cr/O	+	3	67

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Lolium perenne L.	Europe	Ch	H	P	Cr/O	+	19	67
Lolium temulentum L.	Europe	Th	H	A	M	+	13	67
Melinis repens (Willd.) Zizka	South Africa	Ch	H	P	O	+	1	
Panicum maximum Jacq.	Tropical Africa	Ch	H	P	Cr	+	2	
Paspalidium flavidum (Retz.) A. Camus	Tropical Asia	Ch	H	P	Cr	+	4	8
Paspalum conjugatum Bergius	Latin America	Ch	H	P	Cr/O	+	6	8
Paspalum dilatatum Poir.	South America	Ch	H	P	Cr	+	8	
Paspalum notatum Flugge	Tropical and subtropical America	Ch	H	P	Cr/O	+	1	71
Pennisetum polystachion (L.) Schult.	Tropical Africa	Ch	H	P	Cr	+	2	
Pennisetum purpureum Schumach.	Tropical Africa	Ch	H	P	Cr/O	+	1	71
Phalaris arundinacea L.	North Hemisphere	Ch	H	P	Cr/O	+	19	8
Phalaris canariensis L.	Madagascar and North Africa	Ch	H	P	Cr	+	33	2
Phalaris minor Retz.	Mediterranean	Th	H	A	Cr	+	1	71
Phalaris paradoxa L.	Mediterranean and Southwest Asia	Th	H	A		+	1	71
Phleum pratense L.	Temperate Eurasia	Ch	H	P	Cr/O	+	8	72
Pleioblastus gramineus (Bean) Nakai	Japan	Ch	H	P	Cu/O	+	5	
Rhynchelytrum repens (Willd.) Hubb.	Tropical South Africa	Ch	H	P	O	+	1	
Setaria geniculata (Lam.) P. Beauv.	Tropical America	Ch	H	P	Cr	+	9	73
Setaria glauca (L.) P. Beauv.	Eurasia	Ch	H	A/P	Cr/O	+	33	8
Setaria pallidifusca (Schumach.) Stapf & Hubb.	Africa and Tropical Eurasia	Ch	H	P		+	19	73
Setaria palmifolia (Koenig) Stapf	Africa	Ch	H	P	Cr/O	+	19	
Setaria viridis (L.) P. Beauv.	Temperate Eurasia	Th	H	A	Cr/M	+	33	38
Sorghum halepense (L.) Pers.	Mediterranean	Ch	H	P	Cr/Cu	+	6	71
Sorghum sudanense (Piper) Stapf	Africa	Th	H	A	Cr	+	13	38
Spartina alterniflora Loisel.	North America	Th	H	P		+	7	74
Spartina anglica C. E. Hubbard	Europe	Th	H	P		+	2	74
Sporobolus pulvinatus Swallen	North America	Th	H	A	Cr		1	38
Pontederiaceae								
Eichhornia crassipes (Mart.) Solms	Brazil	He	H	P	Cr/Cu	+	33	

Table 4 continued

Species	Origin	RS	LF	HA	U	W	Prov.	RE
Xyridaceae								
Xyris capensis Thunb. var. *schoenoides* (Mart.) Nilsson	Tropical Africa	He	H	P	M		6	23

LF: life form. H: herb; L: liana; V: vine; S: shrub; T: tree

HA: habit. A: annual; B: biennial; P: perennial; A/B: annual or biennial; A/P: annual or perennial; B/P: biennial or perennial; A/B/P: annual or biennial or perennial

RS: Raunkiaer system. Ch: chamaephyte; Cr: cryptophyte; H: hemicryptophyte; Ph: phanerophyte; Th: therophyte

U: usage. Cr: Crop; Cu: cultivation; O: ornamental; M: medicinal; Ti: timbering

W: species listed in Global Compendium of Weeds (Randall, 2002)

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