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Testing the roles of species native origin and family membership in intentional plant introductions using nursery data across the state of Kentucky

Courtney Harris, Hao Jiang, Dongjiao Liu, Zachary Brian, and Kate He[1,2]

Department of Biological Sciences, Murray State University, Murray, Kentucky 42071

HARRIS, C., H. JIANG, D. LIU, Z. BRIAN, AND K. HE (Department of Biological Sciences, Murray State University, Murray, Kentucky 42071). Testing the roles of species native origin and family membership in intentional plant introductions using nursery data across the state of Kentucky. J. Torrey Bot. Soc. 136: 122–127. 2009.—Biological invasions frequently bring about negative impacts on natural ecosystems, including changing their structure and function and causing loss of biodiversity. A large percentage of invasive species are introduced intentionally as horticulture plants by the green industry. Repeated introductions of non-native plant species have accelerated the invasion processes considerably despite the fact that only a small percentage of intentional introductions actually become invasive. Currently, there is a lack of specific information on non-native and invasive plants in the state of Kentucky, especially concerning species origin, taxonomic affinity, and the pathway of species introduction. This study is designed to gather information about plant species found in nurseries across the state of Kentucky to test the hypothesis that species belonging to certain families and coming from particular geographical regions may have a higher possibility to be introduced into new locations as horticulture plants. By identifying and recording 462 species in 101 families and 258 genera from twenty-two nurseries statewide, we discovered that the possibility for a species to be introduced as horticulture plant significantly relates to its native origin and family membership; non-native plant species, especially those with eastern Asian origins, are carried most by nurseries in general. Our results suggest that native origin and family membership of plant species could be used as an effective indicator in identifying the pool of potentially invasive species in the future. Our findings confirm that nurseries have been a major pathway of non-native plants introductions. Most importantly, our study points out the critical needs for having informed and educated personnel in the green industry, so that invasive exotic species will not be introduced in the first place.

Key words: family membership, intentional plant introduction, invasive species, Kentucky, nursery plants, species native origin.

Exotic plant species are also called alien plants, non-indigenous plants, non-native plants, and introduced plants in the literature. Pyšek et al. (2004) defines exotic plants as species in a given area whose presence there, is due to intentional or unintentional human involvement. Some of the non-native species are capable of independent growth and sustain self-replacing populations for at least ten years without direct human intervention. This group of non-native species is categorized as naturalized plants. Among the naturalized plant species, about 10% or less could become invasive in the introduced habitats (Williamson 1996). Here 'invasive' means that plants produce reproductive offspring, often in very large numbers, and thus have the potential to spread over a large area and cause harm to natural ecosystems (Pyšek et al. 2004).

The impact of invasive plants has been observed in major natural ecosystems (Baskin 2002). Typically, plant invasion can change the niches of native species in the communities, alter the structure and function of ecosystems, and disrupt the evolutionary processes (D'Antonio and Vitousek 1992, Mack et al. 2000, Levine et al. 2003). A large percentage of invasive species are introduced intentionally to new ranges as horticulture plants by the green industry (Reichard and White 2001, Mack and Emeberg 2002). Anthropogenic dispersal continuously moves species from continent to continent at an alarming rate. More than 5,000 introduced species have escaped cultivation and become naturalized to natural habitats in the United States (Morse et al. 1995). Among the naturalized species, a small percentage has the potential to become invasive as suggested by Williamson (1996). In the

[1] Author for correspondence. E-mail: kate.he@murraystate.edu

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San Francisco Bay alone, an average of one new invasive plant species has been established every fourteen weeks between 1961 and 1995 (Cohen and Carlton 1998). Repeated introductions of non-native plant species can cause increases in propagule pressure which will accelerate invasions considerably (Lockwood 2005). The economic impact of introduced plant species in the United States is estimated to be at least 34 billion dollars per year (Pimentel et al. 2005).

In the state of Kentucky, plant invasion has become a critical issue for conservation management and ecosystem protection. Currently, nearly 25% vascular plants in the Kentucky flora are introduced (Jones 2005). Over ninety plant species have been declared invasive by the Kentucky Exotic Pest Plant Council (KY-EPPC 2000). However, there is still a lack of specific information concerning native origin, taxonomic affinity, growth form, and the pathway of species introduction. This project is designed to gather information about plant species found in nurseries across the state of Kentucky to achieve the following goals: 1) identify native origin, family membership, and growth form of each species found in the nurseries, and 2) examine the roles of native origin and family membership in relation to species introduction and invasion, i.e., if a species' native origin and family membership relate to its fate of being intentionally introduced to new locations as horticulture plant. We hypothesized that species belonging to certain families and coming from particular geographical regions may have a higher possibility to be introduced. Furthermore, repeated introductions of these plants carry high risks of becoming naturalized and invasive if escaped from cultivation.

We decided to choose nurseries as our main sources of data because it has been well recognized that a substantial amount of plant species, especially woody plants, have been intentionally introduced to new locations through nurseries and botanical gardens (Reichard and Hamilton 1997, Ewel et al. 1999, Reichard and White 2001, Li et al. 2004, Dehnen-Schmutz et al. 2007). In the northeastern United States, 60% of more than 600 naturalized plant taxa were introduced deliberately (Fernald 1950). On a global scale, the majority of alien floras of many areas originate from horticultural introductions (Mack and Erneberg 2002, Pyšek et al. 2002). For example, about 46% of the noxious weeds in Australia were introduced for ornamental or other purposes (Panetta 1993). Moreover, plant information collected at nurseries allows us to examine the role of the green industry in introducing potentially invasive species into nature communities and ecosystems.

Materials and Methods. We collected plant data from the twenty-two sampled nurseries from across the state of Kentucky (Fig. 1). These twenty-two nurseries, including wholesale and retail nurseries and garden centers, were randomly selected based on their zip codes. The size of these nurseries varied from small family-run nurseries to big chain-store nurseries such as Lowe's and The Home Depot. Native plant nurseries were not included in our study at this time. We visited four nurseries located in western Kentucky to collect species information directly. For the rest of the eighteen nurseries, we were able to obtain nursery catalogs as our initial data sources after contacting these nurseries through phone calls and e-mails. Most nurseries mailed their catalogs to us within a month.

Each plant species found in the nurseries or in the catalogs was recorded and identified to species level. Species synonyms were checked using several web-based plant databases including the USDA PLANTS Database (http://plants.usda.gov), Missouri Botanical Garden Plant Finder Database (http://www.mobot.org/GARDENINGHELP/PLANTFINDER/Search.asp), and the Global Compendium of Weeds (http://www.hear.org/gcw).

Family membership of each species was identified using the scheme of Judd et al. (2002) plant classification system. Species native origin, growth form, and life span of each plant were examined and identified. In addition, total numbers of plants per family were counted and recorded. The naturalization status of each species was confirmed using the USDA plant database and Jone's (2005) classification scheme. Species labeled as invasives in our study were based on two selecting criteria: 1) listing of the species by the KY-EPPC, and 2) meeting the criteria for the definition of invasives as described in Pyšek et al. (2004).

Species native origins were identified according to seven main geographical areas which included Asia, Europe, Africa, Eurasia, North America (native), South America, and

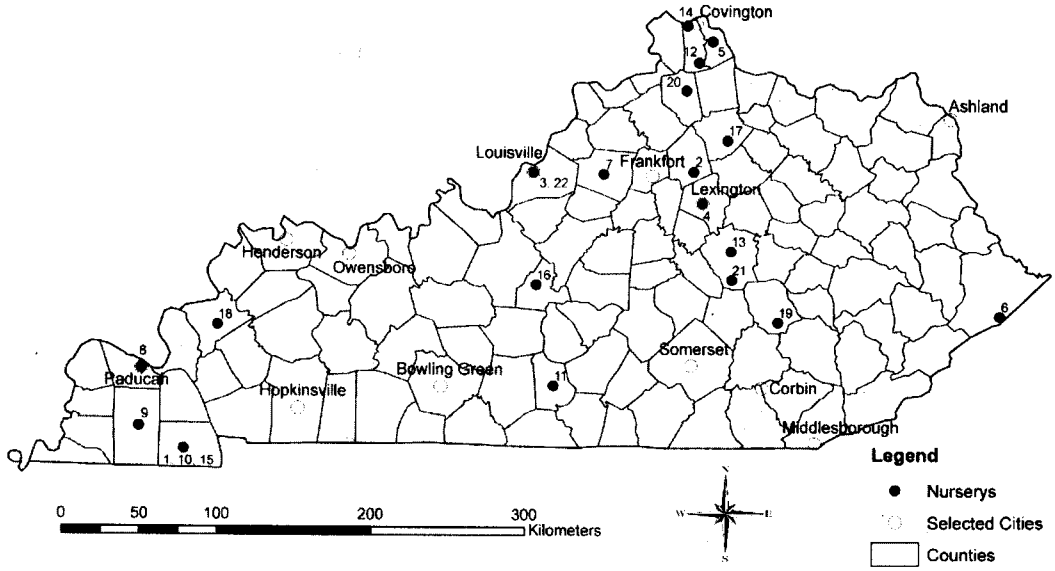

FIG. 1. Distribution map of the twenty-two nurseries across the state of Kentucky. Solid black dots indicate locations of sampled nurseries.

Pacific. Two additional categories were included in this study: multiple origins (species originate from more than two continents) and hybrid (purposely cultivated species for desired traits).

SYSTAT 12.0 (SYSTAT Software, Inc.) was used to perform contingency table analysis to determine if the hypothesis (species belonging to certain families and coming from particular geographical regions may have a higher possibility to be introduced) was supported or not.

Results. There were a total of 462 species in 101 families and 258 genera from the twenty-two sampled nurseries from across the state of Kentucky. The number of native species was much lower than the number of exotic species. There were 149 (30%) native plants while there were 313 (70%) exotic species. Naturalized and invasive plants accounted for 9% and 4.5% of the total exotic species respectively. Data of species growth form and life span showed that most nursery species were woody plants (62%), including 125 shrubs, 155 trees, and 12 vines with multi-year life cycles. Only about 20 (4%) species were annuals. There were 167 herbaceous plants which accounted for about 36% of all species sampled.

The results of contingency table analyses showed that the possibility for a species to be introduced as horticulture plant is significantly related to its native origin and family membership ($P < 0.0001$, Pearson Chi-square test). Among exotic species, about 30% came from eastern Asia and the least number of plants (1%) came from the Pacific area. Results on species native origin revealed that 12% of nursery plants were hybrids. The detailed information on species native origins was shown in Fig. 2.

Results of family membership indicated that Rosaceae obtained the highest number of exotic plants with 25 species, followed by Asteraceae with 15 species, Liliaceae with 15 species, Fabaceae with 14 species, Oleaceae with 14 species, Caprifoliaceae with 12 species, and Hydrangeaceae with 10 species. The Asteraceae had the most number of native plants with a total of 19 species, followed by Fabaceae with 9 species, Rosaceae with 9 species, Cupressaceae with 8 species, Pinaceae with 6 species, and Magnoliaceae with 5 species.

Discussion. Our research shows that more than twice as many exotic than native plants were found in the sampled nurseries. Our results are consistent with other findings that nurseries have been one of the major sources of introducing exotic plants to natural communities (Reichard and White 2001, Mack and Emeberg 2002, Dehnen-Schmutz et al. 2007).

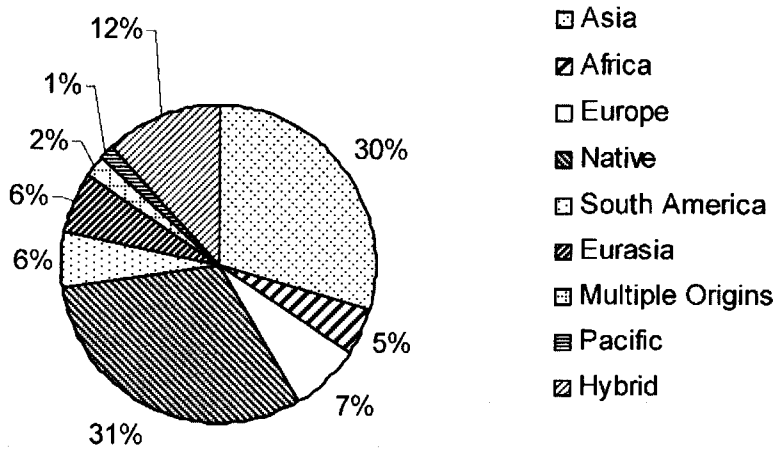

FIG. 2. Percentage of native origins of all plant species found at the twenty-two nurseries across the state of Kentucky.

It is not surprising to observe that most nursery plants are introduced mainly from Europe and eastern Asia as reflected by our data on species native origin. Primarily, this is due to the history of human colonization and global trade and travel. Furthermore, similar biomes are found throughout eastern North America and eastern Asia largely because of the parallel climatic conditions. For example, eastern Asia and eastern North America overlap extensively in latitude, thus leading to similar growth conditions for many introduced plant species (Qian and Ricklefs 2000). Therefore, for some non-native species, the establishment in the new range could be a relatively smooth process after crossing the biogeographical barriers. In addition, it has been a long tradition that gardeners in the United States frequently collect new and exciting plants from different parts of the world. For example, since the 1900s multiple plant exploration expeditions to China have been conducted (Reichard and White 2001). Many plants with eastern Asia origin are introduced to North America also due to the fact that the eastern Asia flora is much more diverse than the flora of eastern North American (Qian 2001, 2002, Qian and Ricklefs 2004, Ricklefs et al. 2004, Guo et al. 2006).

Our study further points out that family membership significantly relates to the possibility that a species is being intentionally introduced to new locations as horticulture plant. Some families contain large numbers of exotic species, such as the Asteraceae and Fabaceae. Both families have been recognized as the main sources of invasive plants in many parts of the world (Holm et al. 1997). This could be linked to the morphological, physiological, and ecological traits associated with species in those families. Certain traits, such as characters in life history, reproduction, life form, and phenotypic plasticity could trigger the invasion success in the introduced habitats (Kolar and Lodge 2001, Richardson and Rejmánek 2004, Hamilton et al. 2005, Rejmánek et al. 2005). For example, species of Asteraceae possess a number of advantageous traits such as high reproductive rates, specialized dispersal means, high level of apomixis, etc. (Pyšek 1998). Therefore, family membership could be used as an effective indicator in identifying and predicting potentially invasive species in the future. Information on native origin of species can serve the same purpose as well. In particular, if a species with known native origin is invasive elsewhere outside its native range, then it carries a high risk of being invasive in the newly introduced locations as suggested by Wiliamson and Fitter (1996), Reichard and Hamilton (1997), Daehler and Carino (2000), Krivanek and Pyšek (2006), and Herron et al. (2007).

Our results also reveal that about 12% nursery plants are reported to be hybrids in origin. In this case, humans have served as a powerful selective agent for creating hybrid species among populations that may have been previously isolated by geographical barriers. Stace (1975) stated that many artificial hybrids have escaped from cultivation and become naturalized invasives, such as poplars,

watercress, mints, etc. Hybridization could occur among exotics as well as between native and exotic species. Studies have shown that both intra- and interspecific hybridization can lead to increased fitness, advantageous life history, and novel genotypes (Lee 2002, Ellstrand and Schierenbeck 2006). Therefore, certain fertile hybrids might have a greater potential to become invasive in the suitable natural habitats. Moreover, many morphological and reproductive traits that make a plant desirable for use in horticulture also increase its invasive potential in the wild (Peters et al. 2006). Consequently, hybridization could be one of the potential pathways for bringing invasive or potentially invasive species into native communities and ecosystems. It is suggested that molecular tools might be able to alleviate the problems by using transgenic approach to create male sterility, female/seed sterility, or parthenocarpy to neutralize the invasiveness of nursery plants (Li et al. 2004).

Among the exotic species found in the twenty-two Kentucky nurseries, unfortunately, we found that fourteen known invasive plants to this region are still carried by some nurseries. Some of these invasive plants have been declared as severe or significant threat to native plant communities by the KY-EPPC (The entire Kentucky invasive species list is available at http://www.se-eppc.org/ky/list.htm). Such species found in our study include exotic honeysuckle species (*Lonicera* spp.), Chinese privet (*Liqustrum sinense*), oriental bittersweet (*Celastrus orbiculata*), multiflora rose (*Rosa multiflora*), tree of heaven (*Ailanthus altissima*), Japanese barberry (*Berberis thunbergii*), English ivy (*Hedera helix*), winged euonymus (*Euonymus alatus*), Chinese silver grass (*Miscanthus sinensis*), Japanese spiraea (*Spiraea japonica*), etc. These species have already caused and will continue to cause significant damage to native ecosystems (Dillenburg et al. 1993, Merriam and Feil 2002, Allen et al. 2006, Webster et al. 2006). Therefore, it is important for nurseries to consider banning the sale of invasives and promoting the use of native species or noninvasive exotics as alternatives.

Conclusions. Although this research was limited to one region, it provides a first and detailed picture on what types of plants are distributed by nurseries in parts of Kentucky. By examining 462 native and exotic nursery plants, our study suggest that family membership and native origin of plant species could be used as effective indicators in identifying the pool of potentially invasive species in the future. Moreover, our findings validate the fact that nurseries have been one of the major sources of introducing exotic plants into natural communities. Therefore, it is important to increase society's awareness of biological invasion and its negative impact on native communities and ecosystems. It is equally critical to have informed and educated personnel in the green industry, so that invasive exotic species will not be introduced and purchased at the nurseries in the first place.

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