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Comparative Study of the Rates of Dispersal of Triadica sebifera (Chinese Tallow) and Imperata Cylindrica (Japanese Blood Grass) in North America

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Abstract

Chinese Tallow (Triadica sebifera) and Japanese Blood Grass (Imperata cylindrica) are two invasive species that wreck havoc on their invaded areas by reducing the biodiversity of their new environments. We studied the rate of dispersal of these two species in North America to determine which species spreads faster. We hypothesized that Chinese Tallow spreads faster than Japanese Blood Grass since Chinese Tallow was introduced in North America long before Japanese Blood Grass and has a greater number of seed dispersal methods (e.g. wind, water, bird, etc.) than Japanese Blood Grass. To test our hypothesis, we collected the record of Chinese Tallow and Japanese Blood Grass in North America from their year of introduction to present and determined the area covered by each species individually over time. After comparing the range covered by the two species over time, we observed that though Chinese Tallow spread faster in its early years, yet in sum, Japanese Blood Grass spreads faster than Chinese Tallow, which opposes our hypothesis. For the log transformed total range difference of Japanese Blood Grass subtracted by Chinese Tallow 70-120 years after introduction, our equation for the trendline was y= =-0.0302*x + 3.39 with an R^2 value of 0.934. This negative slope evident from the trendline refutes our initial hypothesis. For the data analysis, our t=-5.31, d.f=2, p(one-tailed)=.016842. Based on our experiment, it was clear that the rate of dispersal of the Japanese Blood Grass in North America is increasing at an alarming rate and it is necessary to control this species as it is extremely harmful for the environment and biodiversity. As our data showed that the rate of dispersal of the Chinese Tallow is decreasing, the management methods for the Chinese Tallow can be studied to find effective ways to control the Japanese Blood Grass.

Keywords

invasive species, Chinese Tallow, Japanese Blood Grass

Disciplines

Biodiversity | Biology | Plant Sciences | Weed Science

Comments

Written for Bio 111: Introduction to Ecology and Evolution

Comparative Study of the Rates of Dispersal of *Triadica sebifera* (Chinese Tallow) and *Imperata Cylindrica* (Japanese Blood Grass) in North America

Jamie Dinella and Meem Noshin Nawal Khan

Course: BIO 111

Lab Section: BIO 111 L04

Lab Day and Time: Tuesday, 1:10pm- 4:00pm

Instructor's Name: Kay Etheridge

Date: November 9th, 2020

Abstract:

Chinese Tallow (*Triadica sebifera*) and Japanese Blood Grass (*Imperata cylindrica*) are two invasive species that wreak havoc on their invaded regions by reducing the biodiversity of their new environments. We studied the rate of dispersal of these two species in North America to determine which species spreads faster. The purpose of our study was to determine the rate of dispersal of the two species in order to get an idea of the possible severity of these species' presence and possible means of controlling the two species. We hypothesized that Chinese Tallow spreads faster than Japanese Blood Grass since Chinese Tallow was introduced in North America long before Japanese Blood Grass and has a greater number of seed dispersal methods (i.e wind, water, birds, etc.) than the Japanese Blood Grass. To test our hypothesis, we collected the records of Chinese Tallow and Japanese Blood Grass in North America from their year of introduction to present using iDigBio and GBIF and determined the area covered by each species individually over time using QGIS. We hypothesized that the Chinese Tallow spreads faster than the Japanese Bloodgrass. However, after comparing the range covered by the two species over time, we observed that though the Chinese Tallow spread faster in its early years, yet in sum, the Japanese Blood Grass spread faster than the Chinese Tallow, which opposes our hypothesis. For the log transformed total range difference of Japanese Blood Grass subtracted by Chinese Tallow 70-120 years after introduction, our equation for the trendline was y=-0.0302*x + 3.39 with an R^2 = 0.934. This negative slope evident from the trendline refutes our initial hypothesis. For the data analysis, our t=-5.31, d.f=2, p(one-tailed)=.016842. Based on our experiment, it was clear that the rate of dispersal of the Japanese Blood Grass in North America is increasing at an alarming rate and it is necessary to control this species as it is extremely harmful for the environment and biodiversity. As our data showed that the rate of dispersal of the Chinese Tallow is decreasing, the management methods for the Chinese Tallow can be studied to find effective ways to control the Japanese Blood Grass.

Introduction:

The introduction of invasive species is an emerging issue in North America. Ever since humans have developed the technology to build ships that traverse the oceans or planes that can soar from continent to continent, we've brought an immense number of plant and animal species to areas across the globe that would've otherwise never been exposed to these organisms--accidentally and intentionally. This transmission of species can result in disastrous effects. More specifically, invasive plant species can outcompete native species for limited resources such as nutrients, water, sunlight/shade, etc. Since invasives have no natural predators, their populations grow exponentially as they do not have any natural control populations. This research paper explores the similarities and differences between two different invasive plant species, the Chinese Tallow (*Triadica sebifera)* and Japanese Blood Grass *(Imperata Cylindrica)* and will analyze what specific factors aid them in taking over their respective new ecosystems in the United States. (Species Anatomy can be observed in Figure 1) Further, this paper will compare the dispersal rates and total area of these two species, to determine which species is considered to be more invasive and a larger threat to North America's plant biodiversity.

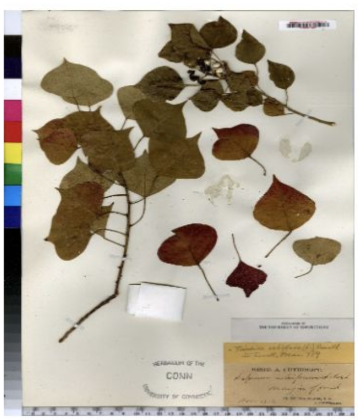
A	B
	

Figure 1: Chinese Tallow (A) and Japanese Blood Grass (B) iDigBio Specimen Records. Chinese Tallow Specimen Collection: A. Cuthbert, George Safford Torrey Herbarium, 1913. Japanese Blood Grass Collection: Robert K. Godfrey, Florida State University Herbarium, 1956.

The Chinese Tallow's native habitat is in eastern Asia, whose climate conditions mirror that of the southeastern United States (Figure 2), since they reside on the same latitude lines. (Jubinsky, 1996). For this reason, its shipment to Florida from China by Benjamin Franklin in

1776 for aesthetics and seed oil (USDA Plant Guide) is regarded as its primary mode of introduction. Initially, the Chinese Tallow grows along waterways, but often invades areas neighboring its establishment site rather quickly (Jubinsky, 1996). Chinese Tallow is self-pollinating and its seeds are primarily dispersed by water or bird species such as the pileated wood-pecker and boat-tailed grackle (Clark, 2016; Jubinsky, 1996). Further, it’s fast growth rate quickly outcompetes native species for ground cover, categorizing the ornamental plant as a significant invasive species in the southern United States. In fact, the Chinese Tallow reaches reproductive rate within its first three years of growth, and mature trees produce 100,000 seeds annually (USDA Plant Guide).

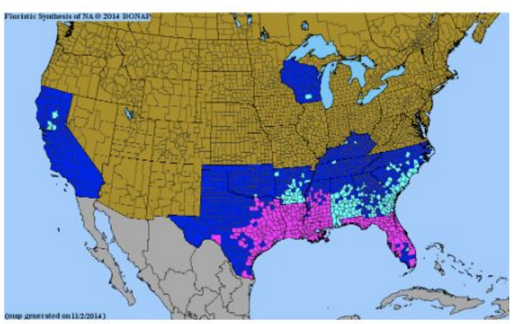
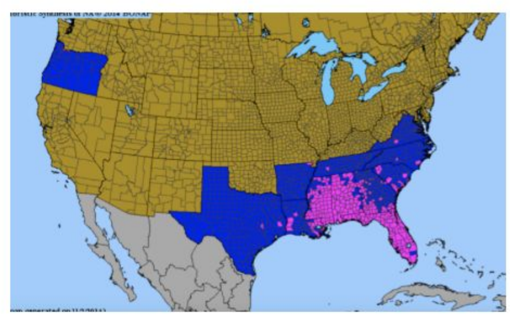
A	**B**
	

Figure 2: Current Biota of North America Program (BONAP) maps for Chinese Tallow (A) and Japanese Bloodgrass (B), 2020. Color Key: pink-noxious; cyan-species exotic and present; dark blue-species present in state and exotic.

Another prevalent invasive in the southeastern U.S would be Japanese Blood Grass, also commonly known as Cogongrass (Figure 2). It was introduced to the United States in two separate instances: once to Alabama in 1912 from Japanese fruit imports, and again to numerous southern states during the 1920s for forage and erosion control. (Estrada, 2015) Japanese Blood Grass seeds are dispersed only by wind, but its tolerance to shade, drought, and poor soil quality, tolerance to wildfires, and its unique rhizome root composition outcompetes natives for water and soil nutrients, which allows the species to persist as an invasive. (Estrada, 2015)

We hypothesize the data outlined in this study will show that The Chinese Tallow spreads more quickly than Japanese Blood Grass due to its aforementioned biological factors, especially its biological seed dispersal. More specifically, the Chinese Tallow is pollinated by wind and bees, and its seeds are dispersed from water and birds. Contrastingly, Japanese Blood Grass is only pollinated and dispersed by wind. Therefore, based on this hypothesis, we predict to see a greater range of Chinese Tallow compared to the Japanese Blood Grass at the conclusion of this study.

Methods:

We studied Chinese Tallow and Japanese Blood Grass to observe the spreading rate of the two species in North America from the time of introduction till present. We compared the attributes of the two species to know more about the factors that might influence the rate of spreading (e.g. seed dispersal method, date of introduction in North America, carriers). Using Encyclopedia of Life, we identified all preferred synonyms of the two species which we used throughout the study. To study the spreading of the species in North America, we found the first recorded record and place of introduction in North America using iDigBio. We selected North

America as a location filter and only used data that had map points in order to exclude range jumps due to possible human-caused spread. After this process, 276 records were found for Chinese Tallow and 129 records were found for Japanese Blood Grass. GBIF was used to find the citizen science records of the distribution of the two species in North America. We filtered range uncertainty to keep it within 1000 meters. Afterwards, 2960 North American specimen records were found for Chinese Tallow and 122 records were found for Japanese Blood Grass from GBIF.com.

With Google Sheets, we cleaned the data from iDigBio and GBIF individually. In this procedure, we resolved taxon names by removing any incorrect scientific name, cleaned location by removing uncertainty coordinates greater than 1 kilometer, and removed outliers by removing any data outside USA, Mexico, and Canada. Finally, data was trimmed and so only latitude, longitude, year, and GBIF ID or coreid for iDigBio remained. We then combined the data from iDigBio and GBIF. There were 2968 records for Chinese Tallow and 145 records for Japanese Blood Grass. Using the QGIS Protocol, we used these records to calculate the area occupied by Chinese Tallow and Japanese Blood Grass over time.

To calculate the area occupied by the two species over time, we used the Concave Hull plugin on QGIS. We removed Chinese Tallow records from California as outliers because they seemed to be spread by humans. We created shapefiles for every 20-year interval for Chinese Tallow and 10-year intervals for Japanese Blood Grass. Chinese Tallow had 6 intervals and Japanese Blood Grass had 4 intervals. We generated area polygons for every time interval and the area of the polygons were calculated.

We plotted range vs. time graphs in scatterplots and fitted a trendline for each species individually using Google Sheets to determine whether a linear or geometric growth represents the data value. (Figure 6) After log transforming the two species data, the r^2 values, a higher r^2 value determined a geometric model best fit the data.

We subtracted the range of Japanese Blood Grass from Chinese Tallow and plotted the difference in range over time. Because of the different time intervals of the shapefiles, we interpolated two data points. These data points were the range of Chinese Tallow at t=90 and the range of Japanese Blood Grass at t=120. To avoid an excess of data manipulation, t=140 was eliminated for both species.

Using VassarStats, we found the correlation and regression of data using the tables of values created in Google Sheets. One sided p value was recorded. The null was accepted or rejected at 5% significance level. We used the data to determine the comparative rate of spread of the two species.

The instructions followed the procedures from Bio11 laboratory instructions (Kerney et al.,2020)

<u>Results:</u>

EOL.org informs that the Chinese Tallow has five scientific preferred synonyms while Japanese Blood Grass has eight. These synonyms were used throughout our research. From the data presented in both Figures 3 and 4, it’s evident that the Chinese Tallow has a greater distribution across North America than Japanese Blood Grass.

A	B

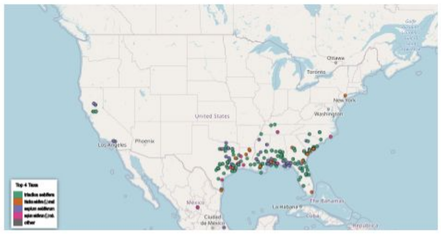
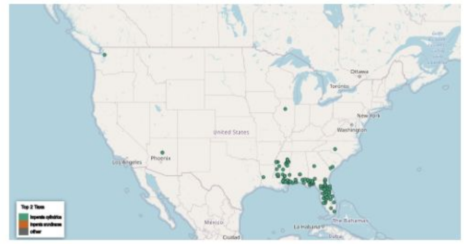

	

Figure 3. Current Chinese Tallow (A) and Japanese Bloodgrass (B) Distribution in the United States according to iDigBio.org, 2020.	

A	B

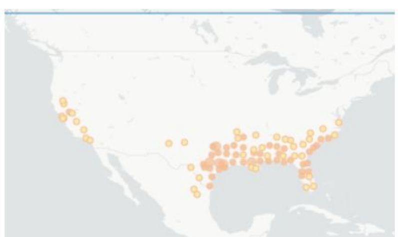



Figure 4. Distribution of Chinese Tallow (A) and Distribution of Japanese Blood Grass (B) in North America according to Citizen Science Data Records and GBIF.org, 2020.	

Over their respective time intervals, Japanese Blood Grass has been contained within the southeastern United States. Contrastingly, Chinese Tallow has expanded its range to the Western United States, including California. However, after the data set was cleaned, the data points in California were excluded and were not present in the GIS maps of Figure 5. We concluded that these occurrences may have been false reports from the citizen science records. Nonetheless, the range of the Chinese Tallow far exceeds that of its counter species. Table 1 outlines how many data points were retrieved using the databases, and how many were included in the final maps from which we analyzed the data.

Table 1: Sources of Data Points Used in the Final CSV file. Sources: GBIF, iDigBio. (2020)

	# of Species Data Points (Chinese Tallow)	# of Species Data Points (Japanese Blood Grass)
iDigBio	276	129
GBIF	2960	122
Cleaned csv. File	2968	144

Once we compared the two species using the QGIS software (Figure 5), it became clear that although Chinese Tallow has a wider range of distribution, the rate of growth suggests that the Chinese Tallow actually increased its range at a slower rate compared to Japanese Blood Grass.

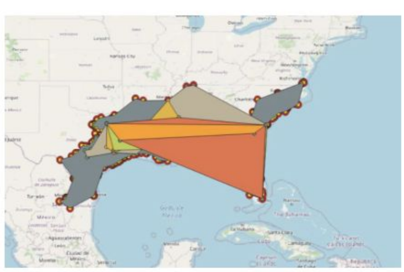
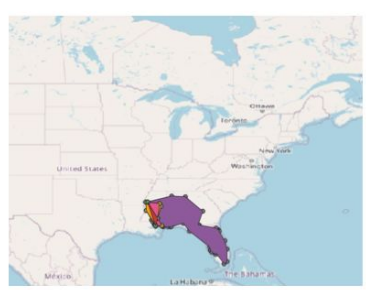
A	**B**
	

Figure 5. Change in Chinese Tallow (A) and Japanese Blood Grass (B) Distribution in North America 70-150 years after their respective introductions according to GBIF and iDigBio data. Map created with QGIS software, 2020.

We further used this data to create linear regression models of the range of each species, as well as the difference in ranges (Figure 6 and 7 respectively).

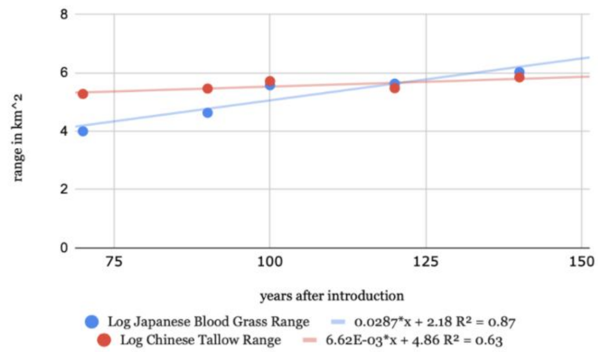


Figure 6. Log Transformed Total Range of Expansion of Japanese Blood Grass and Chinese Tallow in the United States 70-140 years after introduction. (n=5) Sources: GBIF, iDigBio, graph made in Google Sheets.

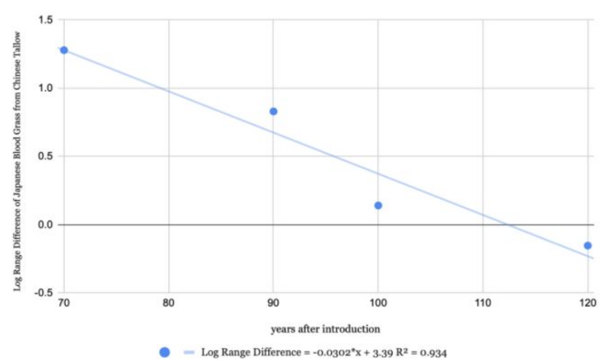


Figure 7. Log Transformed Total Range Difference of Japanese Blood Grass Range subtracted by Chinese Tallow's Range of Distribution 70-120 years after their respective introductions (n=5). Sources: GBIF, iDiobio, graph created in Google Sheets

The strong positive correlation of the difference of ranges of the two species shown in Figure 7 was proven to be statistically significant at the 5% level of significance due to the following statistical results from VassarStats: $t=-5.31$, $d.f=2$, $p=.016842$. These results uncover how the Japanese Blood Grass increased at a greater rate than Chinese Tallow 70-140 years post their respective introductions.

Discussion and Conclusion:

We hypothesized that the Chinese Tallow has a faster rate of dispersal than the Japanese Bloodgrass, which was opposed by the data from our study. The study shows that the range of expansion of Japanese Blood grass increases at a faster rate than Chinese Tallow as there was a negative slope of the trendline after the log transformed slope of the line of Japanese blood grass was subtracted from the Chinese Tallow. This conclusion contrasts our hypothesis. Furthermore, our p-value is less than .05, which means that this strong negative correlation of the differences is unlikely to be due from chance alone.

We predicted a greater spread rate from the Chinese Tallow due to the difference in the time of introduction. Chinese Tallow was introduced in 1855, while Japanese Blood Grass was introduced in 1912. From the data we analyzed, up to 100 years after its respective introduction, Chinese Tallow had a faster dispersal rate than Japanese Blood Grass after which its rate began to decrease. Contrastingly, over time, the rate of spread for Japanese Tallow continued to increase. From these data, it's possible that since Chinese Tallow was introduced earlier, it was identified as an invasive species and therefore preventative measures were put in place. With this line of reasoning, Japanese Blood Grass possibly has not been the primary pest control of recent years, and therefore less steps have been taken to control its populations.

The range of Chinese Tallow has been limited by factors including salinity, soil moisture, and methods of dispersal (Pile et. al., 2017). Therefore, the Chinese Tallow invaded its suitable environment after its introduction in North America, and the dispersal rate decreased after the Chinese Tallow already invaded its favorable habitat and did not have any suitable region left to invade. We also predict that the Chinese Tallow might have failed to invade other regions because of the presence of any strong competitor species or any predator.

Previous studies on the topic suggest that despite Japanese Blood Grass only has two genetic variations in North America, a combination of introduced diversity, propagule pressure, secondary contact, and reproductive flexibility in response to varying environmental conditions have caused the rapid expansion and persistence of Japanese Blood Grass in the last century (Lucardi et al, 2014). Another study shows that though Japanese Blood Grass has limited evolutionary potential to adapt to a new environment, this species did not need local adaptation through hybridization or selection of favourable alleles from a broad genetic base when it was introduced to its invaded region. Therefore, this species shows a broad invasive success, across diversified environments, in a clonal organism with limited genetic diversity (Burrell et al, 2015).

Our study shows an increasing range of Japanese Blood Grass in the USA over time, which is alarming. It clearly shows that the current methods of management of this invasive species are not enough to control it. Therefore, we strongly suggest that effective measures should be taken to control Japanese Blood Grass as soon as possible. If not, the species will keep expanding its range and will be a greater threat to the native species in North America. Its competitive biology poses a threat to the biodiversity of the southeastern United States and should be addressed before it outcompetes native plant species in that region.

We suspect that there might be some errors in our data which might have been caused by inaccuracies in citizen science records of the species and errors caused by the QGIS software while measuring area. There might have been some inaccurate reporting of data in GBIF, the database we used to collect citizen science records of the two species in North America. There were also inaccuracies in measurement of area by QGIS as the software also included a portion of the Gulf de Mexico in its calculation of range of the two species. These errors might have slightly influenced the final data, and thus the dispersal rate we calculated.

Additionally, due to the variability of the data set, we did interpolate two data points that were used for the Figure 7 and 8, which may have attributed to a stronger correlation than what would've been evident in nature if this experiment were to be repeated.

Based on our study, we suggest that there should be further studies to determine the biological factors influencing the rate of dispersal of the Chinese Tallow and the Japanese Blood Grass and the biological and environmental ways of controlling the species, which, we believe, will help greatly to discover more effective ways of controlling the expansion of range of the species. The management methods of the Chinese Tallow should also be studied in order to find ways to control the Japanese Blood Grass. Currently, Chinese Tallow is most often controlled with chemical herbicides, yet this often results in a multiplicity of negative environmental consequences. (USDA Plant Guide). Additionally, since Japanese Blood Grass is fire tolerant (USDA, APHIS), controlled fire may not be an effective control method. Further research on control methods for Japanese Blood Grass is required. We also suggest that a replication of our study should be conducted with more accurate data, which can determine the area invaded by the two species accurately.

Our study shows that among the two invasive species in North America we studied, Japanese Blood Grass (*Imperata cylindrica*) spreads faster than Chinese Tallow (*Triadica sebifera*). The higher dispersal rate of Japanese Blood Grass is supported by two studies conducted by Lucardi et al (2014), and Burrell et al (2015). Based on our study, it is suggested to carry further studies on the dispersal rate of the two species and find effective management methods to protect biodiversity of North America from the negative impacts of these invasive species.

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Appendix:

Link to Presentation:
https://docs.google.com/presentation/d/1EBYrJe7gU8H8gYXPHcpkdIOWEyycSJF4t-wA_i-t9r4/edit?usp=sharing

Vassarstat Screenshot:

Data Summary

$\sum X$ =	380	$\sum X^2$ =	37400
$\sum Y$ =	2.0924	$\sum Y^2$ =	2.3657
$\sum XY$ =	159.5011		

	X	Y
N	4	
Mean	95	0.5231
Variance	433.3333	0.4237
Std.Dev.	20.8167	0.6509
Std.Err.	10.4083	0.3255

r	r^2	Slope	Y Intercept	Std. Err. of Estimate
-0.9663	0.9338	-0.030216	3.393635	0.2052

t	df	P		
-5.31	2		one-tailed	0.016842
			two-tailed	0.033684

0.95 and 0.99 Confidence Intervals for rho

	Lower Limit	Upper Limit
0.95	-1	-0.074
0.99	-1	0.494

0.95 and 0.99 Confidence Intervals for the Slope of the Regression

	Lower Limit	Upper Limit
0.95	-0.0547	-0.0057
0.99	-0.0867	0.0263

Titles and Abstracts of Primary Journal Articles:

The invasive potential of Chinese Tallow-tree (Sapium sebiferum Roxb.) in the southeast

Source: Castanea. Vol. 61 (3). 1996. 226-231

Abstract: A native of eastern Asia, in the same latitudes as the southeastern United States, the Tallow-tree (or popcorn-tree) has long been a popular landscaping choice in this region, for its brilliant fall color, distinctive seed capsules, and easy care as an ornamental. It is shade-, sun-, drought-, flood-, freeze, and salt-tolerant, as shown in recent experiments. These and other characters, such as its adaptability to a wide range of soils and its ease of dispersal via birds, water, and humans, suggest that this introduced species has a high risk potential as an invasive plant outside of cultivation. Surveys conducted by Florida's Department of Environmental Protection demonstrate the increased spread of Tallow into disturbed and undisturbed, upland and wetland sites, with one large wetland site south of Gainesville, Florida having more than 10,000 Sapium trees that have become naturalized. Over half (57%) of Florida's counties now have naturalized populations of the tree. Current options for control of this hardy plant are also provided.

Mechanisms of Chinese tallow (Triadica sebifera) invasion and their management implications - A review

Authors/Editors/Inventors: Pile, Lauren S.; Wang, G. Geoff; Stovall, Jeremy P.; Siemann, Evan; Wheeler, Gregory S.; Gabler, Christopher A.

Source: Forest Ecology and Management. Vol. 404. NOV 15 2017. 1-13

Abstract: Ecosystems are under increasing stress from environmental change, including invasion by non-native species that can disrupt ecological processes and functions. Chinese tallow [Triadica sebifera (L.) Small] is a highly invasive tree species in southeastern US forests, prairies, and wetlands, and effectively managing this invasive species is a significant challenge for scientists and land managers. In this review, we synthesize the literature on invasion ecology and management of Chinese tallow. Our review suggests that the invaded range of Chinese tallow is currently limited by dispersal in many areas and by low temperatures and low soil moisture, and by high soil salinity and frequent flooding in others, but these barriers may be overcome by increased dispersal, phenotypic plasticity, and/or rapid evolution. Invasions by Chinese tallow are facilitated by both the invasiveness of the species and the invasibility of the recipient communities. Invasiveness of Chinese tallow has been attributed to fast growth, high fecundity, a persistent seed bank, aggressive resprouting, abiotic stress tolerance, and the ability to transform fire maintained ecosystems. Some of these traits may be enhanced in invasive populations. Anthropogenic and natural disturbances, lack of herbivore pressure, and facilitation by soil microbes enhance the intensity of Chinese tallow invasions. Biological control of Chinese tallow is being developed. Treatments such as herbicides, prescribed fire, and mechanical control can effectively control Chinese tallow at the local scale. A combination of these treatments improves results. However, a proactive management approach would simultaneously achieve invasion control and promote subsequent ecological restoration, especially in the context of legacy effects, secondary invasions, and/or variable ecosystem responses to different control treatments. Future research should clarify the roles of species invasiveness and community invasibility, increase our understanding of the effects of Chinese tallow in invaded communities, and develop viable management regimes that are effective in both controlling or reducing the probability of Chinese tallow invasion and restoring desired native communities.

Major Concepts: Terrestrial Ecology, (Ecology), (Environmental Sciences)
Chemical Coordination and Homeostasis

Review paper

Cogongrass (*Imperata cylindrica*) invasions in the US: Mechanisms, impacts, and threats to biodiversity

James A. Estrada, S. Luke Flory

Show more

https://doi.org/10.1016/j.gecco.2014.10.014

Abstract

Invasions of non-native species can suppress biodiversity and alter ecosystem functions, but for many of the most widespread invasive species the mechanisms underlying their invasive success and effects on native species are poorly understood. Here we evaluated the peer-reviewed literature on causes and impacts of invasion by cogongrass (*Imperata cylindrica*), one of the most problematic invasive plant species in the southeast US. We assess what is known about why cogongrass is particularly invasive and how it affects native communities and ecosystems, review patterns in research methods employed, and provide a roadmap for future research on cogongrass. Although many studies have focused on the basic biology and management of cogongrass, we found surprisingly few (30) studies that have directly tested mechanisms or impacts of cogongrass invasions. The most commonly tested mechanisms, disturbance and allelopathy, were evaluated 4 and 12 times, respectively, and studies on invasion impacts were limited to five studies total: native plant diversity (2 studies), nitrogen cycling (2), decomposition (1), and fine fuel loads (1). Excluding laboratory studies on allelopathy, 75% (6/8) of impact studies used observational methods, raising questions about cause and effect. Given the paucity of studies on the ecology of cogongrass invasions, and the need to protect conservation areas from invasions, we urge that research efforts focus on: (1) environmental correlates of distribution and performance, (2) the role of propagule pressure in invasion success, (3) enemy release and post-introduction evolution as mechanisms of invasion, and (4) experimental tests of community and ecosystem impacts of invasions.

Invasion Success in Cogongrass (Imperata cylindrica): A Population Genetic Approach Exploring Genetic Diversity and Historical Introductions

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Abstract: Propagule pressure significantly contributes to and limits the potential success of a biological invasion, especially during transport, introduction, and establishment. Events such as multiple introductions of foreign parent material and gene flow among them can increase genetic diversity in founding populations, often leading to greater invasion success. We applied the tools and theory of population genetics to better understand the dynamics of successful biological invasion. The focal species, cogongrass, is a perennial invasive grass species significantly affecting the Gulf Coast and southeastern region of the United States. The literature indicates separate, allopatric introductions of material from East Asia (Philippines and Japan) into the U.S. states of Mississippi and Alabama. Molecular analysis of samples from those two states utilized amplified fragment length polymorphism (AFLP) markers on 388 individuals from 21 localities. We hypothesized that previously isolated lineages of cogongrass are present and crossing in the Southeast. We observed genetic variation within localities (0.013 <= heterozygosity (H-e) <= 0.051, mean +/- 0.028 0.001) with significant and substantial population structure (F-ST = 0.534, P < 0.001). Population structure analyses detected two genetically defined and statistically supported populations, which appear to have experienced some admixture. The geographic distribution of those populations was consistent with the twointroduction scenario reported previously. These results are also consistent with contact in the invasive range of previously isolated lineages from the native range.

Exploring origins, invasion history and genetic diversity of Imperata cylindrica (L.) P. Beauv. (Cogongrass) in the United States using genotyping by sequencing

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Abstract: **Imperata cylindrica** (**Cogongrass**, Speargrass) is a diploid C4 grass that is a noxious weed in 73 countries and constitutes a significant threat to global biodiversity and sustainable agriculture. We used a cost-effective genotyping-by-sequencing (GBS) approach to identify the reproductive system, genetic diversity and geographic origins of **invasions** in the south-eastern United States. In this work, we demonstrated the advantage of employing the closely related, fully sequenced crop species Sorghum bicolor (L.) Moench as a proxy reference genome to identify a set of 2320 informative single nucleotide and insertion-deletion polymorphisms. Genetic analyses identified four clonal lineages of **cogongrass** and one clonal lineage of **Imperata** brasiliensis Trin. in the United States. Each lineage was highly homogeneous, and we found no evidence of hybridization among the different lineages, despite geographical overlap. We found evidence that at least three of these lineages showed clonal reproduction prior to introduction to the United States. These results indicate that **cogongrass** has limited evolutionary potential to adapt to novel environments and further suggest that upon arrival to its invaded range, this species did not require local adaptation through hybridization/introgression or selection of favourable alleles from a broad genetic base. Thus, **cogongrass** presents a clear case of broad invasive success, across a diversity of environments, in a clonal organism with limited genetic diversity.

Contribution and Honor Code Statement:

Jamie wrote the introduction, result, figures, and tables. Meem wrote the abstract, methods, discussion and conclusion, references and appendix sections. Both partners formatted and proofread the final document.

We affirm that we have upheld the highest principles of honesty and integrity in our academic work and have not witnessed a violation of the Honor Code.-*Jamie Dinella and Meem Noshin Nawal Khan*