Decomposition and benthic macroinvertebrate communities of exotic Japanese knotweed (*Fallopia japonica*) and American sycamore (*Platanus occidentalus*) detritus within the Susquehanna River

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Department of Biology, Susquehanna University, Selinsgrove, PA, USA

ABSTRACT

The invasive shrub Japanese knotweed (*Fallopia japonica*) is spreading through riparian forests in Central Pennsylvania. There is concern that detritus from this species may impact adjacent aquatic ecosystems, as allocthonous material forms the basis for aquatic food webs and may impact benthic community structure. This study compares key ecosystem processes within Japanese knotweed leaf litter to leaf litter of a native riparian species, American sycamore (*Platanus occidentalis*). We assess benthic macroinvertebrate communities and decomposition rates within experimental Japanese knotweed and American sycamore leaf packs at three sites within the Susquehanna River. Japanese knotweed detritus hosted a similar macroinvertebrate community to American sycamore and their assemblages had similar representation of functional feeding groups. The similarity between the invertebrate communities occupying American sycamore and Japanese knotweed detritus indicates that macroinvertebrates are able to utilize non-native litter for habitat and potentially as an energy source. American sycamore decomposed at a faster rate than Japanese knotweed, lending support to the Novel Weapons Hypothesis, which suggests that non-native species like Japanese knotweed may inhibit microbial colonization and subsequent litter breakdown. Our results suggest that invasion of Japanese knotweed along riparian corridors of large river systems may not have severe ecological consequences on local ecosystem processes.

Introduction

Riparian detritus is the primary energy source for aquatic food webs, serving as both a substrate for biological activities, such as colonization, and as a food source for microbes and invertebrates (Meehan et al. 1977; Webster and Benfield 1986; Cummins et al. 1989). Fundamental ecological processes of aquatic systems such as nutrient cycling, nutrient availability and organic matter production depend on the breakdown of plant litter (Webster and Benfield 1986; Bottollier-Curtet et al. 2011). Approximately 60%–70% of detrital inputs (leaves, needles, bark, twigs) are retained in a stream long enough to be colonized by microbes and used as a food source for invertebrates (Meehan et al. 1977).

The River Continuum Concept suggests that particulate organic matter transported from upstream reaches is the primary contributor of organic matter to large river ecosystem processes

(Vannote et al. 1980). However, there is evidence that local terrestrial organic inputs may also make significant contributions to large river systems (Chauvet and Jean-Louis 1988; Baldy et al. 1995). Terrestrial leaf litter may contribute more significantly to large rivers like the Susquehanna River, an eighth-order stream, that is characterized by relatively shallow stretches, and may potentially retain riparian leaf litter in slow-moving areas more readily than other large systems.

The rate at which litter breaks down, and consequently contributes to key ecological processes, is determined primarily by the climate of the system, litter quality, and the rate of consumption and colonization by microbes and detritivores (Webster and Benfield 1986). Microbial decomposition and colonization conditions the litter and enhances its palatability to detritivores, increasing the rate of mechanical breakdown (Webster and Benfield 1986; Medina-Villar et al. 2015). Secondary compounds present in leaf litter can influence breakdown, as these molecules (e.g. polyphenols or essential oils) have the potential to delay or inhibit fungal growth, impacting microbial colonization and conditioning, and consequently macroinvertebrate attraction (Webster and Benfield 1986; Graça et al. 2002; Serra et al. 2013). The Novel Weapons Hypothesis (NWH) suggests that secondary compounds produced by exotic species may inhibit native microbes and invertebrates because the native organisms do not share an evolutionary history with the exotic species (Callaway and Ridenour 2004; Bottollier-Curtet et al. 2011; Medina-Villar et al. 2015).

The frequent, and sometimes severe, natural and anthropogenic disturbances that riparian ecosystems experience have been correlated with the colonization of non-native species (Medina-Villar et al. 2015). Exotic plant species can represent greater than 20% of total plant species inhabiting a temperate riparian ecosystem (Richardson et al. 2007; Bottollier-Curtet et al. 2011). Japanese knotweed establishes monospecific stands along riparian corridors, replacing native riparian vegetation, and may alter the makeup of allochthonous inputs into aquatic ecosystems (Conolly 1977; Seiger 1997; Braatne et al. 2007). The impact of terrestrial invaders within terrestrial systems has received attention in the literature; however, little is known about the impact of riparian invaders on stream and river ecosystems (Medina-Villar et al. 2015).

Studies have been conducted previously observing effects of invasive riparian plants on key stream functions. Previous studies comparing litter quality in low-order streams between exotic *Rhododendron* and native riparian species show similar breakdown rates and similar invertebrate communities (Hladyz et al. 2009; Hladyz et al. 2011). Serra et al. (2013) investigated the impacts of exotic *S. fragilis* (crack willow) on streams and found that invertebrate abundance and diversity were similar, but species composition differed and the exotic litter decomposed significantly slower than the native litter. In studies investigating the effects of Japanese knotweed on key ecosystem processes in invaded ranges, it has been found that leaf decomposition and macroinvertebrate assemblages were similar between native and non-native leaf species (Braatne et al. 2007; Bottollier-Curtet et al. 2011). Additionally, it was found that there were no preferences in invertebrate functional feeding groups (Christopher 2014) and no specificity of microbial colonization between exotic Japanese knotweed and native litter species (Lecerf et al. 2007). Lecerf et al. (2007) found that Japanese knotweed had a significantly faster decomposition rate than the native comparison species.

We compare American sycamore (*Platanus occidentalis*) with Japanese knotweed because it occurs sympatrically along the Susquehanna River, has similar lignin content and is identified as having similar leaf properties in previous studies (Lecerf et al. 2007; Claeson et al. 2013; Christopher 2014). The purpose of this study was to assess the impacts of an invasive riparian species, *F. japonica*, on key functions of a river ecosystem. Specifically, the objectives were to (1) compare leaf decomposition rates of exotic Japanese knotweed and native American sycamore; and (2) quantify invertebrate assemblages within exotic and native leaf packs. Based upon the Novel Weapons Hypothesis, we predict that (1) Japanese knotweed will decompose slower than native American sycamore; and (2) Japanese knotweed will have less diverse and less abundant macroinvertebrate assemblages compared to native American sycamore.

Materials and methods

Site description

Our study was conducted within a reach located 5–10 km south of the confluence of the North and West branches of the Susquehanna River in Shamokin Dam, Pennsylvania (320 m above sea level, source). The average annual temperature of the region is 10.14 °C and the average annual precipitation is 103.8 cm (NOAA 2011). Experimental leaf packs were placed in the Susquehanna River at three sites: Shady Nook Boat Ramp (BR; 40.82265N, 76.83890W), Sunbury Generation Power Plant (PP; 40.84545N, 76.1392W), and the Sunbury Boat Ramp (SBR; 40.84723N, 76.80561W). The Shady Nook Boat Ramp and the Sunbury Generation Power Plant are within the plume of the west branch of the Susquehanna River. The Sunbury Boat Ramp is within the plume of the north branch of the Susquehanna River. Water quality data from the west and north branches of the Susquehanna River were collected above the confluence by the Susquehanna River Initiative, Bucknell University Environmental Center (2018) and provided to the authors for use in this study (Table 1). Discharge and gauge height were recorded below the confluence in Sunbury, PA (U.S. Geological Survey 2018; Table 1). Japanese knotweed has established nearly mono-typic stands along the riparian corridor extending through each site.

Deploying experimental leaf packs

After American sycamore and Japanese knotweed leaves had naturally abscised in the fall, leaves were collected from a riparian forest site located near the Sunbury Generation Power Plant. After collection, leaves were dried to a constant weight in a drying oven at 105 °C. Dried litter was aggregated into 10.0 ± 0.5 g batches ($N = 6$ leaf packs per species, per site) and placed into 20×20 cm nylon bags with 1 cm openings. Leaf packs were secured to bricks with cable ties to prevent movement by a high water event or ice gouging. Leaf packs were deployed at the three sites in January 2016. Additional 'travel' leaf packs ($N = 2$ per species) were transported into the field and immediately returned to the lab to estimate the amount of material lost during travel. Six leaf pack replicates per species (8.5 ± 0.5 g) were collected following abscission and processed without exposure to quantify initial dry mass (DM) and ash-free dry mass (AFDM) as a control. Leaf packs were removed from the river after 49–52 days of exposure. Leaf packs were placed into plastic bags, preserved in 70% ethyl alcohol and stored in a refrigerator prior to processing in the laboratory.

Table 1. Characteristics of the north and west branches of the Susquehanna River during the exposure period. Shady Nook Boat Ramp and Sunbury Generation Power Plant sites are influenced by the west branch plume and the Sunbury Boat Ramp is influenced by the north branch plume. Main stem data represent all study sites.

		January	February
North branch	Temp (°C)	1.20	1.68
	Conductivity (μs/cm)	220.83	211.93
	DO (mg/L)	13.71	13.46
	pH	21.98	7.64
	Turbidity (NTU+)	85.74	113.20
	Depth (m)	1.79	2.50
West branch	Temp (°C)		3.45
	Conductivity (μs/cm)		197.75
	DO (mg/L)		14.97
	pH		
	Turbidity (NTU+)		1.65
	Depth (m)		
Main stem	Discharge (cfs)	33,300	47,620
	Gauge height (m)	3.10	3.45

Benthic macroinvertebrates and leaf decomposition

Leaf packs were processed by decanting the alcohol through a 595 micron sieve, placing the leaf pack into a tray, and thoroughly rinsing the mesh bag collecting the contents in the sieve. Leaf material was removed from the mesh pack and fragments were visually searched under a dissecting microscope for benthic macroinvertebrates, which were removed and placed into a sample vial containing 70% ethyl alcohol. After all leaf fragments were searched and benthic macroinvertebrates removed, the tray was rinsed and poured through the sieve. All visible macroinvertebrates were removed from the sieve. Macro debris (stones, woody debris, etc.) was discarded. The leaf fragments were gently rinsed through the sieve to remove sediment and debris that accumulated during exposure. Leaves were dried at 105 °C to a constant mass and weighed to determine DM following the exposure period. Leaf debris remaining in the experimental leaf packs (not decomposed) was ground using a mortar and pestle and was ashed at 400 °C for 4 hours to determine AFDM. Mean AFDM of control leaf samples was used to calculate the initial AFDM of all leaf packs placed into the river for exposure.

Benthic macroinvertebrates were identified to genus or to the lowest possible classification (Brigham et al. 1982; Peckarsky et al. 1990; Wiggins 1996; Stewart and Stark 2002; Gelhaus 2008; Merritt and Cummins 2008). Macroinvertebrates were placed into functional feeding groups using an Index of Biotic Integrity for Benthic Macroinvertebrate Communities in Pennsylvania's Wadeable, Freestone, Riffle-Run Streams as defined by the Pennsylvania Department of Environmental Protection (PA DEP 2012).

Statistical analysis

An adonis permutational multivariate statistical analysis of variance (PERMANOVA) was performed using a Bray–Curtis dissimilarity matrix to test for the effects of leaf litter type and site on invertebrate assemblage composition. The adonis PERMANOVA was conducted using the vegan package in R (Oksanen et al. 2018). In addition, we performed a pairwise comparison PERMANOVA of the Bray–Curtis matrix using the RVAideMemoire package in R to determine which groups (site-species) were significantly dissimilar in average assemblage composition (Hervé 2018). Additionally, we used a permutation test for multivariate homogeneity of group dispersion of the Bray–Curtis matrix using the vegan package in R, to test for the effects of leaf type or site on the variability of invertebrate assemblage. A nonmetric multidimensional scaling (NMDS) of the Bray–Curtis dissimilarity matrix was performed to visualize the similarities and dissimilarities in invertebrate assemblages for site-species groups. The NMDS ordination was conducted using the vegan package in R. The relative abundances were first standardized to unit maxima (number of individuals are a proportion from 0 to 1) to mitigate the dominate effects of highly abundant taxa. We selected the NMDS solution that achieved a stress of <0.2 with the lowest number of axes after 10,000 permutations (Clarke and Warwick 2001).

AFDM was calculated by subtracting the weight of the ash (inorganic material remaining after combustion) from the DM of leaves remaining in the experimental leaf packs following exposure, corrected for loss of leaf material during travel. AFDM represents the weight of organic material, eliminating error from sediment and minerals that accumulated on the leaves and could not readily be washed off (Eggert and Wallace 2003; Hauer and Lamberti 2007). Leaf decomposition was determined by calculating the proportion of organic mass lost over the exposure period.

Proportion of organic material lost was calculated as

$$\frac{AFDM_t}{AFDM_0\ (DM - CF)}$$

where $AFDM_t$ is the AFDM of experimental leaf packs after exposure, $AFDM_0$ is the AFDM of control leaf packs used to calculate the initial AFDM of experimental leaf packs, DM is the initial weight of experimental leaf packs and CF is the correction factor used to account for handling loss. A two-tailed t-test was used to analyze the differences in mean decomposition rate between American sycamore and Japanese knotweed.

Results

Benthic macroinvertebrates

A three-axis solution produced a satisfactory NMDS ordination (stress = 0.16) after 10,000 permutations of invertebrate community composition of samples among leaf species and sites (Figure 1). There was a significant difference in average assemblage composition at the genus level across sites (PERMANOVA, $p = 0.001$) indicated by a shift along the first ordination axis of the Shady Nook Boat Ramp and Power Plant sites from the Sunbury Boat Ramp and a shift along the second ordination axis of the Shady Nook Boat Ramp from the Power Plant site (Figure 1). Japanese knotweed and American sycamore had similar community assemblages within sites (PERMANOVA, $F = 2.557$, $p \geq 0.05$) indicated by similarly located centroids in the ordination (Figure 1). There was no difference in dispersion of community assemblages among Japanese knotweed and American sycamore within or across sites (PERMANOVA, $F = 2.146$, $p = 0.088$).

The communities found in both American sycamore and Japanese knotweed detritus had all functional feeding groups represented (collector/gatherer, scraper, predator, shredder, and filter/collector) and all major taxa (Diptera, Trichoptera, Plecoptera, Ephemeroptera, etc.) represented for each leaf species (Appendix). The dominant taxa represented in Japanese knotweed leaf packs were Chironomidae, *Gammarus*, and Naididae. Dominant taxa represented in American sycamore packs were Chironomidae, *Gammarus*, and *Strophopteryx*. The taxa richness, or number of taxa present, within American sycamore and Japanese knotweed leaf packs, was 53 and 57 taxa, respectively, across all sampling sites.
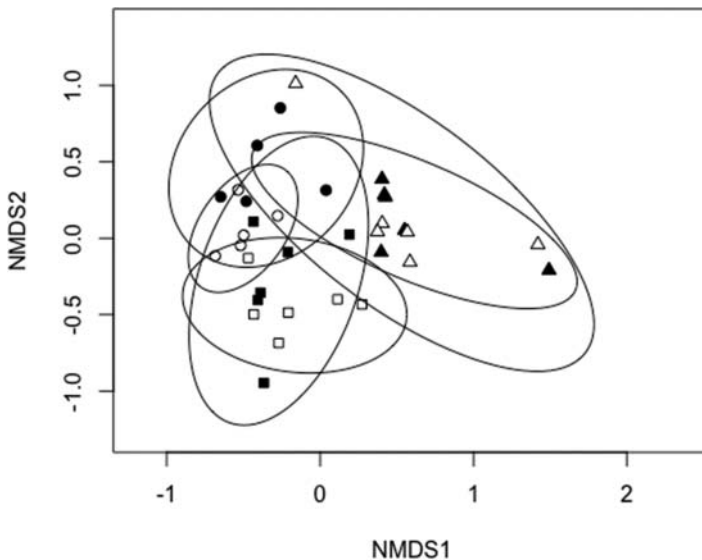

Figure 1. Nonmetric multidimensional scaling (NMDS) ordination of American sycamore (filled symbols) and Japanese knotweed (open symbols) across three sites: Shady Nook Boat Ramp (BR, ○), Sunbury Generation Power Plant (PP, ▢) and Sunbury Boat Ramp (SBR △). Ellipses indicate site-species groupings.

Table 2. Percent representation of functional feeding groups for Japanese knotweed and American sycamore at all samples sites. *N* represents total number of taxa.

Site	Leaf species	Collector/gatherer (%)	*n*	Scraper (%)	*n*	Predator (%)	*n*	Shredder (%)	*n*	Filter/collector (%)	*n*
BR	Sycamore	95.88	9	1.72	4	0.69	2	0.86	2	0.86	2
	Knotweed	91.72	8	3.64	7	1.66	3	1.99	2	0.99	2
PP	Sycamore	90.31	9	2.26	7	1.94	6	1.62	2	3.88	7
	Knotweed	89.27	9	3.95	8	2.64	8	3.39	3	0.75	3
SBR	Sycamore	84.51	10	2.15	10	1.00	8	7.29	3	5.06	7
	Knotweed	86.16	14	3.97	7	1.83	9	3.97	3	4.07	6

Functional feeding group representation was similar between Japanese knotweed and American sycamore leaf packs across sites. Within American sycamore leaf packs across sites, community assemblages were composed of collector/gatherers 85%–96%, scrapers 2%, predators 1%–2%, shredders 1%–7% and filter/collectors 1%–5% (Table 2 and Figure 2). Within Japanese knotweed leaf packs, collector/gatherers represented 86%–92%, scrapers 4%, predators 2%–3%, shredders 2%–4% and filter/collectors 1%–4% of the community assemblage (Table 2 and Figure 2). Across all sites and species, leaf packs were dominated by the collector/ gatherer guild (primarily Chironomidae and *Gammarus*).

Decomposition

American sycamore leaves lost a significantly greater proportion of organic mass than Japanese knotweed leaves during the exposure period, and therefore decomposed at a faster rate (Figure 3; $p = 0.0015$). American sycamore litter lost 88% of organic mass, on average, over the exposure period. Comparatively, Japanese knotweed litter lost 62% of organic mass.
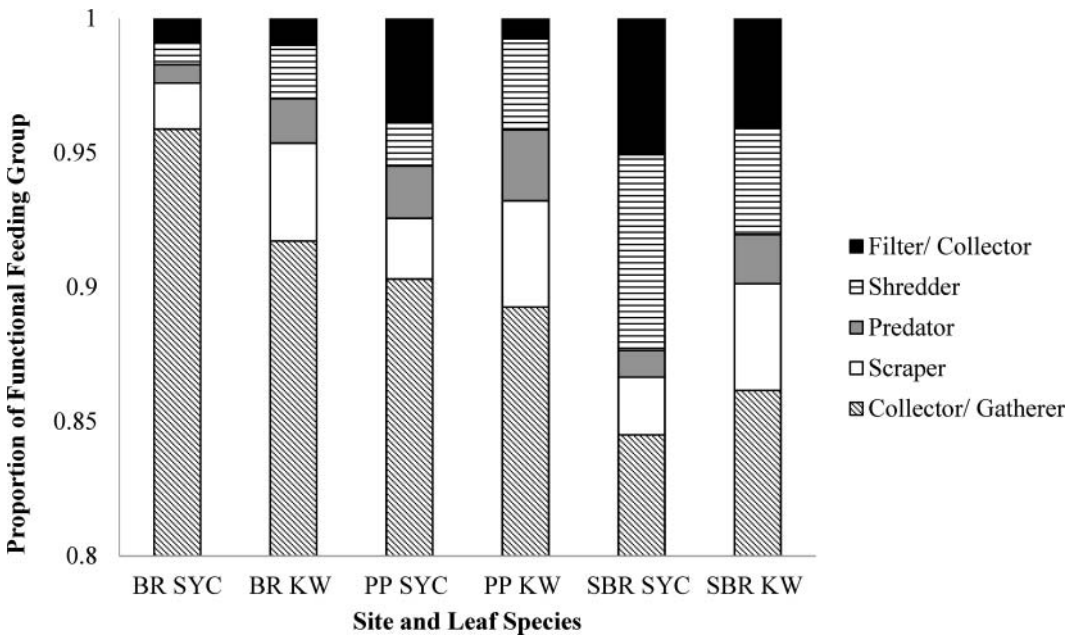

Figure 2. Proportion of functional feeding groups represented in benthic macroinvertebrate communities of all sites. Scale represents proportion of functional feeding group present from 0.8 to 1.
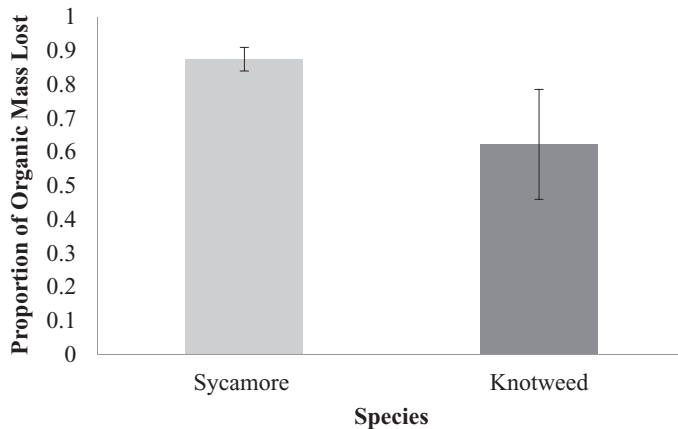
Figure 3. Mean proportion of organic mass lost of Japanese knotweed and American sycamore across all sample sites using initial dry mass and ash-free dry mass. Error bars represent standard deviation.

Discussion

American sycamore is a dominant riparian tree species in the Susquehanna River watershed but Japanese knotweed has aggressively invaded the riparian understory (Christopher 2014). Community invertebrate assemblages between Japanese knotweed and American sycamore experimental leaf packs were similar in average community composition and average beta-diversity at all sites. Species richness, or number of taxa represented, was similar between Japanese knotweed and American sycamore. American sycamore lost significantly more organic mass, and decomposed at a faster rate, than knotweed during the exposure period.

Similar community composition and beta dispersion suggest that there are taxa able to readily utilize invasive Japanese knotweed in this aquatic system. Invertebrate selection of detritus to utilize for food and habit indicates a long-term alteration of the ecosystem after the establishment of an exotic plant (Hladyz et al. 2011; Wiegner et al. 2013; Christopher 2014). However, Lecerf et al. (2007) and Christopher (2014) suggest that co-evolutionary history between Japanese knotweed and aquatic detrital consumers may not be necessary to support efficient trophic dynamics. Our study found that in a large river ecosystem, Japanese knotweed is readily utilized as habitat and as a food source by invertebrates as there seems to be no substrate or food source specificity between Japanese knotweed and American sycamore. This is in agreement with the results of Lecerf et al. (2007) and Christopher (2014) in previous stream studies.

A large proportion of the invertebrates found in both American sycamore and Japanese knotweed leaf packs were collector/gatherers, specifically, Chironomidae (72% and 54% of total individuals represented, respectively), indicating that the majority of species found within the experimental leaf packs were utilizing it as refugium, and not necessarily contributing to decomposition. Due to the order of this system, most individuals inhabiting the experimental packs might not be participating directly in litter processing as they would in headwater streams – explaining the low abundance of shredders, which are the greatest contributors to decomposition, acting as the catalyst for nutrient cycling processes within aquatic ecosystems (Gallo 2003; Serra et al. 2013). This is in agreement with the River Continuum Concept, that primary energy inputs come from fine particulate organic matter upstream (evidenced by the dominance of collector/gatherer), and that local organic inputs are less important (evidenced by the lack of shredders).

We found that American sycamore leaves decomposed faster than Japanese knotweed leaves during the exposure period, determined by calculating the proportion of organic mass lost. Because community assemblage was similar, including the shredder composition, microbial and fungal activity could be responsible for the differences in litter breakdown rates. The NWH (Callaway and

Ridenour 2004; Medina-Villar et al. 2015) suggests that Japanese knotweed, an exotic species, could repel native colonizers and consumers due to the physical and chemical composition of the leaf material. Because microbial colonization is a key process in leaf litter breakdown (Webster and Benfield 1986), it can be suggested that American sycamore may be more palatable to microbes due to its native status, which could explain its faster breakdown rate. In future studies, exploring the differences between Japanese knotweed and native leaf species in the Susquehanna River watershed, observing microbial abundance through ergosterol content (Lecerf et al. 2007; Christopher 2014; Medina-Villar et al. 2015), could reveal further explanation to the differences in breakdown rates of local exotic and native species, and determine whether the Novel Weapons Hypothesis is applicable to Japanese knotweed in this geographic location.

Previously conducted experiments examined the influence of Japanese knotweed on streams (Braatne et al. 2007; Lecerf et al. 2007; Claeson et al. 2013; Christopher 2014). These studies found that leaf decomposition and macroinvertebrate assemblages were similar between invasive Japanese knotweed and native riparian litter. This suggests that in stream ecosystems, Japanese knotweed fulfills a similar detrital function to native litter and is able to be readily utilized in ecosystem processes.

Our study provides a preliminary assessment of exotic Japanese knotweed invasion on key river ecosystem functions, paralleling it with previous research conducted on streams. To further study the effects that Japanese knotweed has on a large river ecosystem, it would be beneficial to observe the effects of water quality and chemistry above and below Japanese knotweed invasion stands (Hladyz et al. 2011). Using multiple exposure time points for an entire year from litterfall to litterfall could reveal the dynamics and succession of invertebrate community structure, revealing how functional feeding groups change over time as detritus is being utilized and exploited for different purposes during different decomposition stages (Webster and Benfield 1986; Lecerf et al. 2007). This would be beneficial in comparing differences between breakdown rates within American sycamore and in Japanese knotweed. This study observed a snapshot in the decomposition timeline of these two species, and it would be informative to analyze breakdown rates from fall abscission to the next fall, where the resources sustain the invertebrate communities for an entire year (Bottollier-Curtet et al. 2011; Staelens et al. 2011). However, despite the short exposure period in this study, it was long enough to observe sizeable and diverse communities within experimental leaf packs. It would also be informative to analyze aquatic hyphomycete fungi colonization on detritus of native and exotic focal species to better understand exotic impacts such as the Novel Weapons Hypothesis (Webster and Benfield 1986; Lecerf et al. 2007). Finally, comparing Japanese knotweed to other native species (both fast- and slow-decomposers) and utilizing 'mixed' experimental packs containing both exotic and native litter, to better simulate natural detrital availability, could indicate whether Japanese knotweed has expected breakdown rates between other native riparian litter (Lecerf et al. 2007; Christopher 2014).

To conclude, our study suggests that exotic Japanese knotweed does not alter invertebrate community structure and further research must be done to determine if it is anomalous in the key ecosystem process of litter breakdown in a large river ecosystem. Riparian invasion has severe terrestrial consequences that have been thoroughly analyzed, but the consequences of exotic riparian detritus altering stream and river ecosystems has only begun to be studied.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Kaelyn J. Fogelman, BS Susquehanna University, Biology and Ecology, 2016. Fogelman is an aquatic ecologist who specializes in food web ecology. She has conducted research on the Susquehanna River, and several river basins in Central Texas including the Colorado River. In 2017, she assumed a MS position at Auburn University studying the food web ecology of threatened freshwater mussels (Family: Unionidae). She is a member of the Society for Freshwater Science, American Fisheries Society and the United States Aquaculture Society.

Michael D. Bilger, BS University of Maryland, Natural Resources and Conservation Biology, 1972; MS University of Maryland, Estuarine Invertebrate Biology, 1977. Mr Bilger has been an aquatic biologist for nearly 45 years. He started his career with the Massachusetts Division of Water Pollution Control from 1974 to 1980; US Environmental Protection Agency at the New England Regional Laboratory from 1980 to 1991; US Geological Survey from 1991 to 2006. After nearly 32 years as an environmental regulator he worked as an environmental consultant from 2006 to 2014 with EcoAnalysts. In 2006, he assumed a position as a research scientist with Susquehanna University, R.K. Mellon Foundation, Freshwater Research Initiative where he conducts aquatic research with faculty and students on stream ecology specializing in macroinvertebrate taxonomy and systematics and fish community composition in a variety of habitats ranging from small headwaters to major rivers.

Jack R. Holt, PhD from University of Oklahoma, MS from University of Oklahoma, BS from Harding University. Holt is a freshwater ecologist who studies the biology of algae and their roles in aquatic ecosystems. He and his students conduct research on the algal communities of local areas such as Penns Creek and the Susquehanna River, as well as those in Yaroslavl, Russia. He is a member of the Susquehanna River Heartland Coalition for Environmental Studies, also known as "The River Group." He and his students present their work at regional and national conferences and in journals such as the *Journal of Freshwater Ecology* and the *Journal of the Pennsylvania Academy of Science*. Holt's teaching includes systematic biology, aquatic ecology, and thought and the Natural Sciences for Honors Program students. In addition, he is the director of the ecology program. He is the director of Saturday Science, a hands-on science experience for local elementary students and teachers in training. The program has been funded by Pennsylvania Space Grant since 1993. A collection of essays that he wrote as part of his duties in Saturday Science has been published as Paths of Science, which is now in its second edition. Saturday Science also provides scholarships for students to study with him in Yaroslavl, Russia, for four to five weeks during the summer.

David P. Matlaga is a plant population ecologist interested in the evolution of plant reproductive strategies. He and his students investigate the common mixed reproductive strategy used by plants of reproducing by making both sexual (seeds and seedlings) and clonal offspring (plantlets, bulbils, etc.). The question underlying Matlaga's research is: Why do many plants make both sexual and clonal offspring? Recent publications include: "Age-dependent vital rates of the bioenergy crop Miscanthus × giganteus in Illinois" published in *Invasive Plant Science and Management* and "Context-dependent pollinator limitation in stochastic environments: When does increased seed set overpower the cost of reproduction in an understory herb?" published in the *Journal of Ecology*. Matlaga's teaching includes Ecology, Evolution and Heredity, and Ecosystems. He is a member of the Botanical Society of America, Ecological Society of America, and the Association of Tropical Biology and Conservation.

ORCID

Kaelyn J. Fogelman http://orcid.org/0000-0002-1270-7383

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Appendix. Taxa list, individual counts and functional feeding guilds (FFG) of benthic macroinvertebrates found in American sycamore and Japanese knotweed leaf packs across all sample sites

Phylum	Class	Order	Family	Genera	Sycamore	Knotweed	FFG
Annelida	Oligochaeta		Naididae		76	122	CG
			Lumbricina		0	4	CG
	Hirudinea		Erpobdella		0	1	PR
	Clitella	Branchiobdellida	Branchiobdellidae		1	0	CG
		Collembola	Hypogastruridae		0	1	CG
Arthropoda	Arachnida	Acari	Hydracarina		1	1	PR
	Crustacea	Decapoda	Cambaridae	Orconectes	4	1	CG
		Amphipoda	Gammaridae	Gammarus	186	425	CG
			Crangonyctidae	Crangonyx	11	21	CG
	Crustacea	Isopoda	Asellidae	Caecidotea	34	30	CG
	Insecta	Coleoptera	Elmidae	Macronychus	6	11	SC
				Dubiraphia	0	4	SC
				Stenelmis	2	6	SC
				Optioseruus	1	2	SC
				Ancyronyx	1	0	CG
				Promoresia	1	0	SC
			Hydrophilidae	Berosus	0	1	PR
		Diptera	Chironomidae		1826	1163	CG
			Empididae	Hemerodromia	1	2	PR
				Chelifera	8	9	PR
			Simuliidae	Prosimulium	2	0	FC
		Ephemeroptera	Caenidae	Caenis	10	20	CG
			Ephemerellidae	Ephemerella	53	63	CG
				Eurylophella	3	1	SC
				Serratella	1	3	CG
			Isonychiidae	Isonychia	13	15	CG
			Heptageniidae	Maccaffertium	5	9	SC
				Stenacron	22	19	SC
				Unknown	1	10	SC
			Baetidae	Baetis	2	0	CG
				Unknown	1	1	CG
			Ephemeridae	Hexagenia	0	3	CG
			Potamanthidae	Anthopotamus	0	1	CG
		Megaloptera	Corydalidae	Nigronia	0	1	PR
				Corydalus	1	0	PR
			Sialidae	Sialis	0	1	PR
		Odonata	Coenagrionidae	Argia	1	4	PR
			Coenagrionidae	Unknown	1	1	PR
			Corduliidae	Epitheca	1	0	PR
			Macromiidae	Macromia	2	1	PR
			Gomphidae	Dromogomphus	0	1	PR
				Gomphus	0	1	PR
		Plecoptera	Perlidae	Paragnetina	2	0	PR
				Acroneuria	4	0	PR
				Agnetina	0	1	PR
			Taeniopterygidae	Strophopteryx	83	34	SH
			Nemouridae	Amphinemura	5	5	SH
				Prostoia	5	4	SH
			Perlodidae	Isoperla	0	7	PR
				Unknown	1	0	PR
			Unknown	Unknown	0	1	PR
		Trichoptera	Limnephilidae	Pycnopsyche	17	25	SH

Phylum	Class	Order	Family	Genera	Sycamore	Knotweed	FFG
			Hydropsychidae	Cheumatopsyche	45	23	FC
				Hydropsyche	10	8	FC
			Philopotamidae	Chimarra	5	2	FC
			Hydroptilidae	Oxyethira	1	1	CG
				Hydroptila	1	1	SC
			Polycentropodidae	Polycentropus	4	1	FC
				Neureclipsis	21	11	FC
			Uenoidae	Neophylax	2	0	FC
			Leptoceridae	Triaenodes	0	1	SH
				Ceraclea	0	1	CG
Mollusca	Bivalvia		Corbiculidae	Corbicula	4	3	FC
			Sphaeriidae	Sphaerium	2	2	FC
	Gastropoda		Ancylidae	Ferrissia	6	5	SC
			Physidae	Physa	2	11	SC
			Pleuroceridae	Leptoxis	1	0	SC
				Pleurocera	0	3	SC
			Lymnaeidae	Pseudosuccinea	1	0	SC
Platyhelminthes	Turbellaria				6	9	PR
				Total	2506	2118	