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Abstract:

The Asian knotweed complex gathers some of the world's most successful plant invaders including the Japanese knotweed (*Reynoutria japonica*), the giant knotweed (*R. sachalinensis*) and the hybrid of these two species species, the Bohemian knotweed (*R.* × *bohemica*). Hybrid species often present higher competitive abilities compared to their parent species. While several studies have focused on the effects of knotweed invasion on plant communities, few have simultaneously considered i) effects of the three taxa on native plant communities and ii) effects on litter and soil faunal components. In this study, we compared the differential effects of three Asian knotweeds on vegetation and soil macroinvertebrates communities across seven sites on a regional scale in North Western France. All three knotweed species displayed similar negative effects on local plant species richness, while promoting the taxonomic richness of litter-dwelling macroinvertebrates. Belowground macroinvertebrate taxonomic richness appeared reduced by the presence of the hybrid *R.* × *bohemica*, more so than those of sites colonized by *R. japonica* or *R. sachalinensis*. These changes of belowground communities were correlated to associated changes of composition and richness within plant communities. This study provides new insight into the consequences of ecosystem invasion by these species, especially revealing the even further strength of impacts of the hybrid Bohemian knotweed on local vegetation and belowground macroinvertebrates than those of other Asian knotweeds, which points to the need for monitoring the spatial spread of *R.* × *bohemica* and describing further its effects on ecosystem properties.

Keywords: *Fallopia*, Japanese knotweed, invasive species, litter fauna, soil fauna, macroinvertebrates

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Introduction

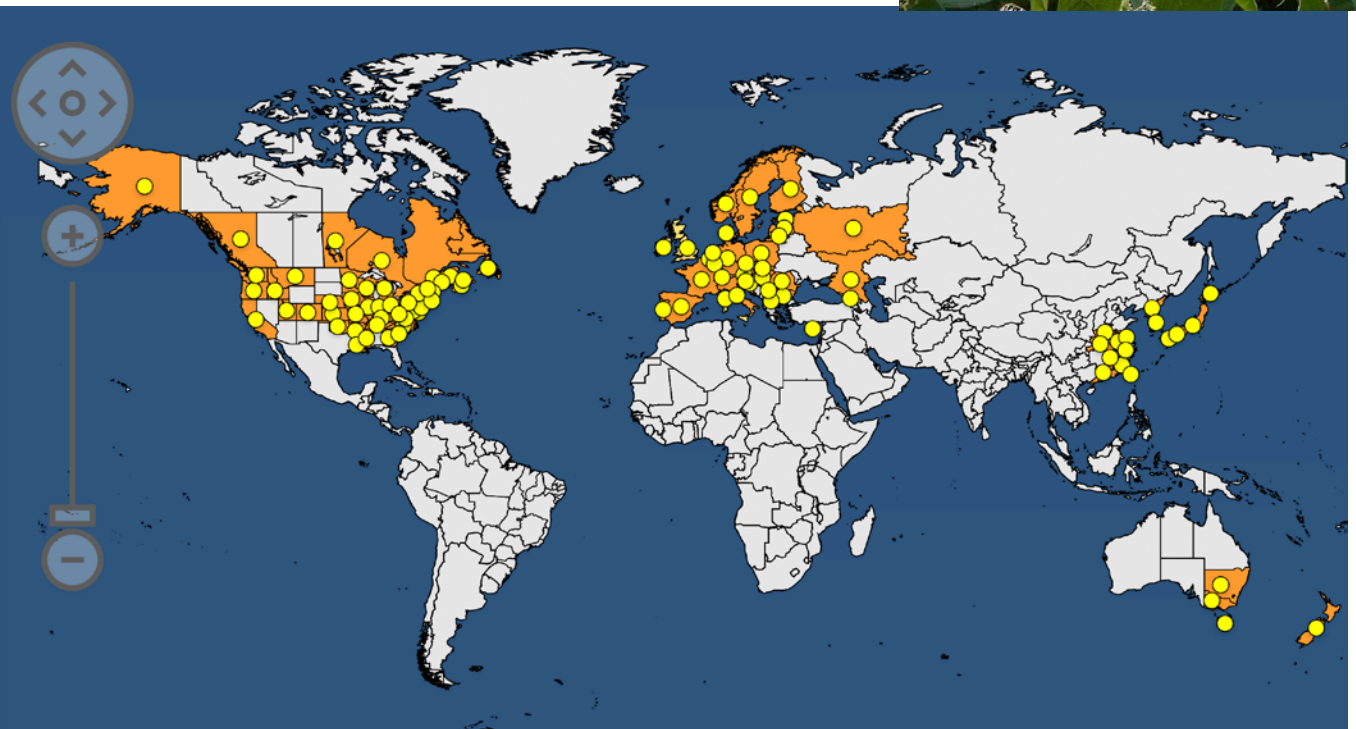
The Asian knotweed species are invasive in Europe, North-America and Australia, and are cited among the world's worst invasive species.

Three species have been described:

- Japanese knotweed (*Reynoutria japonica*)
- Giant knotweed (*Reynoutria sachalinensis*)
- Bohemian knotweed (*Reynoutria* × *bohemica*)

(Invasive Species Specialist Group, 2016; Barney *et al.* 2011)

https://cbnfc-ori.org



Synonyms encountered in the literature:

- *Reynoutria japonica*
- *Fallopia japonica*
- *Polygonum cuspidatum*

EPPO Global Database

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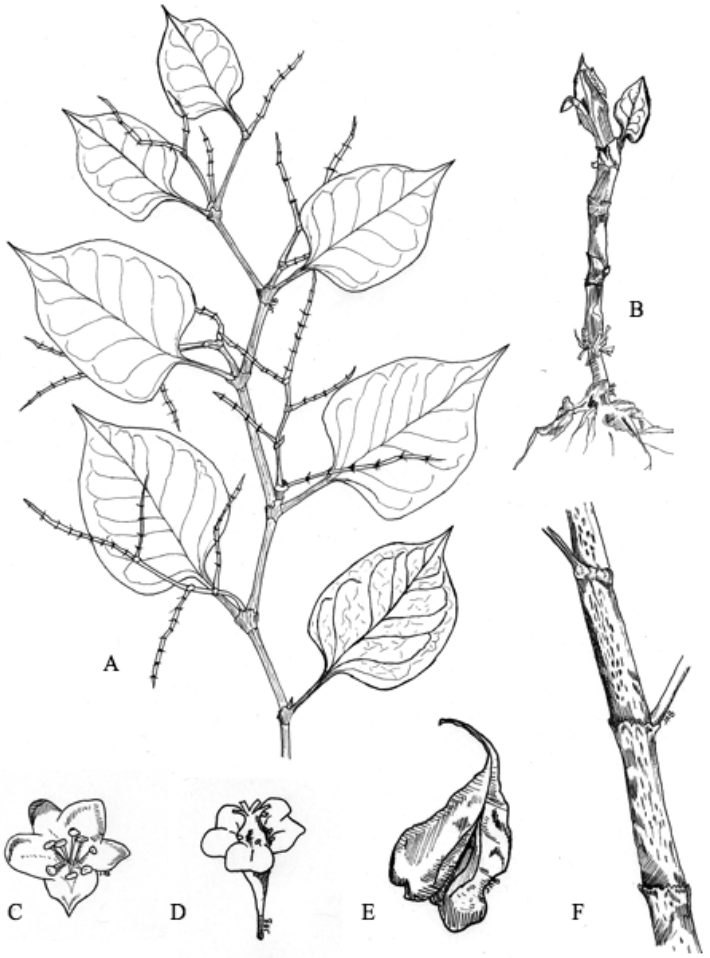
Introduction



Polygonum cuspidatum A. flowering stalk after fruit shed; B. emerging ramet from rhizome fragment showing nodes and fibrous roots; C, male flower; D, female flower; E, winged-sheath covered trigonous-achene; F, bamboo-like stalk showing spots and ocreae (Drawings by J. N. Barney) (Barney *et al.* 2011)

The aims of this study:

- To describe the impact of knotweed invasion on belowground macroinvertebrates, which is largely absent from the body of literature .
- To compare the effects on native communities of the three knotweed taxa; the hybrid *R.* × *bohemica* has been proven to be the most invasive of the the three, so we expected it to modify the invaded communities more heavily.

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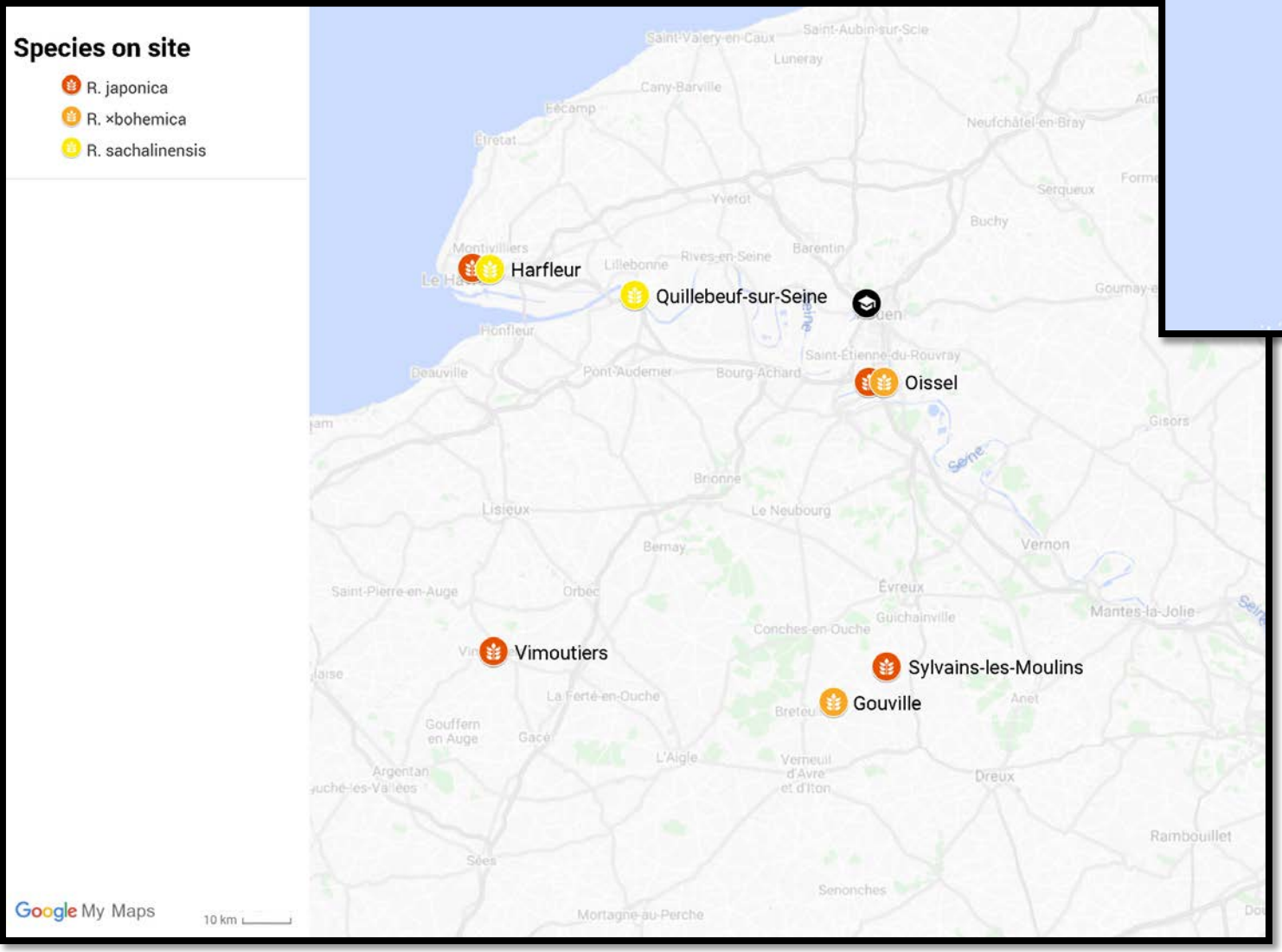
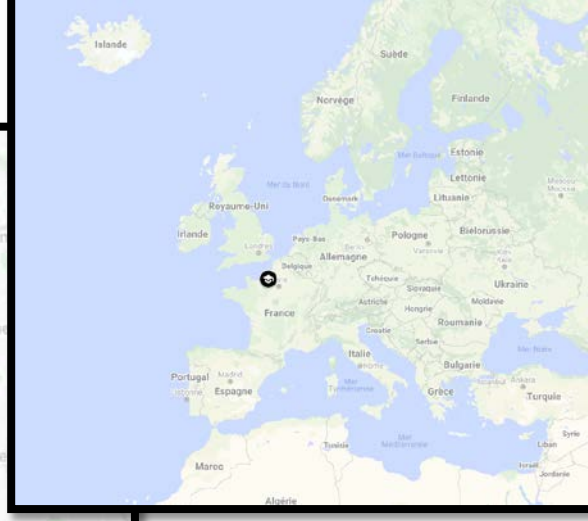
Material & Methods





6 study sites have been sampled in Normandy, Northern France, all invaded by Asian knotweed.

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On each site, samples were collected in *invaded* (see green area above) and *uninvaded* plots in close vicinity. In each of both areas, we placed:

- 5 plots for **vegetation surveys** (1m²), using the Braun-Blanquet method;
- 3 plots for invertebrate macrofauna sampling, where we collected invertebrates in a 25 × 25 cm area in:
  - The **litter compartment** (OL, OF & OH),
  - The **superficial 20 cm of soil**.

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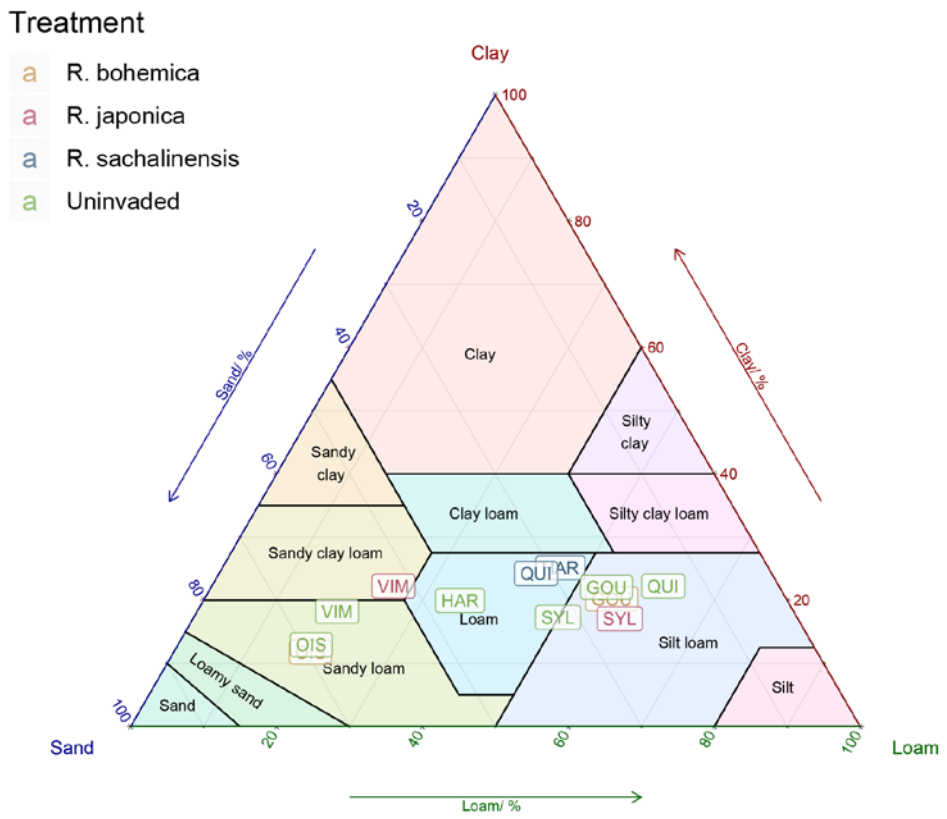
Material & Methods



The table shows that the soils of the six selected sites present similar physico-chemical parameters, which is necessary to compare results across sites. The diagram also shows that within each site, the invaded areas present a similar soil texture to the uninvaded areas, validating our choices.

Soil texture (above) and physico-chemical parameters across the six study sites (below)

pH	Organic C content (%)	Total N content (%)	Native litter amount (cm)	Invaded litter amount (cm)
6.03 - 8.00	1.42 – 5.46	0.12 – 0.55	0 – 5.6	0.7 – 14.9

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Results and Discussion

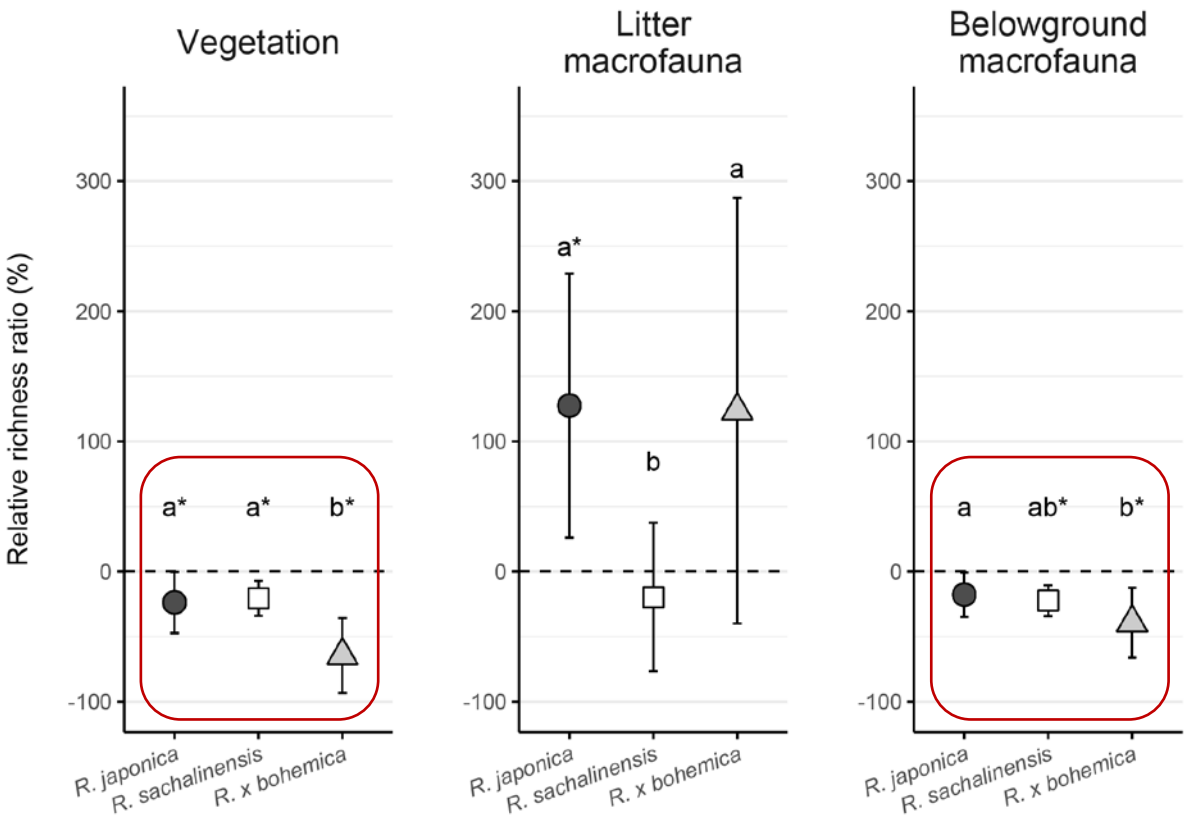

Figure 1. Relative taxonomic richness ratio (%) according to invader species. RRR that differ statistically from zero (M.-W. test, $\alpha = 0.05$) are marked with an asterisk. Within each of the three compartments, differences between the knotweed species are labelled with the group-letters from a Kruskal-Wallis test ($\alpha = 0.05$).

We found a significative reduction of plant species **richness** in invaded plots, accompanied by a similar reduction of belowground macrofauna. In those two compartments, *R.* × *bohemica* had the strongest impact on native communities.

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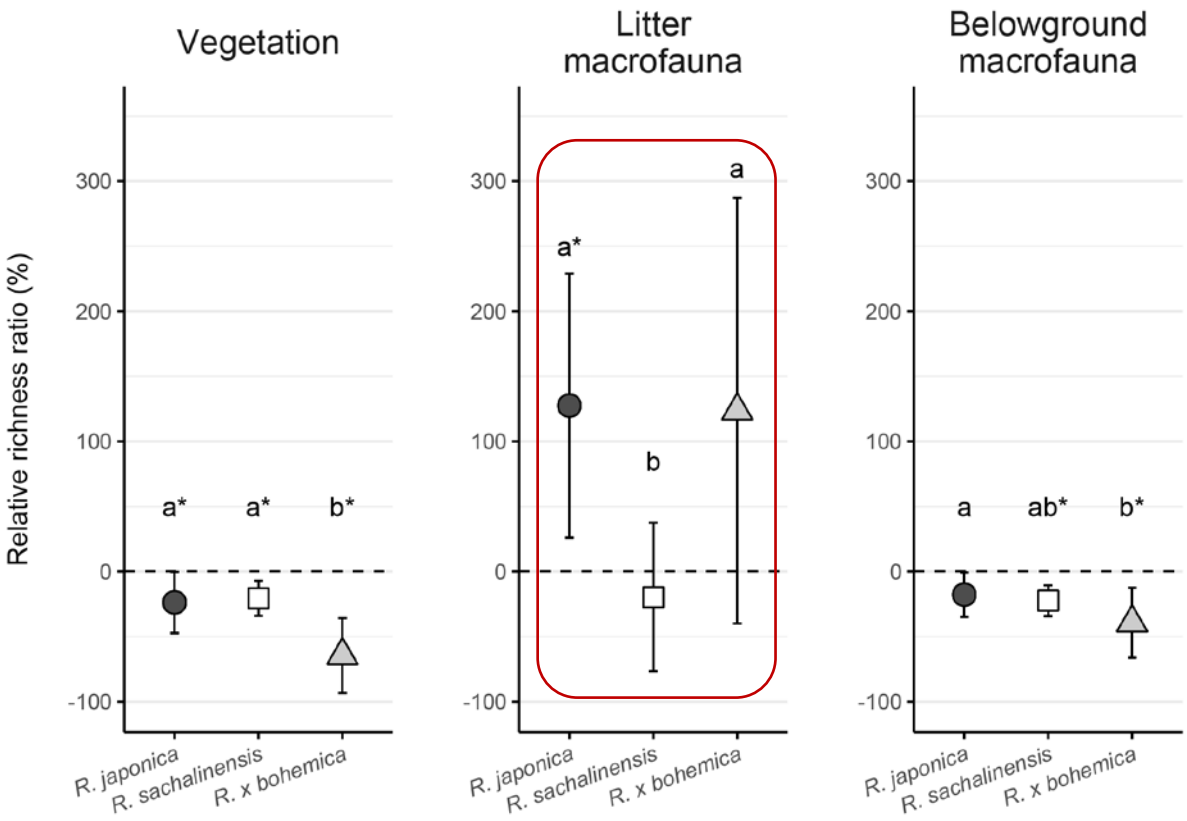
Results and Discussion



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The response of litter macrofaunal communities to knotweed invasion was more heterogenic, with a promotion of species richness caused by *R. japonica* and *R. sachalinensis*.

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Results and Discussion

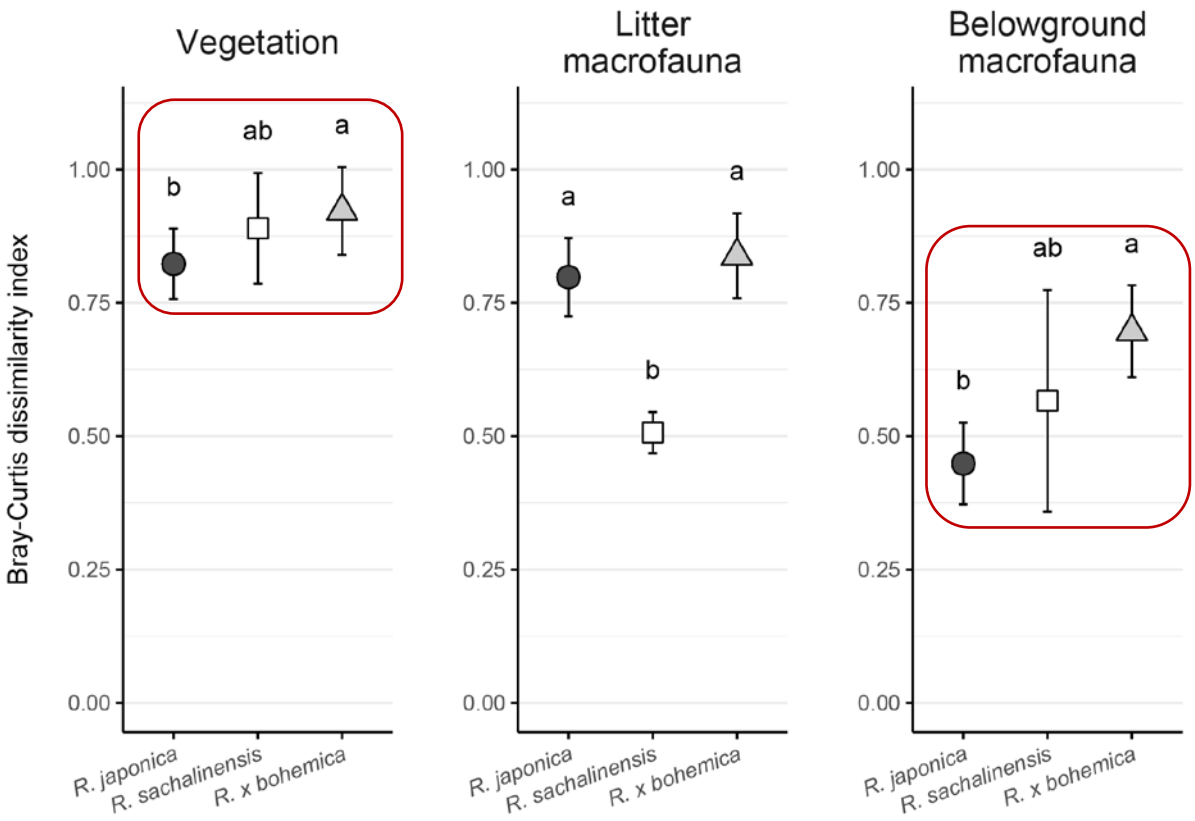

Figure 2. Bray-Curtis dissimilarity index of invaded communities compared to the native communities. Within each of the three compartments, differences between the Reynoutria species are labelled with the group-letters from a Kruskal-Wallis test (α = 0.05).

Plant **community composition** appeared to be heavily modified by invasion of the Asian knotweeds, with *R.* × *bohemica* displaying the strongest effect once more. The pattern of alteration of plant communities is mirrored by the belowground macrofauna, which presents the same pattern across knotweed species, albeit slightly attenuated (Pearson's correlation test; r = 0.86, p = 0.01).

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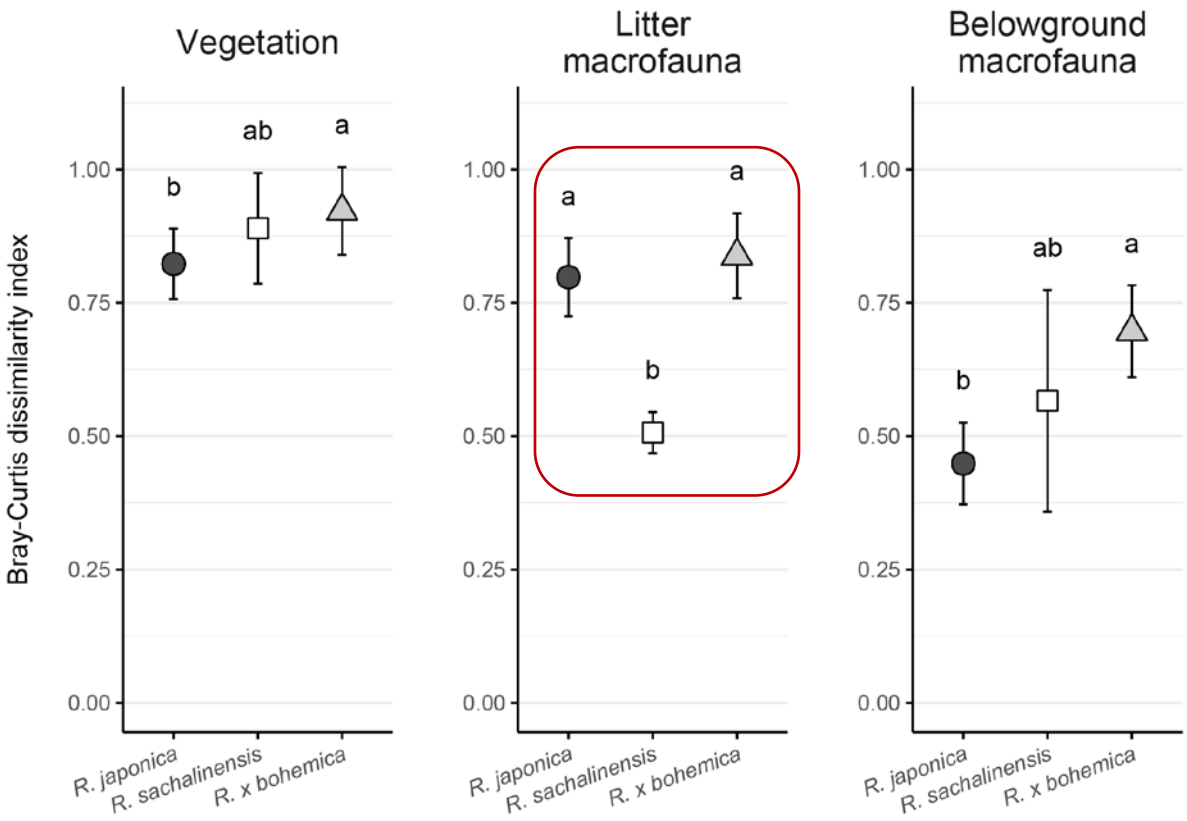
Results and Discussion



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Litter macrofaunal communities are also heavily alterated, but *R. sachalinensis* does not present a lower impact as the two other species.

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Discussion

Effects of knotweed invasion on plant communities

We observed a strong reduction of native plant richness (up to 93.3%, in agreement with a consistent body of literature), and a heavy alteration of community composition, capable of reaching a complete dissimilarity between native and invaded assemblages.

We also found that *R.* × *bohemica* had the strongest negative effect on native plant communities. Previous studies have shown that the hybrid knotweed had a higher biomass production and inhibited native biomass more than its parent species.
(Chmura *et al.* 2015; Parepa *et al.* 2014)

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Discussion

Effects of knotweed invasion on litter-dwelling communities

Overall, our samples of litter-dwelling macroinvertebrates yielded heterogeneous results regarding the effect of knotweed invasion on species richness. This can be due to the fact that knotweed invasion **creates a new litter habitat**, different from the (sometimes absent) litter material of the uninvaded grasslands. This resulted in a promotion of taxonomic richness in the case of invasion by *R. japonica* and *R.* × *bohemica*.

We found that *R. sachalinensis* had the weakest impact on these communities compared to the other two species. This might be explained by the initial non-invaded communities of the different study sites. Sites invaded by *R. sachalinensis* presented more diverse initial communities of litter-dwelling macroinvertebrates than the sites invaded by *R. japonica* and *R.* × *bohemica*.

R. sachalinensis has also been proven to be more susceptible to herbivory than the other species, resulting in a potentially lesser accumulation of litter.
(Krebs et al. 2011)

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Discussion

Effects of knotweed invasion on belowground communities

Our study revealed that the three Asian knotweed species have negative effects on the taxonomic richness of belowground macrofauna as well as on their community composition. Once again, *R.* × *bohemica* impacted native communities the most. We also found a strong correlation between the impact of each knotweed species on plant communities and on belowground macroinvertebrate communities. This symmetry of effects has been described before. (Krebs et al. 2011)

These findings suggest an indirect alteration of belowground communities through the modification of plant communities, possibly due to the reduction of trophic resource diversity. Interestingly, there was no such relation between above-ground and belowground macroinvertebrate communities, implying a disruption of the trophic link between those two compartments of our study sites through knotweed invasion. Such a difference between responses of invaded soil compartments has been described for other invasive plants such as *Arundo donax* L., 1753 and *Impatiens glandulifera* Royle.
(Tanner *et al.* 2013; Herrera *et al.* 2003)

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Conclusion

We found a dramatic reduction of plant species richness and heavily modified plant communities, which were positively correlated to the changes in belowground macroinvertebrate communities and presented the same order of magnitude. The response of the litter compartment presented very heterogeneous results but were mostly positive in terms of taxonomic richness and unrelated to the alteration of vegetation or belowground macroinvertebrates. Additional research is needed to disentangle and quantify the consequences of knotweed invasion on the litter and belowground compartments (ideally on a greater geographical scale), and to describe the alteration of trophic networks in the invaded ecosystems. Furthermore, we found that the negative impact of the hybrid *R.* × *bohemica* on native vegetation and belowground macroinvertebrates was generally stronger than those of *R. japonica* and *R. sachalinensis*, confirming the results of numerous previous studies. The hybrid knotweed appears therefore to pose an even larger threat to invaded ecosystems than its two parent species. Knowing that its actual spread is insufficiently documented, it appears necessary to increase efforts to monitor its dispersion (especially with the hybrid's ability to reproduce sexually), and to describe the differences between knotweed taxa in greater detail in order to devise adapted management techniques.

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Acknowledgments

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