Articoli

Climatic suitability of the accidentally introduced leaf beetle *Ophraella communa* in Europe: a potential biological control candidate for ragweed

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Summary - The distributions of an invasive alien plant species and of its potential biocontrol candidate are modelled simultaneously and both under current and future climatic conditions in view of predicting the high suitability of the candidate for specific geographic areas in the invaded range.

Keywords: *Ambrosia artemisiifolia,* biological invasion, climate change, species distribution model

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Introduction

Biological control using natural antagonists has been a most successful management tool and is currently the curative and sustainable control measure of choice against alien invasive plants, owing to its effectiveness and relatively high environmental safety (Mueller-Schaerer and Schaffner 2008). The selection of candidate agents remains a critical step in a biocontrol program before more elaborate and time-consuming experiments are conducted. Species distribution models (SDMs) provide statistical inference on drivers of species ranges by relating geo-located observations of occurrence data to environmental variables that contribute to a species' survival and propagation (Guisan and Zimmermann, 2005). A number of studies showed that biocontrol agents with an optimal climatic match between home and release locations established better and became more efficient than agents with a less good match (Hoelmer and Kirk 2005). SDMs predicting suitable areas and potential future spread of invasive alien plants, together with their biocontrol candidates, have thus become an important tool in successful invasion management. Here we propose a biogeographic approach to identify the cover of *Ambrosia artemisiifolia* (common ragweed), native to North America (NA) and invasive worldwide, by the accidentally introduced biocontrol candidate, *Ophraella communa*, for the invasive European (EU) range of ragweed, both under current and future bioclimatic conditions.

Materials and Methods

We collected all available occurrences for *A. artemisiifolia* and *O. communa* worldwide. We used WORLDCLIM climate data at 5 minutes spatial resolution to derive a set of meaningful predictors that are considered critical to plant or insect physiological functions and survival of our species. Ordination techniques were used to explore climatic constraints of each species and to perform niche overlap tests with ragweed.

Results

Within the 150 years after its introduction into central Europe (Essl et al. 2015), the range of *A. artemisiifolia* already extends well above the 50° latitude (Fig. 1), which corresponds to climatic conditions at the very northern limit of the distribution in North America. Under climate change, *A. artemisiifolia* is expected to expand its range in Europe even further North and East, whereas its native range is predicted to expand very little (Fig. 1). Model predictions based on current climate and four future climate scenarios indicate a relatively large overlap in climatic space between *O. communa* and *A. artemisiifolia*, but a considerable discrepancy in geographic range overlap between EU and NA (18.1% & 62.0% for current climate respectively, and 7.6% & 52.0% for future climate respectively). The geographic overlap between *O. communa* and *A. artemisiifolia* is expected to decrease under climate change in both ranges Fig. 1).

Discussion

Cover of the *A. artemisiifolia* area by *O. communa* is far higher in the native NA as compared to the introduced EU range. Large areas in EU are unsuitable for *O. communa*, while few areas were predicted to be unsuitable for *O. communa* in NA. These unsuitable EU areas are located in Central, Western and Northern Europe, where *A. artemisiifolia* faces lower temperature seasonality and more precipitation compared to the main conditions occupied in NA. This is likely due to the effects of the Gulf Stream, which strongly buffers the climate of Western and Northern EU. Hence, limitation of insect presence by climate appears a likely explanation, but no differentiation between the plant invader and its potential agents are found in the climatic space, as those EU habitats are rare in NA, but still exist. Moreover, this might be due to niche unfilling and expansion of *A. artemisiifolia* in EU and the fact that habitats with high *A. artemisiifolia* occurrences in EU are rare in NA and predicted to be unsuitable for *O. communa*.

Our analyses also identified abiotic conditions, to which adaptation would be needed in order to result in climatically adapted strains for particular regions, where *A. artemisiifolia* is currently unlikely to be controlled. For this, genetic variation in relevant performance traits will be crucial. Measures of genetic variation in functional traits, however, have rarely been studied in biocontrol agents to predict their evolvability. Previous research with *O. communa* did, however, find genetic variation in relevant performance traits. For example, Tanaka (2009) found genetic variation for flight activity and Tanaka et al. (2015) reported rapid evolution in photoperiod response to environmental conditions in different colonized regions, both indicating the potential for local adaptation to different abiotic conditions. In line with these findings, Zhou et al. (2013) were able to select for strains of *O. communa* adapted to colder temperatures by cold acclimation in previous generation to facilitate their range expansion towards Northern China and thus to track their host-plants into colder climate. This indicates the potential to select for strains that could cover the *A. artemisiifolia* range in Northern Europe presently unsuitable for the insects.

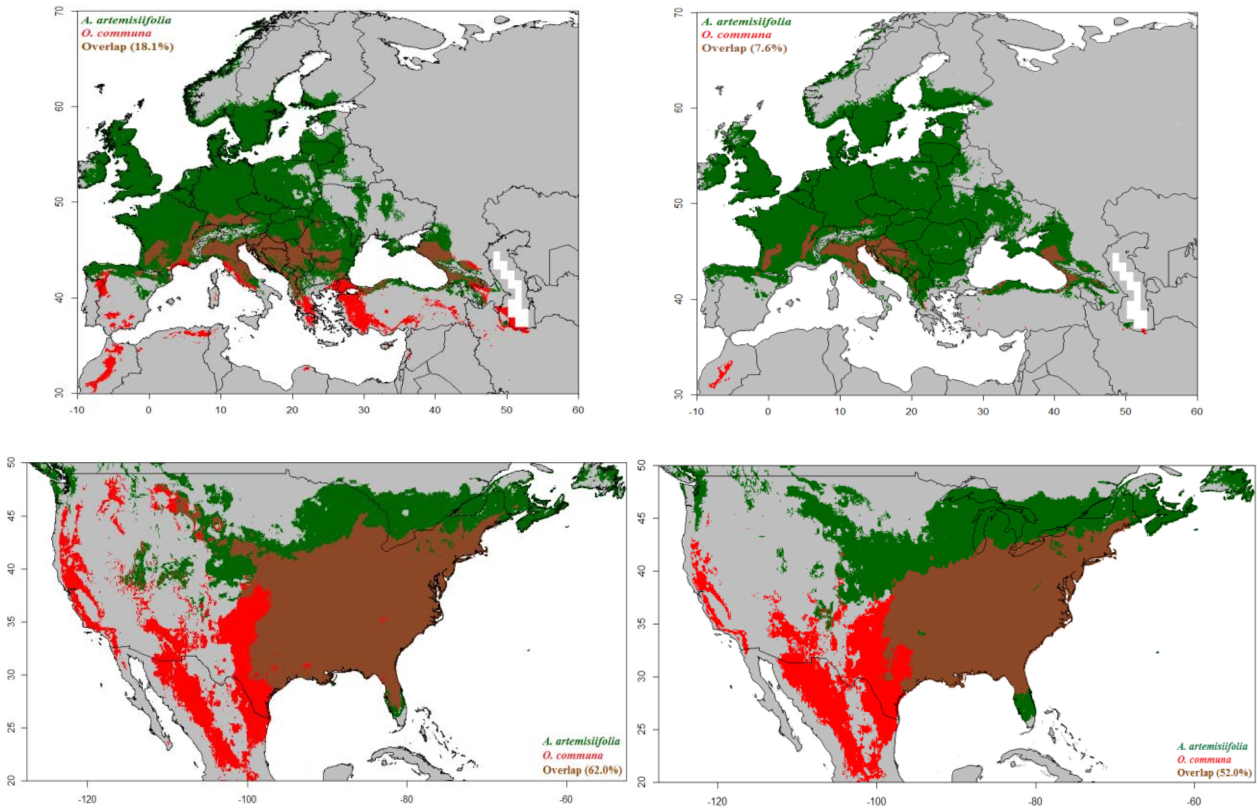

Fig. 1
Geographical predictions of *A. artemisiifolia* and its potential biocontrol agent *O. communa* under present (left) and future (right) climatic scenarios. The climatic suitability (dark green, red) indicates the optimal threshold of the percentage of models predicting each species. The "overlap" region of the invasive *A. artemisiifolia* with *O. communa* is also given (sienna and the overlap percentage). Models calibrated in Europe only (top) and models calibrated in USA only (bottom).

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