Evolutionary imbalance hypothesis may explain global plant invasions

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Credit: University of Konstanz

Human activities—for example, global trade and travel—are driving the spread of plants beyond their natural ranges and around the globe.

However, not all species benefit equally from these movements; only some are able to successfully establish populations (i.e., naturalize) in new locations. Data on the global distribution of alien plants reveal that plants originating from certain geographic regions are more successful at naturalizing than others.

The evolutionary imbalance hypothesis (EIH) offers possible explanations for this phenomenon, but has not yet been verified on a global scale. An international research team led by biologist Mark van Kleunen from the University of Konstanz has now succeeded in confirming key predictions of this hypothesis using extensive global data.

In their study published in *Nature Ecology & Evolution*, the researchers also discover intriguing similarities in the origins of plants that successfully establish populations outside their natural ranges and those that humans have selected for cultivation and economic use—suggesting that biogeographic factors influence biological and cultural systems in similar ways.

Dating back to Darwin

At its essence, the ideas of the EIH date back to Charles Darwin. "Darwin proposed that geographic barriers divide the Earth's ecosystems into various evolutionary arenas," says Trevor Fristoe, first author of the study and ecologist at the Department of Biology at the University of Konstanz.

Within each of these arenas, the organisms inhabiting them would be exposed to unique geographic and ecological conditions that influence the intensity of natural selection. "The result is differences in the absolute fitness for species originating from different regions—evolutionary imbalances—and these differences have

consequences for which species are more likely to successfully establish in new areas when barriers are removed," Fristoe continues.

Based on these ideas, the EIH makes predictions about the characteristics of global regions that drive the evolution of particularly successful aliens. For example, larger regions should support larger populations and higher genetic diversity to allow for more efficient natural selection. Species-rich regions should serve as intense proving grounds where species must evolve to persist in the presence of a wide variety of competitors and enemies.

The study tested these predictions on a global scale. For this, the researchers used an unprecedented data set that included the native and alien distributions of over 99% of all known seed plants—over 330,000 species. Consistent with the EIH, they demonstrated that plants originating from vast, species-rich regions are among the most successful alien plants. "Thus, our study confirms two key predictions of the EIH on a global scale," says Mark van Kleunen, head of the international research team.

Economic plants show a similar pattern

What is more, the data revealed a previously unrecognized link between evolutionary imbalance and the economic use of plants by humans: the native range characteristics that select for successful invaders are also associated with the species that we grow for economic use.

"All else equal, humans should chose to cultivate plants with a higher capacity for survival, growth, and proliferation. This has resulted in feedbacks where species with high potential as invaders are also more likely to be intentionally moved around the globe. Our study demonstrates these intriguing links and suggests how evolutionary imbalances in biological and cultural systems may even interact," says

van Kleunen.

More information: Evolutionary imbalance, climate and human history jointly shape the global biogeography of alien plants, *Nature Ecology & Evolution* (2023). DOI: 10.1038/s41559-023-02172-z

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