Losing stream in our battle to predict and prevent invasive species

August 22 2012

This is invasive giant hogweed (*Heracleum mantegazzianum*) in the Czech Republic. Credit: Petr Pyek

Invasive species – plants, animals, and microbes introduced to regions beyond their native range – carry a global price tag of $1.4 trillion dollars. They are responsible for the loss of natural resources and biodiversity, damages to infrastructure, and an uptick in infectious diseases.

Not all non-native species pose a threat. Scientists around the world have spent the last several decades teasing apart the conditions that set the stage for debilitating invaders, like giant hogweed, zebra mussels, or gray squirrels. A number of hypotheses have emerged to help predict how natural areas will respond to introduced plants, animals, and microbes.

An analysis of 371 invasion studies using six dominant invasion hypotheses has revealed their predictive power is weakening. The paper's authors – Jonathan Jeschke, Lorena Gómez Aparicio, Sylvia Haider, Tina Heger, Christopher Lortie, Petr Pyšek, and David Strayer – found empirical support for all six hypotheses declining, with recent studies showing the lowest levels of support. Hypotheses that were too broad or omitted ecosystem interactions fared among the worst, plants proved easier to predict than animals, and, contrary to popular belief, diverse ecosystems were not inherently resistant against invaders. The study was published in the open-access journal *NeoBiota*.

These are invasive zebra mussels (*Dreissena polymorpha*) on a rock collected in the Hudson River, NY, USA. Credit: Heather Malcom

The paper's authors comment: "The observed decline effect means our confidence in making sound policy and management decisions based on the six analyzed hypotheses is lower today than it was in the past. Scientists were overly optimistic about the predictive power of these hypotheses. Given that invasive species are an expensive and ever growing problem, this is a situation that needs to be addressed."

Similar "decline effects" have been noted in other disciplines, among them pharmacological research, psychology, and animal behavior. The effect has been attributed to publication bias, inadequate sample sizes, and a tendency of early tests of hypotheses to pick study organisms or systems where positive results are expected.

This is an invasive gray squirrel (*Sciurus carolinensis*) in London, UK. Credit: Jonathan Jeschke

Lead author Jonathan Jeschke, of Technische Universität München, concludes: "The decline effect is both worrying and fascinating. It's a phenomenon that should be investigated across disciplines, as medical and psychological researchers have shown its effects can be strong, and it can distort the predictive power of hypotheses."

The paper's authors offer four solutions to improve current hypotheses in invasion biology: (1) Existing gaps in empirical tests of hypotheses should be filled. The study revealed crucial gaps in empirical studies, showing that most studies have focused on terrestrial plants but have ignored other organisms and aquatic habitats. (2) Existing hypotheses should be specified for groups of organisms and habitats. (3) Interactions

of invasive species with their new ecosystems should be regularly considered. The study shows that hypotheses considering such interactions are better supported by empirical evidence than other hypotheses. (4) Revised hypotheses should be rejected if they do not work. Those hypotheses that still lack empirical support after specification for groups of organisms and habitats (solution 2), consideration of invader-ecosystem interactions (solution 3), or another form of revision should be discarded. Scientists should not waste time and resources to continue working with these hypotheses. Instead, fresh ideas and novel hypotheses are needed to further our understanding of biological invasions – something that is essential to effective management in today's rapidly changing world.

More information: Jeschke JM, Gómez Aparicio L, Haider S, Heger T, Lortie CL, Pyšek P, Strayer DL (2012) Support for major hypotheses in invasion biology is uneven and declining. *NeoBiota* 14: 1-20. doi: 10.3897/neobiota.14.3435

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