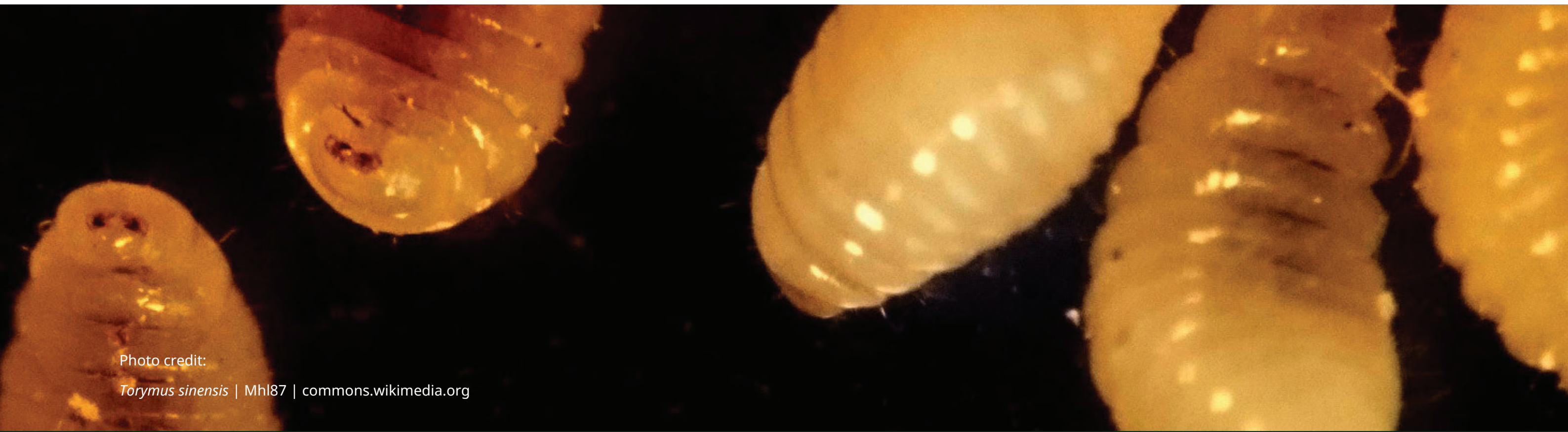
CLASSICAL BIOLOGICAL CONTROL AGAINST INSECT PESTS: WHAT INFLUENCES ITS SUCCESS?

HOLISTIC MANAGEMENT OF EMERGING FOREST PESTS AND DISEASES



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Summary

This policy brief is based on a scientific article by HOMED project partners Lukas Seehausen, Catarina Afonso, Hervé Jactel, and Marc Kenis, which was published in the open access scholarly journal *Neobiota*.

Classical biological control (CBC) relies on the introduction of natural enemies from the region of origin of the exotic target insect. It is an efficient and cost-effective tool for limiting invasive insect pests. Nevertheless, its success rates can be influenced by a variety of factors, which tend to be studied independently of each other. To get a more holistic understanding of what impacts the outcome of CBC, HOMED researchers analysed introductions regarding three levels of success: biocontrol agent establishment, impact on the target population, and complete control of the target pest. Their findings suggest that considering holistically biocontrol agent-related characteristics, the type of target pest, climatic factors and management methods, is necessary to increase the chances of successful control.

Keywords

forest insects, invasive species, pest control, natural enemies, release

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Relevance to legislation

International conventions

- **Convention on Biological Diversity**
- **International Plant Protection Convention (IPPC)**
- **Agreement on the Application of Sanitary and Phytosanitary Measures (SPS agreement)**

EU legislation

- **EU Biodiversity Strategy for 2030**
- **EU Regulation 1143/2014 on Invasive Alien Species**
- **Directive 2009/128/EC on the sustainable use of pesticides**

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Relevance to actual environmental problems

Forest threats and vitality, Biodiversity loss, Climate change, Alien species invasion, Forest pest management

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Description of the problem

Classical biological control (CBC) is a pest management method that aims to permanently control a specific exotic pest (e.g. insect), through the introduction of one of its natural enemies from the region of origin of the exotic target pest (e.g. parasitoid) (Kenis et al., 2017). Although CBC has proven to be an efficient tool for controlling invasive insect pests, including forest pests, a global analysis shows that only 30% of the targets have been properly controlled by at least one introduced natural enemy (Cock et al., 2016). These estimations raise questions as to what influences CBC's success and what can be done to increase it.

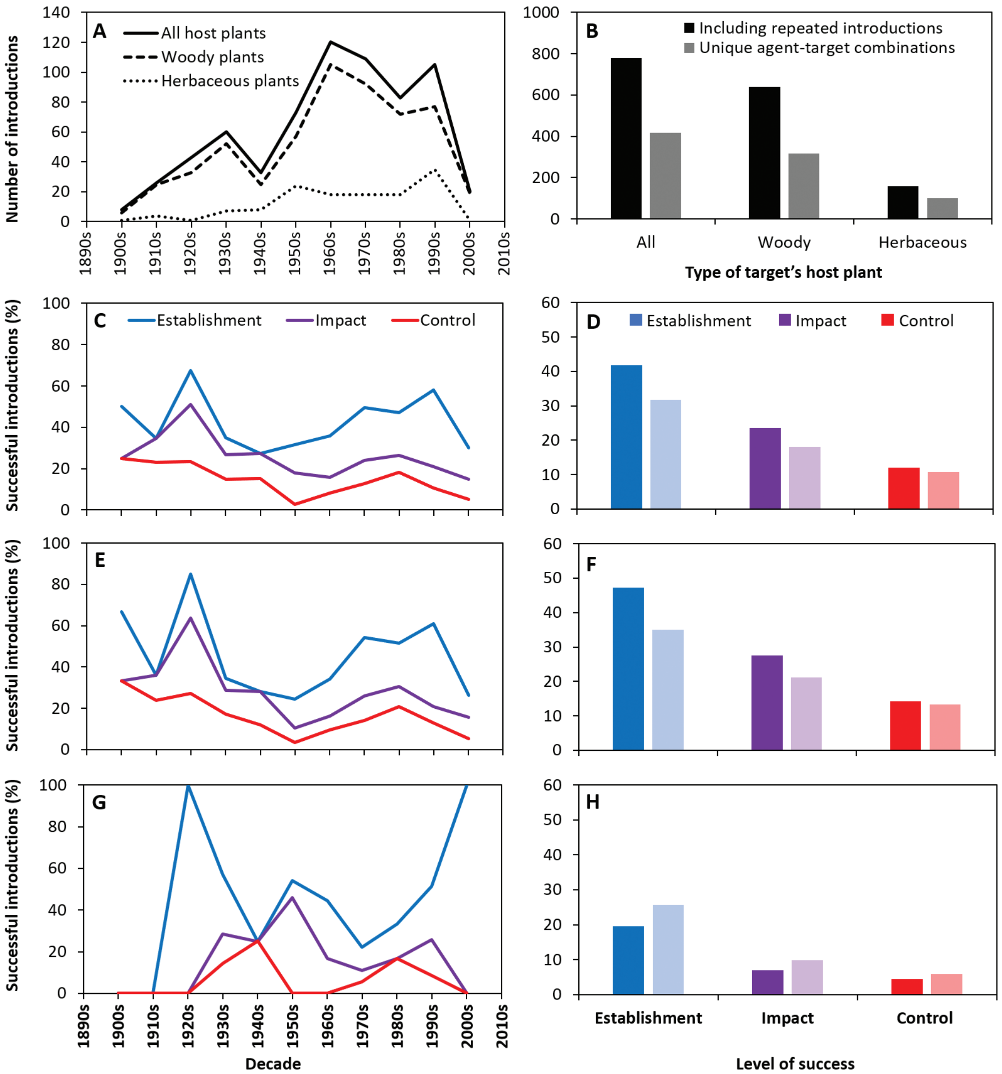
CBC is a complex process but, broadly speaking, the factors impacting its success rate can be divided into five categories: the type of biological control agent, characteristics of target host or prey, the associated host plants, the environment where introductions are made (e.g. climate conditions) and the release procedures involved, such as location or quantity, quality, and life stage of released individuals. We carried out an analysis of the relative importance of these factors to improve the success of future biological control programmes. Entries were extracted for Europe from the BIOCAT catalogue and 15 new explanatory variables were added, in relation to the characteristics of the released biological control agents, the target pests, the host plants of the target, and the number of introductions for specific agent-target combinations. Those were then analysed regarding three levels of success: biocontrol agent establishment, impact on the target population, and complete control of the target pest.

Interestingly, the overall success of CBC was considerably higher when targeting pests of woody plants, compared to those of herbaceous plants: the success of establishment was more than twice as high for woody plants (47.2 vs. 19.5%), the impact on target pests was almost four times as high (27.5 vs. 6.9%), and the control of pests more than three times as high (14.2 vs. 4.4%).

Then, a number of findings were identified, which can lead to an improved approach for biological control introductions. First, very few characteristics of the biocontrol agent in fact influence the success of control, besides the fact that parasitoids are often more effective than predators (e.g. Kenis et al., 2017). Additionally, using more specialised parasitoids (feeding on species within the same genus) results in a higher chance of complete control.

The factor with the strongest influence on CBC's success rates is the feeding behaviour of the target insect pest. Specifically, sap feeders (e.g. aphids, scale insects) were found to offer the highest chance of successful control on all three analysed levels, which is consistent with previous research (e.g. Greathead & Greathead, 1992). Target pest species with several generations per year are also more likely to be successfully controlled by CBC agents.

Finally, introducing the biological control agent several times in a row is more successful in managing pest populations than a single introduction. As few as 10 introductions increased the probability of CBC agent establishment to 75%, whereas with 20 introductions, success on all levels (establishment, impact, and control) increased to nearly 100%.



*Number and success of classical biological control (CBC) introductions. Upper two panels **A** number of introductions of CBC agents per decade introduced in Europe, North Africa, and the Middle East against pests on (full line) all plants, (dashed line) woody plants, and (dotted line) herbaceous plants **B** total number of introductions for all target host plants, woody plants, and herbaceous plants (black bars) including repeated introductions of agents against the same target and (grey bars) for unique agent-target combinations. Note that some targets feed on both woody and herbaceous plants. Lower six panels: Percentage of successful biological control introductions (left side) per decade and (right side) overall, against pests on **C, D** all plants **E, F** woody plants, and **G, H** herbaceous plants. Success was measured in terms of (blue line) agent establishment, (purple line) partial to complete control of the target (i.e. impact), and (red line) substantial to complete control (i.e. control). Repeated introductions within specific agent-target combinations are included in the calculation of the percentages per decade and in full-coloured bars. Light-coloured bars indicate percentages based on unique agent-target combinations. Source: Seehausen, M.L., Afonso, C., Jactel, H., & Kenis, M. (2021).*

Recommendations

In light of the above-mentioned findings, we have identified the following recommendations, which aim to increase the success of future CBC programmes against insect pests:

- Taking into account that predatory insects have less establishment success, we recommend the use of parasitoids for classical biological control, especially the more specialised (monophagous) parasitoids.
- Because the success rate of CBC increases with the number of introductions of CBC agents, we recommend repeated introductions (10 to 20 times if necessary), and if possible to use CBC agents from different places of origin, as the more diverse genetic sources of the agents may lead to a greater possibility that at least one of the strains will be able to adapt well to the environment of the new release location.
- The effectiveness of classical biological control of forest pests is not negligible, with a success rate in the total control of the targeted alien species of about 15%. However, it has not progressed much in recent years. It is, therefore, necessary to maintain efforts to improve the method by taking more into account the methodology of selection and release of CBC agents.

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Ctenarytaina eucalypti | Manuela Branco

Sources

Main source

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