Pre-release risk assessment for classical biological control of harmful alien species

The article highlights the importance of a careful risk assessment of deliberate introduction of species of insects, useful to the biological control of harmful alien species

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Classical biological control is an interesting field of pest control, aimed at reducing the use of pesticides not only in agriculture, but also in forestry and, more generally, in all natural ecosystems. In the context of food production, this leads to a more environmentally friendly approach with the purpose of producing healthier products, starting from human food first. Moreover, this technique is also an economically sound solution for long-term pest management strategies [1].

Conceptually, biological control is based on the use of a natural enemy (BCA, Biological Control Agent) to control a given harmful organism; an example might be an insect vs. another insect, but many other organisms can be involved, such as nematodes, mites, fungi, vertebrates and plants. In classical biological control the context is the presence, in a given area, of an invasive pest, an alien species, which has been accidentally introduced. Here, its control is performed by an intentionally imported natural enemy, native to the same geographical region of the pest, whose purpose is to establish, in the new area, the natural balance existing between the two organisms in the original context. After the collapse of the pest population, the hypothetical effect of a BCA should be to maintain the fluctuations of the target organism constantly below a certain economic threshold subject to the prey-predator relationship.

The history of biological control is long dating back to more than 2000 years ago, but only in the last 100 years there has been a dramatic increase in the use of this method [2], [3]. In the modern era, the first important success in classical biological control was obtained in 1888, using the predator *Rodolia cardinalis* to control *Icerya purchasi* [2]. Positive results were also achieved in the rest of the world: in Italy for example, successful control was obtained using *Encarsia* (*Prospaltella*) *berlesei* vs. *Pseudaulacaspis pentagona* at the beginning of the nineteenth century, *Neodryinus typhlocybae* vs. *Metcalfa pruinosa* in the 1980s and, *Torymus sinensis* vs. *Dryokosmus kuriphylus* in the last decade.

Biological control has always been considered an environmentally safe strategy for pest eradication, Therefore, the risks inherent in this method have been overlooked for a long time, though in 1897 Perkins had already warned about them for the Hawaii islands [4]. However, in recent decades, the side effects of such an approach have been thoroughly debated and currently, the method is not considered entirely safe for the environment anymore. Regrettably, in the past, the biocontrol theory focused essentially on simple predator-prey relationships, ignoring more complex community interactions and side effects [5]. The apparent absence of negative impacts, led many biocontrol workers to view non-target effects as infrequent and/or often unimportant. This trend was only recently reversed and further emphasis was placed on undesired effects and, in general, on pre-release risk assessment in classical biological control.

Several aspects are to be considered in a pre-release risk assessment, such as risk reports, protocols and step-by-step approaches proposed by different institutions and researchers (e.g. FAO, EPPO, IPPC, or the EU-ERBIC project) [6]. Risks can involve failure, a nothing-done, and a depletion of resources, both human and economic, but most of all potentially severe environmental risks. Therefore, risk analyses are nowadays mandatory and crucial in classical biocontrol programs.

In the context of classical biological control by parasitoids, there are many aspects that need to be evaluated in a pre-release study: parasitization efficiency, parasitization efficacy, searching ability, intraguild predation (e.g. hyperparasitism), ability of establishment, ability of dispersal and hybridization potential are just some examples of parameters that require to be investigated in a BCA. In a natural enemy, characteristics such as host and habitat specificity are essential since they are probably the most important aspects in terms of environmental safeguard of a BCA, because only a restricted host range and habitat can ensure a feasible and reliable control.

In fact, in a classical biological control, the most severe risk is indeed the "non-target species effect", i.e. the fact that the BCA attacks not only the target species, but also other native species. This is the most undesired event, because in most cases the post-release scenario is that of a point of no return, since, theoretically, the introduced organisms are self-sustaining, self-perpetuating and self-dispersing in the environment. Therefore, the BCA that exhibits a high host and habitat fidelity, ensures minimal impacts on non-target species. For this reason, host specificity is probably the most desirable aspect, though even polyphagous species that display habitat fidelity remaining confined to a specific territory, can ensure the safety of the BCA.

A clear example of failure of a classical biological control is the case of the introduction of the fly *Compsilura concinnata* in the USA to control the gipsy moth *Lymantria dispar*. Some evidence showed that the population of some saturniid species gradually declined due to the parasitizing effect of the fly, whereas populations of gipsy moth evenly increased.

Pre-release studies include laboratory and semi-field tests and, eventually, field trials (also post-release analyses are required to test

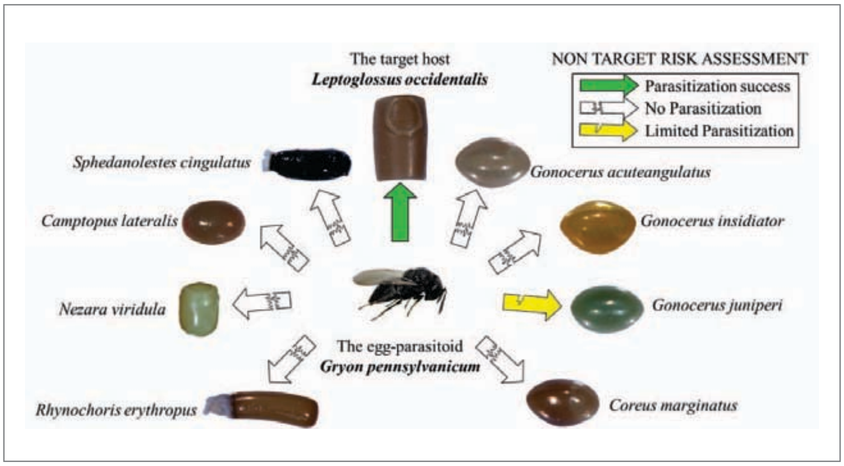

Fig. 1 *Gryon pennsylvanicum* host range assessment in laboratory tests using non-target species of the Italian Heteroptera fauna and the target species *Leptoglossus occidentalis*

success/failure and recognize potentially undesired effects). Non-target species exploration presents several constrains, and laboratory tests are not always entirely predictive. However this is the only first step that can be reasonably performed, in order to define the safety of a BCA in a classical biological control program.

Testing non-target species means defining a list of species to be tested in laboratory for a host-range exploration. Different approaches are generally used to select the best candidates among a hypothetically large number of potentially suitable hosts. The choice is generally based on phylogenetical, biological, ecological, morphological, phenological and environmental safeguard issues (e.g., beneficial or endangered species). To this end, literature reviews can be initially useful whereas field surveys of the available species and the possibility to establish laboratory-reared populations represent the final step of species selection.

A recent case study is *Gryon pennsylvanicum* (Hymenoptera, Platygastridae), a parasitoid under investigation for a classical biological control program against *Leptoglossus occidentalis* (Heteroptera, Coreidae, Coreinae). *L. occidentalis*, a North American pest responsible for severe conifer and seed losses, was accidentally introduced to Italy in 1999 and rapidly spread all over the European Union. Its BCA, *G. pennsylvanicum*, is an egg-parassitoid that parasitizes host species belonging to the North American tribes Anisoscelini, Hypselonotini and Chelinideini, Chelinidea included in sub-family Coreinae. In the European mainland fauna, there are no representatives of tribes including known hosts of the original area. The BCA, introduced to Italy under quarantine condition, has a strict relationship with taxa that display distinct features in terms of egg structure. This knowledge is an essential starting point for a deeper investigation of such aspects in the Italian Fauna, restricting the range of potential hosts that need to be tested in laboratory trials [7]. In fact, starting from a list of 37 coreid species present in Italy, 20 were deleted because they were not included in the sub-family coreinae. From the 17 potentially non-target species, only 9 displayed morphological key features similar to the natural hosts in the native area. Among the 9 species, 5 could be collected in the field in a 2-year survey, and of these only 4 species could be successfully reared in laboratory to obtain a representative population to use in the tests. Four additional insect species were collected in closely related environments and were more or less taxonomically related with the potential hosts (at least 2 of these, considering also the environmental safeguard issues).

G. pennsylvanicum was able to parasitize only the target species, except for extremely low *Gonocerus juniperi* parasitization levels (only one female emerged from a single egg of *G. juniperi*, the 5% of all cases, and it died soon after emergence). No other parasitization events were observed and only in few cases of non target egg parsitization, specimens of *G. pennsylvanicum* died in the egg before the emergence [7].

Results obtained in laboratory tests, showed that *G. pennsylvanicum* is a good candidate for classical biological control against *L. occidentalis* in Italy. However this is the first step in the flow chart of the whole suggested procedure. Further experiments in semi-field conditions together with field trials have to be performed in order to confirm these results.

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