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Thoughts of a travelling ecologist 16.

Biological control impacts and the Cartesian mirage

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As humans spread over the globe, they carried with themselves plants and animals that they considered useful at their new residences. Sometimes they did this because they depended on them. Typically, domesticated plants are not the most common or widespread today where they were domesticated — they have been spread over vast areas, and also outside their original area of distribution (Piperno, 2017). Sometimes people just wanted to be surrounded by familiar species — thus the "naturalisation societies" of the European colonies that set out to make their surroundings "more familiar" by introducing various plant and animal species from their old homeland to the new ones (Wilson, 2004). It would be illogical to expect that these species would forever remain without consumers, be those herbivores or pathogens, and indeed they had not been. Often the consumers travelled with the host from the original area of distribution, otherwise there was a delay — but once established, they often caused grave problems in the new environments. These "following" organisms were often termed invasive species (while their host species, even if extensively planted, have never been declared such), and one persistent idea why they could reach damaging densities is the "enemy release hypothesis". This hypothesis claims that these consumers have left their natural enemies behind, and now have little to check their intrinsic rate of increase (Williamson & Fitter, 1996). This can quickly create problems; it is enough to remember Darwin's (1859) famous example to realise that virtually any species can become "a pest" — i.e. is capable to reach high densities that will create problems for humans.

From the perspective of a primary consumer, agriculture is about resource concentration, and by increasing the area covered by a suitable host plant, particularly in monocultures, agriculture makes it easier for a herbivore or pathogen to find its host. And when it does, the consequences could be deadly, such as the pathogen-caused Irish potato famine in the 19th century. No wonder that humans have tried a multitude of means, sometimes desperate, to protect their crops.

Frequently, though, the cultures to protect were of exotic origin and the "pest" was also unknown before, at least at that new location, having made the trip to the old resource unaided or unnoticed. If arrival to the new location happened by human assistance, that was certainly unintended (we know of no example of "bioterrorism" by this route/procedure, although this was suggested a few times, e.g. by socialist coun-

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tries when the Colorado potato beetle (*Leptinotarsa decemlineata*) arrived to Europe after the second World War (Lövei, 2019)). It was then a logical reaction to try to import "native" natural enemies of this host/resource from their joint area of origin. In other words, they employed biological control, which by definition is the "suppression of populations of pests, weeds and disease-causing organisms by living organisms" (Heimpel & Mills, 2017). Humans have recruited secondary consumers to help them to decrease densities of primary consumers since at least 3000 YBP (Olkowski & Zhang, 1998).

This went on without considering consequences or heeding warnings (Perkins, 1897), and largely by trial and error. Along the way, big successes were peppered with big failures. Big successes are not only historical. For example, one of the important staple foods in many African countries is cassava (*Manihot esculenta*), a native of South America. The looming disaster after the relatively recent introduction of the (also South American) cassava mealybug (*Phenacoccums manihoti*) into Africa was averted by the subsequent introduction of its biological control agent, the egg parasitoid *Anagyrus lopezi* (Neuenschwander, 2001). Failures, however, have occasionally been even more spectacular. The introduction into Australia of the cane toad (*Rhinella marina*), instead of the expected control of sugarcane pests, caused widespread and negative ecological effects that are still unfolding (Shine, 2018).

Throughout its history, biological control was aiming to find suitable "specialist" natural enemies that will attack the "target" species and as little else as possible. During the 20th century, more and more sophisticated and detailed tests were required before a new natural enemy got a permit to be released at a location where it was not native. In spite of this, biological control was often considered "an art, as much as a science" (Sheppard & Raghu, 2005).

Thus, the field of biological control, inflated by remarkable successes and in turn, deflated by colossal failures, has been largely unaware that at the root of the problem may lie in the piecemeal approach to nature, reflecting a mechanical perception of ecological systems: we got a "problem species" — find a solution for it. We have to realise that this is a Descartian inheritance. According to French philosopher René Descartes (1596—1650), living beings work as machines, and he believed that nature could be understood by the principles of physics, of independent bodies affecting each other (Garvey & Stangroom, 2012). His continuing influence is demonstrated by our continued use of his terms, such as "mechanisms", "machinery", etc. This view of independent bodies and principles of physics regulating interactions divides nature as if its elements would be separate; thus the talk about "target" and "non-target" species in various settings. This is reflected in many cases when biological control is considered: a new, unwanted species invades a new geographical area, and becomes a problem, and we try to introduce a biological control agent to "control" it: the machine got a new element, so we need to add a new regulating cog. We only have to make sure the new cog only interacts with that new element.

However, what are us, biologists invited to do? Essentially, we want to create an intentional invasion. We want to find a species that will successfully establish in the area where we introduce it, quickly form self-sustaining populations, increase in abundance and geographical range — that is, be a successful invader itself. In addition, we have in mind a very specific aim: that the introduced species should only interact with, i.e. feed on, one species – the one we want to control, which is usually an exotic species. We call that the "target" species. It is very improbable, though, that the species will only interact with that one species — therefore let me call this the "Cartesian mirage".

It is a mirage, of course, because if the introduced species becomes established, it will become part of that ecosystem. It will logically become part of a new food web, as well as other interaction webs. It will not remain isolated from other species, and it will never form interactions only with the intended "target" species — this is why I call this view the Cartesian mirage — it is false, it is an illusion.

Ecology is much more advanced and sophisticated than that, and ecologists have the tools by which they can make a reasonable guess of the expected role of the "new" species in its new environment. The concept of food webs (Memmott, 2009) can be eminently useful for this purpose, but the now fast-developing field of network analysis (Bascompte, 2007) provides a practical tool for an even more comprehensive, ecologically more articulate view. Both can provide a more realistic assessment of the embedding of the introduced organism and its possible impact on the organisms living in its new habitat. Biological control and in general, environmental risk assessment can and should move towards recognising, then abandoning the Cartesian mirage: the piecemeal view of nature is untenable.

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