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Mediterranean container plants and their stowaways: A potential source of invasive plant species

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Introduction: An expanding catalogue of neophytes

A recently published catalogue of neophytes (Verloove 2006) lists 1969 non-native vascular plants recorded from Belgium between 1800 and 2005. By the end of 2008, only a few years later, 144 new taxa (+ 7.3 %) had been added to the catalogue, not including some 20 new taxa resulting from the current study. The composition of the group of 144 new additions differs markedly from the one of the catalogue 1800-2005. Species originally introduced as ornamentals make up 60 % of the additions, against 33 % in 1800-2005. Together the two most important families in the catalogue (Poaceae and Asteraceae) make up only 5 % of additions, as compared to 29 % in the catalogue.

The clear differences between the catalogue and the additional recent dataset are linked with real changes and inevitable bias. The area of origin of diaspores of alien plant species and the routes and vectors involved have changed as a result of historical trends and events, which often reflect worldwide economic change. Certain categories have disappeared, whereas others are new or at least more important today than before. For instance, 14 % of the species in the 1800-2005 catalogue have only been recorded as wool aliens from the Vesdre valley. Yet, the historical bias in the cumulative dataset explains only part of the differences. The list of post-2005 additions also reflects an important bias. The increased number of introduced ornamentals in the list, recorded as garden escapes or locally naturalizing species, undoubtedly reflects more intensive fieldwork in urban areas in the past few years. The partial shift from grain terminal aliens to urban aliens has several different causes, including the attraction of formerly unexplored fields for the fieldworker, a possible real reduction in the number of imported grain aliens in Belgian port areas, a strongly diminished potential for finding novelties in the well-studied group of grain aliens in Belgium, and a long-standing neglect of certain groups of escapes from cultivation (e.g. shrubs and trees).

Cardamine corymbosa, from New Zealand, is a rapidly spreading plant species. In 2008, while doing fieldwork on this weed in nurseries and garden centres, we chanced upon a seemingly important and largely overlooked category of introduced aliens. We therefore decided to study this alien weed flora more in detail.

Mediterranean container aliens in Belgium

Propagule pressure has recently been described as “the new frontier in invasion ecology” (Richardson & Pyšek, 2008). However, our knowledge about the precise pathways followed by incoming aliens is often very incomplete. The information we gathered during a single year of prospection in garden centres in Belgium amply illustrates this.

Between late spring and autumn a large number of garden centres were visited, with the aim of preparing a list of alien weeds growing in containers with Mediterranean plants, especially palms, olives and figs. Occasionally we also recorded plants that had obviously

escaped from such containers and that thrived on the ground in the direct vicinity of the containers.

In Belgium, the highly increased popularity of Mediterranean container plants is a very recent, early 21st century phenomenon. This popularity can be seen as the end result of a cascade of events and trends, linking the increased level of prosperity of the 1960s with tourism around the Mediterranean, a heightened esteem for gardening, and finally the desire to evoke in the home garden a tinge of the Mediterranean flavour and memories from summer holidays in the South.

In Western Europe, most Mediterranean container plants are imported from Spain or Italy. Together with the ornamentals, large numbers of weeds (seeds as well as young plants), and frequently also other organisms such as snails, are unintentionally introduced in garden centres, situated all over the country. Once sold, the containers and their stowaway weeds find their way into hundreds and thousands of private gardens, parks, etc. While a lot of these weed species have also been recorded as grain aliens in port areas, this recently discovered pathway offers excellent opportunities for widespread dispersal. Furthermore, seeds can germinate in a microhabitat that is literally the same as the one in which the mother plant once grew.

An overview of the results of our prospections is given in table 1. Of 122 identified species, 27 are indigenous to Belgium, and these are also indigenous to Spain and/or Italy. The remaining 95 species are naturalized in Belgium (28 species), casuals (44), or are recorded for the first time (23). A remarkably high number among these 95 species (33 = 35 %) entered Belgium from a secondary distribution range in Spain and/or Italy, not from their natural range. (It should be kept in mind, though, that in the past some of these, e.g. *Coronopus didymus*, might have entered Belgium directly from their natural range too.) See for more details on the species list Hoste *et al.* (2009).

Table 1. An overview of records of Mediterranean container aliens from garden centres in Belgium in 2008.

Status in Belgium (*)	**Number of container aliens (records 2008)**		
	Indigenous to Spain and/or Italy	**Naturalized, casual or not yet recorded from Spain and/or Italy**	**Total**
Indigenous s.l.	27	0	27
Not indigenous, but rather widespread and/or more or less naturalized	16	12	28
Casual	30	14	44
Not previously recorded	16	7	23
Total	**89**	**33**	**122** (**)

(*) Based on Lambinon et al. (2004) and Verloove (2006).

(**) Not including a number of crypto-aliens (that is, species that are common in both Belgium and at least part of the western Mediterranean), probable ornamental escapes, and taxa that could only be identified to genus level.

All species from our survey have in common that they followed more or less the same trajectory and used the same vector to travel from the Mediterranean to Western Europe. As such, they illustrate a new episode in the worldwide exchange of biota that has been going on for centuries. Apart from that, many species often previously had a rather different species history, as suggested by a few individual examples.

In the mid-19th century *Bowlesia incana*, indigenous to America, persisted for some years at a single location in southern France. It was first recorded from Spain in 1986, where it is now well established but rare. From Spain it reached Belgium in 2008 (figure 1). In contrast with other *Bowlesia*, this weedy species has little apparent morphological adaptation for seed dissemination. It is therefore remarkable that this plant, which has fruits devoid of glochids, has become a much more widespread alien in several parts of the world than all seven glochidiate-fruited *Bowlesia* combined (Mathias & Constance 1965).

Today three American *Chamaesyce* frequently enter Belgium from Spain, but their pre-2008 history is different. *Chamaesyce maculata* (first recorded <1950) is a well-established weed in nurseries. Before 2008, *C. serpens* (first recorded in 1992) was only known as a rare casual grain alien from America. Finally, it seems rather likely that *C. prostrata*, first recorded in 2002 and known as a rare urban weed, entered Belgium exclusively as a Mediterranean container alien.

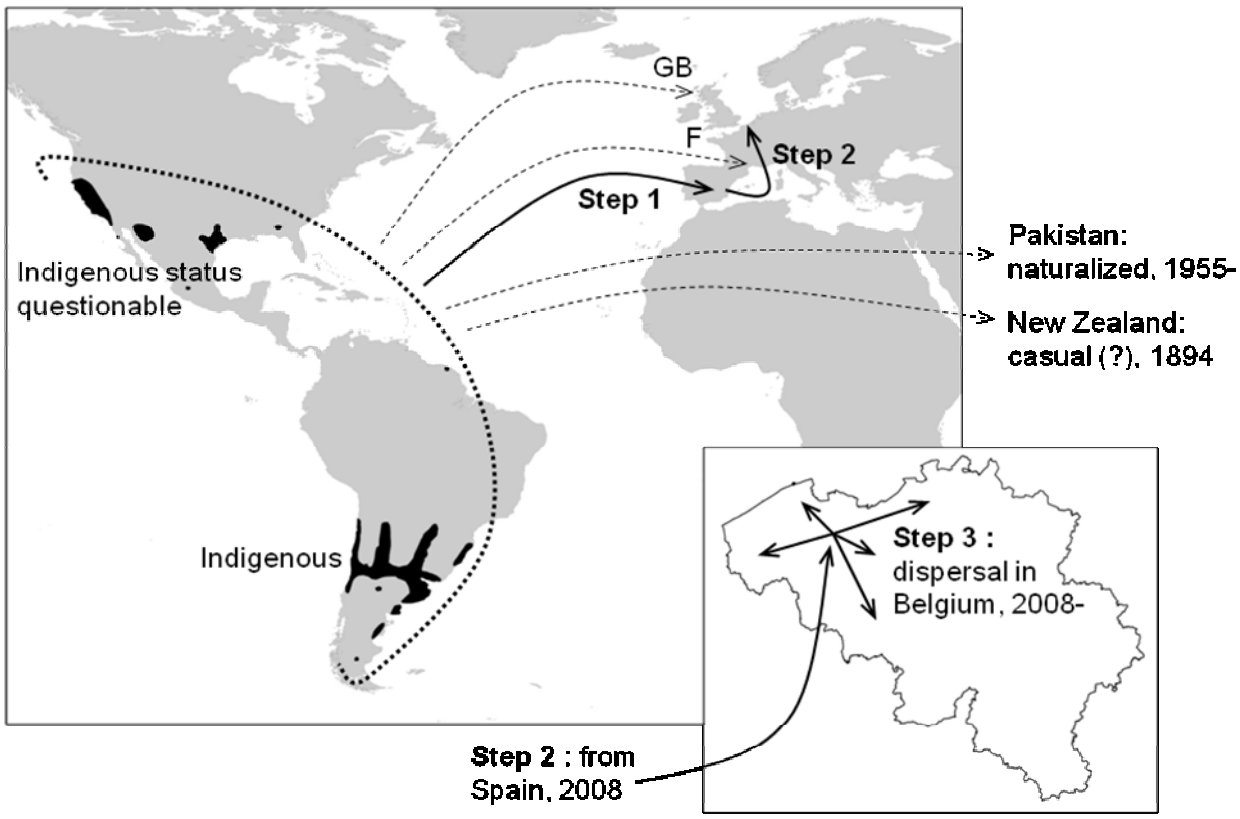

Figure 1. Bowlesia incana*, indigenous to America, has been recorded from several different parts of the world. Introduced in the mid-19th century, it persisted for some years in southern France ('F' on the map), and was recorded as a casual from Great Britain before 1930 ('GB' on the map). In theory, three steps are sufficient to link its native range with any garden in Belgium, using nurseries in Spain and Belgian garden centres as stepping stones. (Map based on Mathias & Constance [1965], with additions.)*

The new link between the Mediterranean and Western Europe has brought us some new species, along with a much larger group of species that previously followed other trajectories and used alternative vectors to enter Belgium. The active importation of a relatively homogeneous group of Mediterranean plants creates a propagule pressure bias toward species of warmer climates, and we should therefore not interpret this upsurge of Mediterranean aliens as a clear-cut illustration of global warming. Several species in the list apparently have not yet been mentioned in the Spanish or Italian botanical literature, indicating that the study of propagule pressure is indeed still hampered by insufficient data on the precise area of origin – primary or secondary – of introduced aliens.

Given the large number of arrivals (both range of species and amount of diaspores), we can expect that at least some species will naturalize in Belgium as a result of the importation of Mediterranean container plants. The tens rule, a useful rule of thumb, states that 10 % of imported species become casuals, and 10 % of those casuals become naturalized (Williamson 1996). There are indications that in the early 21st century some candidates for naturalization are increasing in urban areas, including several species from our container aliens list: *Piptatherum miliaceum*, *Polycarpon tetraphyllum*, *Sisymbrium irio*, *S. orientale*. Species from our list have recently been recorded from similar habitats in England, e.g. *Urtica membranacea* (Boucher & Partridge 2006, anon. 2008) and *Galium murale* (Nicolle 2008), and in France (e.g. *Chamaesyce prostrata*; Bedouet 2008).

Where do we go from here?

The present study on Mediterranean container aliens clearly shows that there is still an urgent need for new data on propagule pressure. Again and again new data remind us of the complexity of the naturalization and invasion process. In our urge to find the laws and mechanisms that drive these processes, we should never forget that invasions are context specific (Richardson & Pyšek 2008).

The early stages of invasion include long-distance transport and successful introduction of plants and animals outside their natural area of distribution. Especially in these early stages human activities largely determine what happens, where, when, and how. Among invasion ecologists these activities are often perceived as annoying *interference with* or *disturbance of* ecological processes. A more fitting approach accepts humans for what they really are: A primary agent in the bewilderingly rich and complicated succession of events that constitutes the essence of history.

Both deficiencies in the available data and the fads and fancies of human history often make it difficult to interpret cumulative datasets on individual species. Before analysing results we should always carefully check whether the data is uniform. A single cumulative curve, based on historical data that span decades or more than a century, is often based on two or more subsets of records. This may result from changing global trade routes, from dwindling or increased trade volumes, etc.

An example is the small dataset for *Setaria adhaerens* in Belgium: in the first half of the 20th century it was exclusively recorded as a rare wool alien, whereas in 2008 it was frequently recorded from garden centres. A quite different example is the invasion of *Senecio inaequidens* in Western and Central Europe. In a recent study, Bossdorf *et al.* (2008) argue that *S. inaequidens* could only start to spread after new frost-resistant and competitive genotypes had been introduced from mountainous regions in southern Africa, decades after the species had first been introduced in Central Europe. Such studies on the introduction and invasive history of an individual plant species, based on molecular research, illustrate the

dangers of uncritically using the term ‘lag time’. Close scrutiny of data that span long periods of time can prevent us from turning lag time into a black box.

Barabási (2002) observed that we live in a small world. Our world is small because society is a very dense web. It is indeed humans who have created this small world in which plants and animals continue to disperse and propagate, basically following the same ecological rules as before. The science of networks described by Barabási offers opportunities for a new framework for the study of biological invasions. On all levels, from the local to the intercontinental, it is important to better understand how propagules are actively or passively being dispersed. How and in what numbers are seeds dispersed within and between plant nurseries, garden centres, private gardens, and their immediate vicinity? And how have pathways for the introduction of aliens changed over time?

What explains the arrival of over 100 *Bowlesia incana* seedlings in a Belgian garden centre in the spring of 2009, thousands of kilometres away from its natural area of origin in America? Chances are small indeed for this to happen if dispersal were only possible through a distributed network (figure 2c). But that is not what networks look like in the real world. Real networks don’t have a homogeneous, mesh-like architecture. Ideas and goods, including ornamentals and weeds, spread across heterogeneous networks with numerous tiny nodes and a few large hubs characterized by an extraordinary number of links (figure 2b). For *Bowlesia* to reach Belgium, chances rise dramatically once it can travel through large decentralized networks.

In theory, *Bowlesia* in its native range could be just three steps away from your home garden (figure 1). First it travels incognito from America to southeast Spain, where it settles as a persistent weed in a nursery that operates as a major node in an international horticultural trade network. The second step takes *Bowlesia*, still incognito, from Spain into a Belgian garden centre. There *Bowlesia* and its companion *Trachycarpus* palm abide their time, until one day they are sold and together transported into your private garden.

“Networks are only the skeleton of complexity, the highways for the various processes that make our world hum.” (Barabási, 2002) *Our* world. And the container aliens’ world as well.

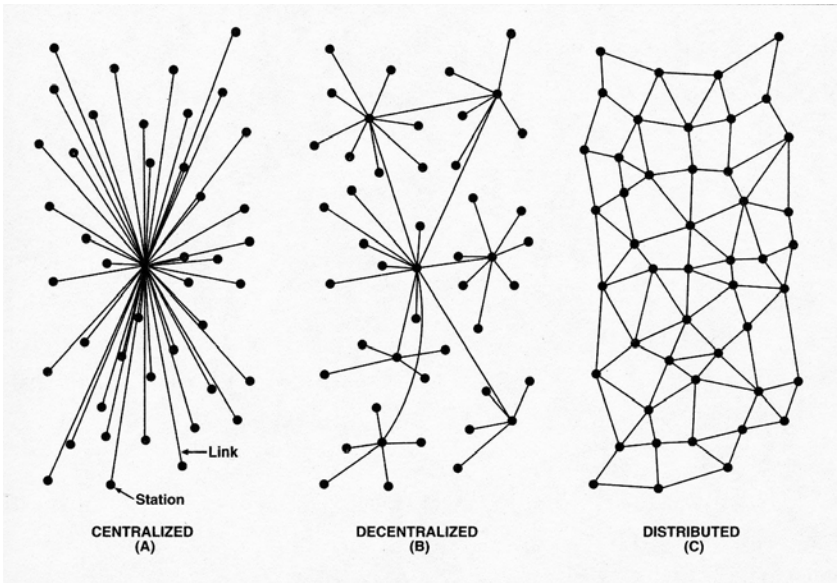

Figure 2. Centralized, decentralized and distributed networks. (Source: A.-L. Barabási, Linked)

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