

## **Non-native invertebrate plant pests established in Great Britain: an assessment of patterns and trends**

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### **ABSTRACT**

We constructed a database containing information on 325 non-native invertebrate plant pests that have established, or are suspected to have established, in Great Britain between 1787 and 2004. The database is designed to identify trends in pest establishments and aid the prediction of future plant health risks. Records of establishment were analysed in relation to the taxon, type of environment, mode of entry, origin of the pest and changes over time. The Homoptera and Lepidoptera formed the majority of non-native species. Only 15% of establishments occurred in protected environments. Forty seven percent of all establishments occurred during or after 1970. Thirty four percent pose a significant risk to plant health and approximately half of these became established after 1970. All but one of the significant post-1970 establishments were on ornamental plants. Of the post-1970 pests on cultivated hosts, 44% were accidentally introduced, compared to 6% colonising naturally. The mode of entry could not be designated for the remaining species. Most non-native plant pests originated in continental Europe, with substantial minorities contributed by North America and East Asia. The number and composition of species that have established in Great Britain since 1970 is broadly similar to that observed in France, Italy and Spain.

### **INTRODUCTION**

There is no up-to-date, comprehensive database of non-native invertebrates that are injurious to plants and have established in Great Britain. Although information for certain taxa, e.g. the Lepidoptera (Bradley, 2000), is relatively complete, a review by Brown (1986) and records of non-native invertebrate herbivores held in the Phytophagous Insect Data Bank (Ward 1988) are inconsistent, contain numerous omissions and are now out of date. An accurate database of non-native established species injurious to plants is required to assist the UK Plant Health Service in identifying which sectors are most vulnerable to damage from invaders, permitting trends in non-native species establishments to be monitored, indicating which countries or regions are the sources of the most successful colonisers and contributes to requirements under Article VII (paragraph 2j) of the International Plant Protection Convention (FAO, 1997) to maintain adequate information on pest status. Such a database also has important applications for the conservation of biodiversity (Defra, 2003).

## **MATERIALS AND METHODS**

Published and unpublished information on non-native species was extracted from files at the Central Science Laboratory (CSL) and from the professional and amateur literature, particularly checklists of the British fauna. Non-native, terrestrial invertebrates known to be injurious to plants and to have established self-sustaining populations in Great Britain were added to the database. Species strongly suspected to be established were also incorporated to make the database as comprehensive as possible. Species currently under official control (i.e. eradication or containment), reintroductions (e.g. of extinct natives), migrants and species forming only transient populations were excluded. Although many definitions of non-native species require human action to have been responsible for species entry, the mode of entry is often very difficult to determine for invertebrates and we have therefore included all newly arrived established species in the database. The database was restricted to plant pests as defined by the FAO (2002), i.e. species which are directly or indirectly injurious to plants. Indirect pests include disease vectors or those species that harm organisms beneficial to plants, such as earthworms, pollinators and parasitoids of pests.

In order to gauge the threat posed by established non-native species, those species that have caused or may cause economic or environmental impacts must be identified. However, with little information available for so many species, there is no straightforward method for distinguishing these species. We have therefore adopted a surrogate method based on administrative procedures at CSL. A separate file is opened whenever a new established non-native species is reported to have caused damage in Great Britain. We used a list of these species files to determine the proportion of non-native invertebrate plant pests posing a significant risk to plant health.

Plant pests were analysed in relation to the taxon, type of environment, mode of entry, origin of the pest and changes over time. We have concentrated our analysis on pests that have entered since 1970 because the data for this period are more robust, being more generally accessible in on-line bibliographic databases.

## **RESULTS**

Records of 325 non-native plant pest species established between 1787 and 2004 were obtained. Thirty-eight species strongly suspected to be established were included but a further 135 species, mainly nematodes, were excluded because there is no British checklist and their non-native status cannot therefore be confirmed. One hundred and fifty-eight (48.6%) of the 325 species were first recorded in or after 1970. However, 46 of the established non-native species (14.1%) lacked a date of first record. The majority of the 325 established non-native species were found in the Homoptera (Sternorrhyncha and Auchenorrhyncha) (37.1%) and in the Lepidoptera (31.3%) (Table 1). The majority of the 325 establishments (77%) occurred outside, with only 15% in protected environments. A similar proportion of establishments in protected environments has been recorded in the period 1970-2004.

Table 1. The taxonomic composition of the 325 non-native plant pests established between 1787 and 2004. Those establishments with no date are distinguished from those first recorded before and after 1970.

Taxon	No date	Before 1970	After 1970	Total established
Homoptera (leaf hoppers and allies)	28	46	47	121
Lepidoptera (butterflies & moths)	10	49	43	102
Coleoptera (beetles)	2	5	20	27
Hymenoptera (ants, bees and wasps)	1	5	8	14
Heteroptera (shield bugs and allies)	2	3	8	13
Orthoptera (grasshoppers & allies)	0	5	5	10
Tricladia (flatworms)	3	3	2	8
Thysanoptera (thrips)	0	2	4	6
Diptera (true flies)	0	0	6	6
Acari (mites)	0	3	11	14
Nematoda (nematodes)	0	0	4	4
Total	46	121	158	325

Of the 109 (33.7%) established species with a CSL file (indicating a significant pest risk), 59 (54.1%) species have established since 1970. Only 3 (5.1%) of these 59 species were indirect pests, either honey bee parasites or predators of beneficial invertebrates. The pests established on cultivated hosts were all associated with ornamental plants apart from *Dendroctonus micans* which feeds on forest trees. In the period following 1970, 46 (80.7%) species posing a significant pest risk occurred outside protected cultivation.

Knowledge of the pathways by which plant pests enter a territory is critical to risk management. The first step in identifying sources of risk is to assess which plant pests have established naturally and which have been intentionally or unintentionally introduced by man. Although there were insufficient data for 54.1% of established species (176 out of 325), 67.8% (101) of all known cases established unintentionally. For the two largest taxa in the database, a higher proportion of the Lepidoptera compared to the Homoptera established by natural colonisation (46.5% versus 5.7%, respectively). Of the post-1970 species posing a significant pest risk to cultivated hosts, 43.6% (24) were introduced unintentionally by man, compared to 5.5% (3) that established naturally. The mode of entry could not be designated for the remaining 50.8%. After 1970 there was no clear upward or downward trend in the number of species establishing unintentionally; the proportion of unintentional establishments in each decade (including 2000-04) fluctuated between 30 and 60%.

Identifying trends in the principal countries of origin for non-native pests is also of great importance. Here, origin is defined as the country or region where a pest is indigenous, rather than the direct source of entry into Great Britain, although such information is still important when identifying the principal entry pathways for non-native pests. The greatest proportion of established non-native plant pests, 19% (51), originated in Europe. However, 60% of the 325 plant pests lacked data on origin. For plant pests posing a significant risk of damage and established since 1970, 36% (21) originated in continental Europe, while 20% (12) came

from North America (Table 2). Only 10% (6) of these post-1970 establishments lacked data on origin, e.g. where the native range was unconfirmed.

Table 2. Areas of origin of plant pests posing a significant pest risk established since 1970.

Origin	1970's	1980's	1990's	2000-04	Total	%
Africa	0	1	1	0	2	3.4
Asia	1	0	6	1	8	13.6
Australia & New Zealand	1	1	2	0	4	6.8
Europe	3	7	7	4	21	35.6
Japan	0	0	2	0	2	3.4
North Africa	1	0	0	0	1	1.7
North America	3	4	3	2	12	20.3
South America	0	2	0	1	3	5.1
Insufficient data	1	0	4	1	6	10.2
Total	11	15	25	9	59	

Some data on non-native plant pests are available from France (Martinez & Malausa, 1999), Italy (Pelizzari & Dalla Monta, 1997) and Spain (Pérez Moreno, 1999) for comparison.

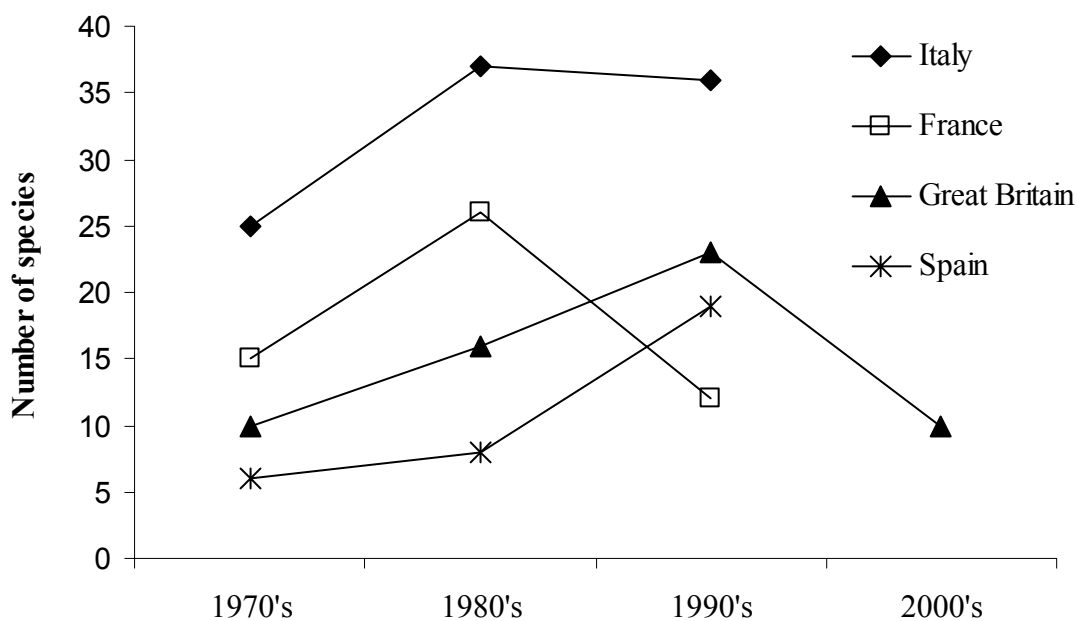


Figure 1. Trends in plant pest establishments in four European countries since 1970. Apparent declines are probably due to incomplete reporting for the decade in which studies were published.

These countries experienced substantial increases in the number of establishments between the 1970's and the 1980's (Figure 1), and any apparent declines in the 1990's are only likely

to be due to the lag in reporting new species. The overwhelming majority of pests belong to the Homoptera (Table 3). As in Great Britain, relatively few establishments in Italy (18.4%) have occurred in protected environments. In contrast, in the Netherlands, although strictly comparable data are unavailable, at least 30 out of 72 species (41.7%) have established in protected environments since 1900 (Van Lenteren 1987).

Table 3. Numbers of established non-native plant pests recorded from selected European states since 1970 (see text for sources).

	Great Britain	Italy	France	Spain
Homoptera	26	76	37	15
Lepidoptera	6	8	8	3
Coleoptera	8	7	3	5
Acari	3	0	0	4
Diptera	3	4	3	3
Thysanoptera	2	3	2	2
Heteroptera	3	0	0	1
Hymenoptera	4	0	0	0
Nematoda	2	-	-	-
Tricladia	1	-	-	-
Total	58	98	53	33

## DISCUSSION

As for any country, it is exceedingly difficult to compile an accurate database containing all the non-native plant pests which have established in Great Britain. Even if all the original sources of reports can be read to ensure that the new record is not a taxonomic revision or the new finding of a species which is likely to be native, some records will remain unclear. This is particularly the case for taxa, such as the Nematoda and Acari, for which no British lists exist. In addition, new non-native records may include species which have arrived but subsequently died out. Evidence for their continued existence can only be obtained by field visits. Even with an accurate list of names, further work will be necessary to obtain the additional information for each species required to analyse trends. High priority needs to be given to obtaining accurate and up-to-date estimates of the damage caused by plant pests. Alternative surrogate measures could be based on the research effort per species, number of hosts, pesticide usage or host value. The acquisition of further information on modes of entry and pathways of introduction is also very important. The analysis of trends in establishment rates is greatly influenced by variations in recording rates over time. Controlling for such biases in establishment rates is very difficult because they may be due to changes in such factors as the number, ability and enthusiasm of recorders, the availability of good identification keys, the number of taxonomists, the degree of general interest in non-native species and the accessibility of data.

This assessment of non-native plant pests in Great Britain suggests that, over the last 30 years, the establishment rate has been increasing by approximately five damaging species per decade. Only a thorough examination of pre-1970 records would confirm whether this is a long term trend. However, exotic insect introductions have been shown to be correlated with trends in international trade (Levine & D'Antonio 2003). While the number of organisms invading Great Britain is too low to confirm changing trends in respect to geographical source, Asia stands out as a region supplying a relatively higher number of recent introductions. Given that most damaging new pests which have recently been recorded in Great Britain are associated with non-native ornamental plants and that this is an expanding area of trade, it seems likely that such establishments in Great Britain will continue to accelerate for the time being. Although the scale of introductions in Great Britain is broadly similar to that of other European states, and the pattern in taxonomic composition is repeated across countries, greater standardisation in reporting is needed before robust comparisons can be drawn.

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