# An overview of selected alien invasive fungal pathogens of woody plants in the Czech Republic

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The aim of this mini-review is to compile the first comprehensive list of alien invasive pathogens of forest woody plants in the area of the Czech Republic that is comparable with the European datasets. The presented overview is based on the paper previously published in Forest Protection Reporter (17/2013; in Czech) and later updated. The list has been compiled to at least partially fill the great gap in this field in the Czech mycological dendropathology. Surely, the list is incomplete and it would require the great additions and specifications. However we hope that it is well usable in confrontation with published comparative European data subsets of alien invasives (Desprez-Loustau et al. 2010; Santini et al. 2013).

The potential presence of pathogens mentioned in both subsets was briefly verified in basic Czech phytopathological literature, in Mycological Herbarium of National Museum (PRM) and our database and herbarium (RILOG). The unquestionable or reliable positive findings were entered and, if available, the first findings of particular pathogens were identified.

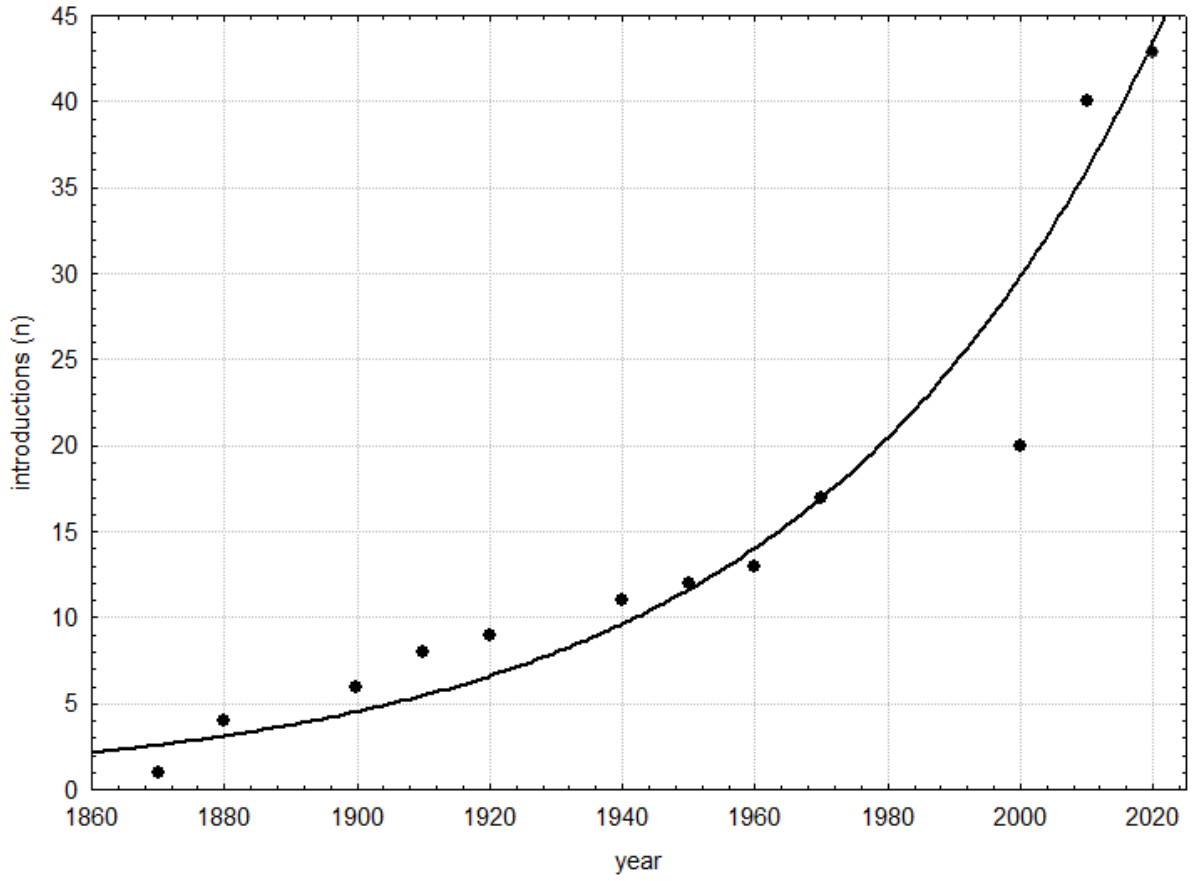
In total, the presence of 90 alien fungal and fungal-like taxa of forest pathogens was identified. The invasion status and distribution of 52 alien invasives found in the area and mentioned in Santini et al. (2013) was also described (Table 1). The outcomes show that the Czech Republic belongs among the most invaded European countries. The cumulative graph of alien species in the area is based on the 43 taxa with reliable documented first findings placeable in a decade (Fig. 1). The curve of number of alien invasives is of similar course as those published for European dataset (Desprez-Loustau 2009). However, the most recent increase in the introduction rate has been identified since 2000 (in the decade of admitting the country to the EU) and, likely, it is delayed about 2 or 3 decades in comparison with published European data (Desprez-Loustau 2009; Santini et al. 2013). Likely, the delay of the introductions increase could be caused at least partially by the former economic isolation of the country.

Among the other alien or invasive fungal taxa distributed in the area belong following species: *Aglaospora profusa, Annulohypoxylon cohaerens, Apiognomonia errabunda, Botryosphaeria dothidea, Cristulariella depraedeans, Cryptocline taxicola, Cryptodiaporthe castanea, Erysiphe palczewskii, Glomerella miyabeana, Gremmeniella abietina, Guignardia philoprina, Chrysomyxa abietis, Lachnellula wilkomii, Leucostoma kunzei, Lophodermium piceae, Melampsora larici-populina, Melanconis modonia, M. oblongum, Meria laricis, Monilinia fructicola, Neonectria galligena, Phacidium coniferarum, P. infestans, Phloeospora robiniae, Phytophthora palmivora, P. parasitica, P. polonica, Pycnostysanus azaleae, Rhizosphaera kalkhofii, Rhytisma acerinum, Sawadaea tulasnei, Sphaeropsis pinea, Splanchnonema platani, Strasseria geniculata, Taphrina deformans, T. pruni, Venturia populina, V. saliciperda* a *Verticillium dahliae*. Many other are probably distributed but still not reported – for instance *Phomopsis juniperivora, Kabatina juniperi,* or many mildews.

**Table 1. Overview of alien invasive pathogens of forest trees in the Czech Republic. There is the name of the pathogen in the table, supposed year of the introduction, source of information, species status in Europe, evaluation of distribution and supposed invasion stage in the Czech Republic (terminology according to DAISIE and Santini et al. 2013). Year of introduction: the reliable exact information is in bold, information in parentheses are identifications on imported plants or to a certain extent doubtful information, the date with arrow indicates the probably earlier but not reliably documented presence of the pathogen before the mentioned year. PRM: specimen in Mycological Herbarium of the National Museum in Prague.**

| | Taxon | Year of introduction | source | status | distribution (according to DAISIE) | Invasion status (according to Santini et al. 2013) |
|---|---|---|---|---|---|---|
| 1 | *Apiognomonia veneta* (Sacc. & Speg.) Höhn. (1920) | **1906** | PRM | alien | abundant | naturalised |
| 2 | *Blumeriella jaapii* (Rehm) Arx (1961) | **1873** | PRM | alien | common | naturalised |
| 3 | *Ceratocystis laricicola* Redfern & Minter (1987) | **2006** | Novotný 2010 | cryptogenic | single record | spreading? |
| 4 | *Cronartium ribicola* J.C. Fisch. (1872) | **1896** | PRM | alien | common | naturalised |
| 5 | *Cryphonectria parasitica* (Murrill) M.E. Barr (1978) | **2002** | Jankovský et al. 2004 | alien | rare | eradicated |
| 6 | *Cryptostroma corticale* (Ellis & Everh.) Greg. & Waller (1951) | **2005** | Koukol et al. 2015 | alien | rare | spreading? |
| 7 | *Cylindrocladium buxicola* Henricot (2002) | **2010** | Šafránková et al. 2012 | cryptogenic | single record | spreading? |
| 8 | *Diaporthe oncostoma* (Duby) Fuckel (1870) | **1912** | PRM | cryptogenic | common | naturalised |
| 9 | *Didymascella thujina* (E.J. Durand) Maire (1927) | ←2000 | DAISIE | alien | common? | naturalised |
| 10 | *Drepanopeziza punctiformis* Gremmen (1965) | ←2000, **2003** | Jančařík 2003 | alien | common? | naturalised |
| 11 | *Entoleuca mammata* (Wahlenb.) J.D. Rogers & Y.M. Ju (1996) | ←2000, **2003** | Jančařík 2003 | alien | rare | naturalised |
| 12 | *Erysiphe alphitoides* (Griffon & Maubl.) U. Braun & S. Takam. (2000) | **1907** | Cejp et Skalický 1954 | cryptogenic | abundant | naturalised |
| 13 | *Erysiphe arcuata* U. Braun, V.P. Heluta & S. Takam. (2006) | ←2000, **2004** | Palovčíková et al. 2007 | alien | common? | naturalised? |
| 14 | *Erysiphe azaleae* (U. Braun) U. Braun & S. Takam. (2000) | ←2000, **2003** | Lebeda et al. 2007 | alien | common? | naturalised |
| 15 | *Erysiphe flexuosa* (Peck) U. Braun & S. Takam. (2000) | **2007** | Palovčíková et al. 2007 | alien | common? | naturalised |
| 16 | *Erysiphe hypophylla* (Nevod.) U. Braun & Cunningt. (2003) | **2011** | Michálek 2012 | cryptogenic | common? | naturalised? |
| 17 | *Erysiphe syringae* Schwein. (1834) | ←2000, **2004** | Palovčíková et al. 2007 | alien | common? | naturalised |
| 18 | *Erysiphe vanbruntiana var. sambuci-racemosae* (U. Braun) U. Braun & S. Takam. (2000) | **2005** | Palovčíková et al. 2007 | alien | common? | naturalised |
| 19 | *Eutypella parasitica* R.W. Davidson & R.C. Lorenz (1938) | ←2010**, 2015** | RILOG | alien | rare | eradicated? |
| 20 | *Glomerella acutata* Guerber & J.C. Correll (2001) | **2005** | Šindelková et Širučková 2006, Novotný et al. 2007 | cryptogenic | local? | spreading? |
| 21 | *Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk (1903) | ←2000, **2002** | RILOG | alien | common | naturalised |
| 22 | *Gnomonia leptostyla* (Fr.) Ces. & De Not. (1863) | ←1900, **1900** | PRM | alien | abundant | naturalised |
| 23 | *Guignardia aesculi* (Peck) V.B. Stewart (1916) | **1873** | PRM | alien | abundant | naturalised |
| 24 | *Hymenoscyphus fraxineus* (T. Kowalski) Baral, Queloz & Hosoya, 2014 | **2007** | Jankovský et al. 2007 | cryptogenic | abundant | naturalised |
| 25 | *Kabatina thujae* R. Schneid. & Arx (1966) | ←2000, **2003** | State Phytosanitary, RILOG | alien | common? | naturalised |
| 26 | *Melampsoridium hiratsukanum* S. Ito ex Hirats. (1927) | **2001** | Müller 2003 | alien | abundant | naturalised |
| 27 | *Mycosphaerella dearnessii* M.E. Barr (1972) | **(2000), 2007** | (Širučková 2006), Jankovský et al. 2009 | alien | rare | introduced |
| 28 | *Mycosphaerella pini* Rostr. (1957) | **(1999), 2000** | (Širučková 2006), Jankovský et al. 2000 | alien | local | spreading |
| 29 | *Ophiostoma novo-ulmi* hybrids *(novo-ulmi x americana)* | **2007** | Dvořák et al. 2007 | hybride | local | spreading? |
| 30 | *Ophiostoma novo-ulmi subsp. americana* Brasier & S.A. Kirk (2001) | ←2000, **2007** | Dvořák et al. 2007 | alien | common | naturalised |
| 31 | *Ophiostoma novo-ulmi subsp. novo-ulmi* Brasier & S.A. Kirk (2001) | **1963, 2007** | (Černý 1976), Dvořák et al. 2007 | alien | abundant | naturalised |
| 32 | *Ophiostoma ulmi* (Buisman) Nannf. (1934) | **1932** | Černý 1976 | alien | rare? | naturalised |
| 33 | *Pestalotiopsis guepinii* (Desm.) Steyaert (1949) | **1873** | PRM | cryptogenic | local? | naturalised |
| 34 | *Phaeocryptopus gaeumanni* (T. Rohde) Petr. (1938) | ←2000**, 2002** | Pešková 2003, DAISIE | alien | local? | naturalised |
| 35 | *Phloeospora robiniae* (Lib.) Höhn. (1905) | **1853-56** | PRM | alien | abundant | naturalised |
| 36 | *Phytophthora ×alni* (Brasier & S.A. Kirk) Husson, Ioos & Marçais | **2003** | Černý et Strnadová 2010 | hybride | abundant | naturalised |
| 37 | *Phytophthora cactorum* (Lebert & Cohn) J. Schröt. (1886) | **1870** | Erwin et Ribeiro 1996 | cryptogenic | common | naturalised |
| 38 | *Phytophthora cambivora* (Petri) Buisman (1927) | **(1997), 2006** | (Gregorová 2000), Černý et al. 2008 | alien | local | naturalised |
| 39 | *Phytophthora cinnamomi* Rands (1922) | **2007** | Černý et al. 2011 | alien | local | spreading |
| 40 | *Phytophthora citricola* Sawada (1927) | **(1959), 2006** | (Cejp et Jechová 1962), Černý et al. 2011 | cryptogenic | abundant | naturalised |
| 41 | *Phytophthora citrophthora* Sawada (1927) | **(1961), 2007** | (Cejp et Jechová 1962), Černý et al. 2011 | cryptogenic | rare | spreading |
| 42 | *Phytophthora cryptogea* Pethybridge & Lafferty (1919) | **(1949), 2011** | (Nicklová-Navrátilová 1949), RILOG | cryptogenic | single record | introduced |
| 43 | *Phytophthora gonapodyides* (H.E. Petersen) Buisman (1927) | **2006** | Černý et al. 2011 | cryptogenic | common | naturalised |
| 44 | *Phytophthora hedraiandra* De Cock & Man in 't Veld (2004) | **2010** | RILOG | cryptogenic | rare | spreading |
| 45 | *Phytophthora megasperma* Drechsler (1931) | **2008** | Černý et al. 2011 | cryptogenic | local | naturalised |
| 46 | *Phytophthora pseudosyringae* T. Jung & Delatour (2003) | **2015** | RILOG | cryptogenic | single record | naturalised |
| 47 | *Phytophthora ramorum* Werres De Cock & Man in 't Veld (2001) | **(2006), 2009** | (Běhalová 2006), Černý et al. 2011 | alien | rare | eradicated |
| 48 | *Phytophthora syringae* (Kleb.) Kleb. (1909) | **1961** | Cejp 1961 | cryptogenic | rare? | naturalised? |
| 49 | *Phytophthora uniformis* (Brasier & S.A. Kirk) Husson, Ioos & Aguayo, | **2007** | Černý et Strnadová 2010 | alien | local | naturalised |
| 50 | *Rhabdocline pseudotsugae* Syd. (1922) | **1938** | Kalandra 1939 | alien | common? | naturalised |
| 51 | *Seiridium cardinale* (Wagener) Sutton & Gibson (1972) | **2002** | RILOG | alien | single record | introduced |
| 52 | *Septotis podophyllina* (Ellis & Everh.) B. Sutton (1970) | ←2000 | DAISIE | alien | common? | naturalised |

**Fig. 1. The increase in the number of alien fungal species recorded in the area of the Czech Republic expressed for decades (only reliable reports). Exponential adjustment in dashed line**




## Brief analysis of *Phytophthora* spp. distribution in the Czech Republic

The data on the distribution of *Phytophthora* spp. in the Czech Republic well document the spread, impact and time of arrival of alien forest pathogens.

25 *Phytophthora* taxa potentially parasitizing on trees have been found in the area till now. 16 taxa from this amount (including *P. multivora*, i.e. *P. citricola* p.p.) are listed in the database of European invasive forest pathogens (Santini et al. 2013) – and only one species of them (*P. polonica*) is considered to be native to Europe. *P. ×alni* and *P. plurivora* are the most frequent and most important in the area of the Czech Republic. The other presented species are *P. palmivora, P.* taxon kelmania (alien to Europe), *P. gregata*, *P. rosacearum* and *P.* taxon walnut (probably cryptogenic) and *P. gallica*, *P. hungarica*, *Phytophthora lacustris*, *P. bilorbang*. The last four species were found only in natural environments – forest and riparian stands and they are probably native. Finally, it can be concluded that only 5 taxa are native and 20 are probably alien or cryptogenic (!).

The analyse of the distribution of 20 alien or cryptogenic taxa shows that seven taxa (28 % of total number of *Phytophthora* species in woody plants) are more or less regularly distributed in natural stands in the area: *P. ×alni* and *P. uniformis*, *P. plurivora*, *P. multivora* (*P. multivora* is probably alien), *P. gonapodyides*, etc. Their introductions are usually of older data (*P. plurivora*) or their natural spread is extraordinarily effective (*P. ×alni*). The six other species (24 %) are regularly distributed in anthropogenic environments (for instance parks and alleys) and only occasionally in riparian stands. The distribution of the last seven pathogens (28 %) is scarce and limited to nurseries, gardening centres and ornamental plantings (for instance *P. cinnamomi*, *P. citrophthora*, *P. cryptogea* and *P. ramorum*). Their introductions are primarily of recent origin.

The differences among four characteristic invasion types or stages of alien *Phytophthora* species are presented in Figs. 2–5 (the visualised distribution is based only on the strains deposited in the Czech collection of phytopathogenic oomycetes).

**Fig. 2. Distribution of *P. cinnamomi* is restricted to nurseries, gardening centres, ornamental plantings, etc. (red points). Likely, the pathogen was currently introduced in the area.**

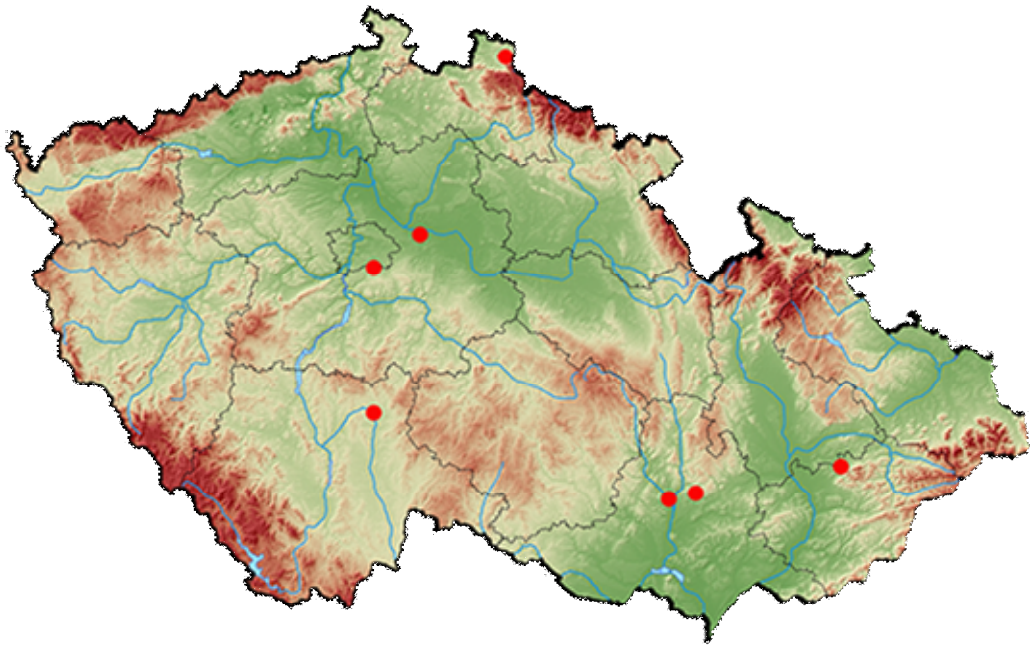


**Fig. 3. Distribution of *P. cactorum* is restricted to nurseries, gardening centres, ornamental plantings (red points) and urban greenery (black points). Apparently, the pathogen is naturalised in anthropogenous areas.**

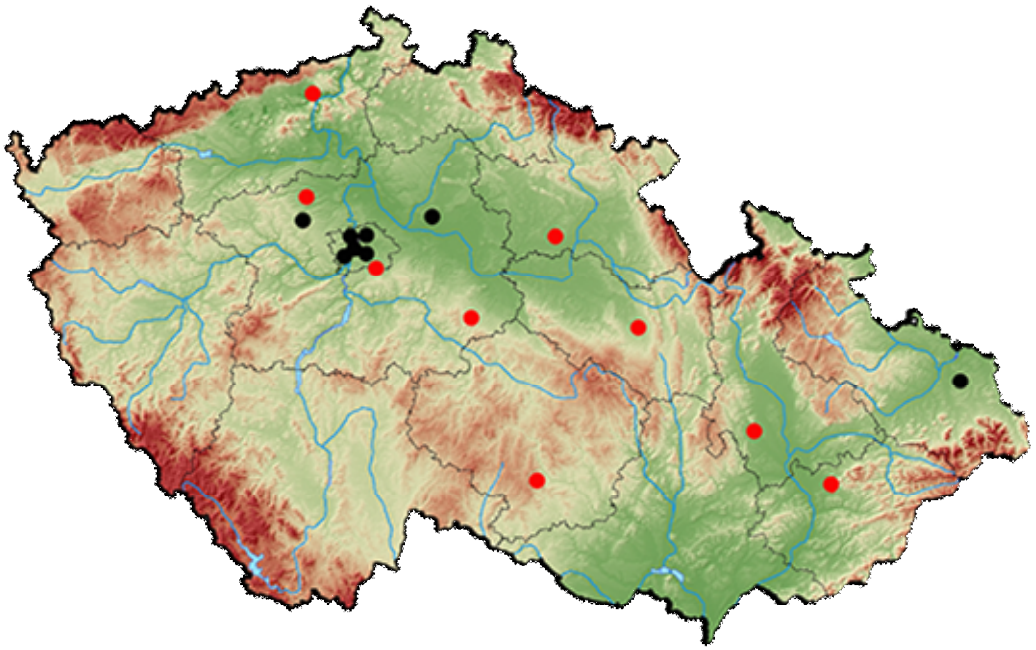


**Fig. 4. Distribution of *P. plurivora*. The pathogen is distributed in ornamental stands, nurseries, etc. (red points), urban greenery (black points), riparian (blue) and forest stands (green points). Apparently, the pathogen was introduced a long time ago and invaded the natural environments.**

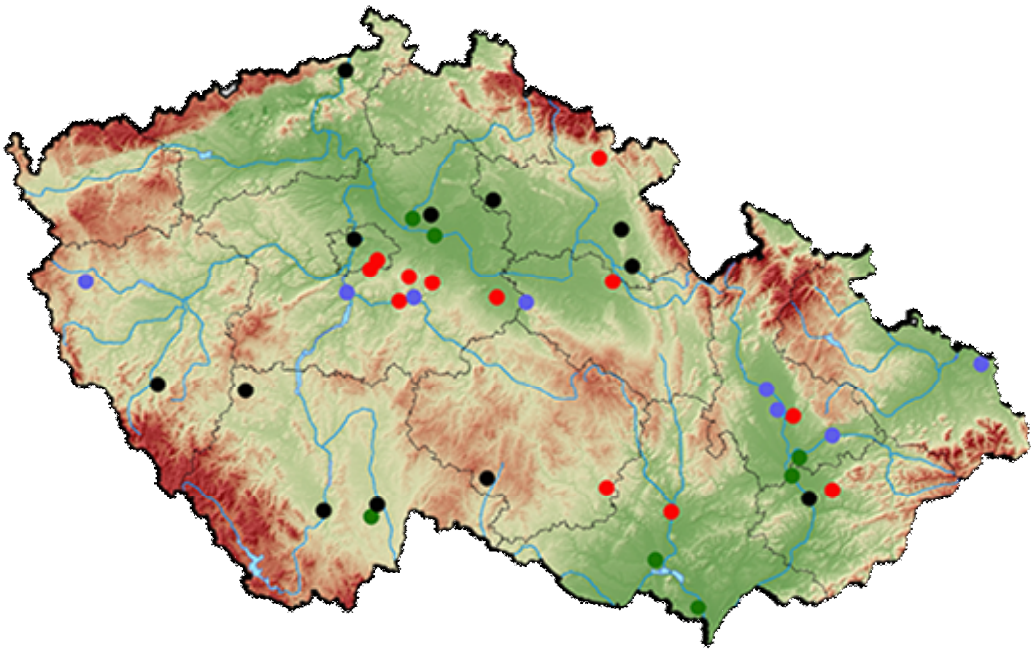
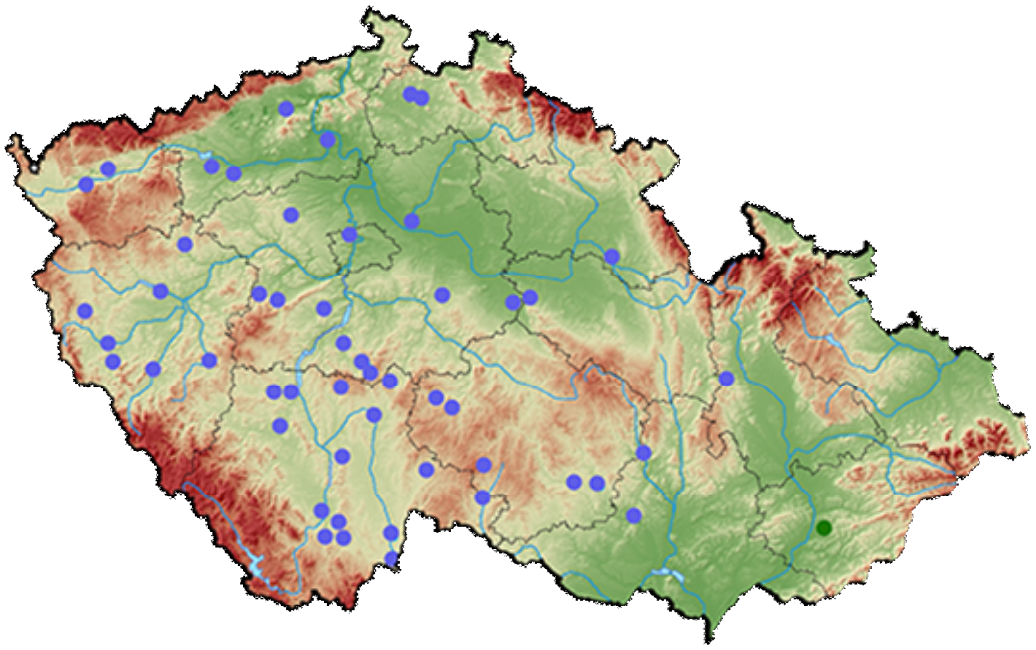


**Fig. 5. Distribution of *P. ×alni*. The pathogen spread effectively and settled a large area during 1 – 2 last decades.**



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