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.

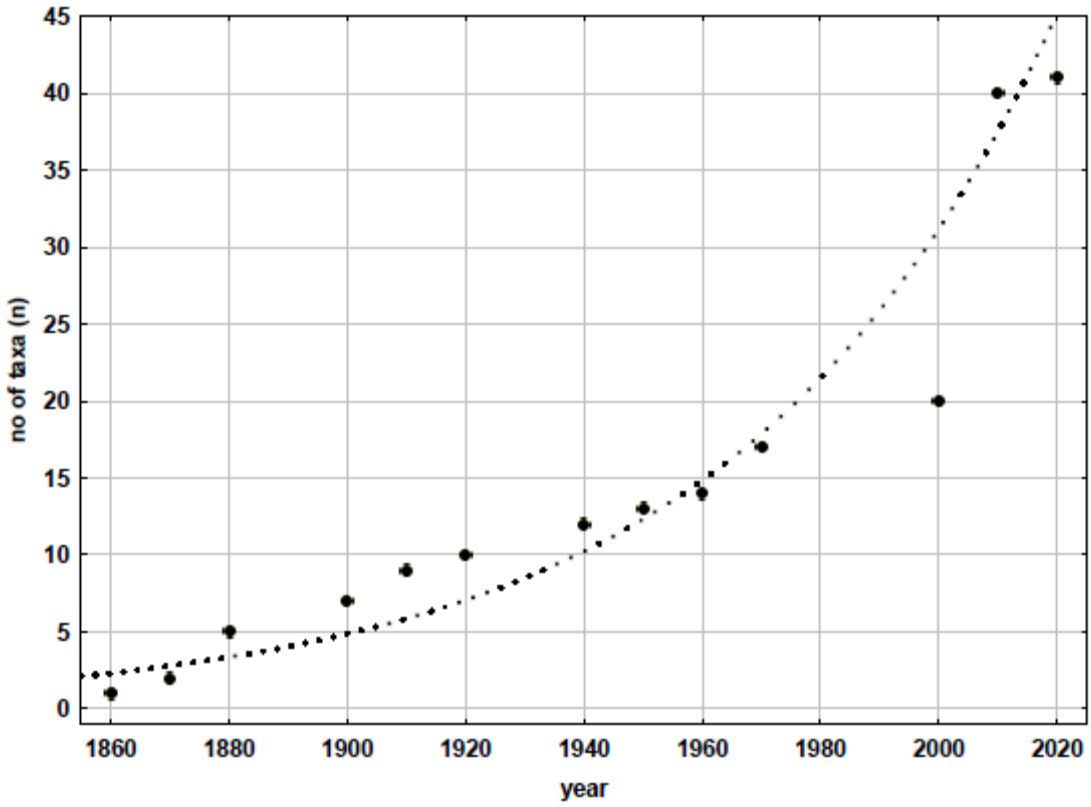
In total, the presence of 88 alien fungal and fungal-like taxa of forest pathogens was identified. The invasion status and distribution of 50 alien invasives found in the area and mentioned in Santini et al. (2013) was also described (Table 1). The outcomes show that the Czech Republic belongs among the most invaded European countries. The cumulative graph of alien species in the area is based on the 41 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. 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**	RILOG	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	*Glomerella acutata* Guerber & J.C. Correll (2001)	**2005**	Šindelková et Širučková 2006, Novotný et al. 2007	cryptogenic	local?	spreading?
20	*Glomerella cingulata* (Stoneman) Spauld. & H. Schrenk (1903)	←2000, **2002**	RILOG	alien	common	naturalised
21	*Gnomonia leptostyla* (Fr.) Ces. & De Not. (1863)	←1900, **1900**	PRM	alien	abundant	naturalised
22	*Guignardia aesculi* (Peck) V.B. Stewart (1916)	**1873**	PRM	alien	abundant	naturalised
23	*Hymenoscyphus pseudoalbidus* V. Queloz, Grünig, Berndt, T. Kowalski, T.N. Sieber & O. Holdenrieder (2011)	**2007**	Jankovský et al. 2007	cryptogenic	abundant	naturalised
24	*Kabatina thujae* R. Schneid. & Arx (1966)	←2000, **2003**	State Phytosanitary, RILOG	alien	common?	naturalised
25	*Melampsoridium hiratsukanum* S. Ito ex Hirats. (1927)	**2001**	Müller 2003	alien	abundant	naturalised
26	*Mycosphaerella dearnessii* M.E. Barr (1972)	**(2000), 2007**	(Širučková 2006), Jankovský et al. 2009	alien	local	spreading
27	*Mycosphaerella pini* Rostr. (1957)	**(1999), 2000**	(Širučková 2006), Jankovský et al. 2000	alien	rare	introduced
28	*Ophiostoma novo-ulmi* hybrids *(novo-ulmi x americana)*	**2007**	Dvořák et al. 2007	hybride	local	spreading?
29	*Ophiostoma novo-ulmi subsp. americana* Brasier & S.A. Kirk (2001)	←2000, **2007**	Dvořák et al. 2007	alien	common	naturalised
30	*Ophiostoma novo-ulmi subsp. novo-ulmi* Brasier & S.A. Kirk (2001)	**1963, 2007**	(Černý 1976), Dvořák et al. 2007	alien	abundant	naturalised
31	*Ophiostoma ulmi* (Buisman) Nannf. (1934)	**1932**	Černý 1976	alien	rare?	naturalised (replaced?)
32	*Pestalotiopsis guepinii* (Desm.) Steyaert (1949)	**1873**	PRM	cryptogenic	local?	naturalised
33	*Phaeocryptopus gaeumanni* (T. Rohde) Petr. (1938)	←2000**, 2002**	Pešková 2003, DAISIE	alien	local?	naturalised
34	*Phloeospora robiniae* (Lib.) Höhn. (1905)	**1853-56**	PRM	alien	abundant	naturalised
35	*Phytophthora alni* Brasier & S.A. Kirk (2004) ssp. *alni*	**2003**	Černý et Strnadová 2010	hybride	abundant	naturalised
36	*Phytophthora alni* Brasier & S.A. Kirk (2004) ssp. *uniformis*	**2007**	Černý et Strnadová 2010	hybride	local	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 ramorum* Werres De Cock & Man in 't Veld (2001)	**(2006), 2009**	(Běhalová 2006), Černý et al. 2011	alien	rare	eradicated
47	*Phytophthora syringae* (Kleb.) Kleb. (1909)	**1961**	Cejp 1961	cryptogenic	rare?	naturalised?
48	*Rhabdocline pseudotsugae* Syd. (1922)	**1938**	Kalandra 1939	alien	common?	naturalised
49	*Seiridium cardinale* (Wagener) Sutton & Gibson (1972)	**2002**	RILOG	alien	single record	introduced
50	*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.



A short 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.

21 *Phytophthora* taxa have been found in the area since 2006. 15 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 alni* (*Paa*) and *P. plurivora* are the most frequent and most important in the area of the Czech Republic. The other presented species are *P. palmivora* (alien to Europe), *P. rosacearum* and *P. gregata* (both probably cryptogenic) and *P. gallica*, *Phytophthora lacustris*, *P.* taxon oaksoil. The last three species were found only in natural environments – forest and riparian stands and they are undoubtedly native. Finally, it can be concluded that only 4 taxa are native (19 %) and 17 (81 %) are probably alien or cryptogenic (!).

The analyse of the distribution of 17 alien or cryptogenic taxa shows that 6 taxa (28.6 % of total number of taxa) are more or less regularly distributed in natural stands in the area: *Paa* and *P. alni uniformis* (hybrids; *P. a. uniformis* is probably alien), *P. plurivora*, *P. multivora* (*P. multivora* is probably alien), *P. gonapodyides* and *P. cambivora*. Their introductions are probably older (*P. plurivora*) or their natural spread is extraordinarily effective (*Paa*). The 6 other species (28.6 %) are regularly distributed in anthropogenic environments and only occassionally in riparian stands. The distribution of the last 5 pathogens (23.8 %): *P. cinnamomi*, *P. citrophthora*, *P. cryptogea*, *P. palmivora* and *P. ramorum* is scarce and limited to nurseries, gardening centres and ornamental plantings. Their introductions are apparently of recent, post-revolutional origin.

The differences among four typical invasion stages of alien *Phytophthora* species are visible in Figs. 2 – 5 (the visualised distribution is based only on the strains deposited in the culture collection).

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.

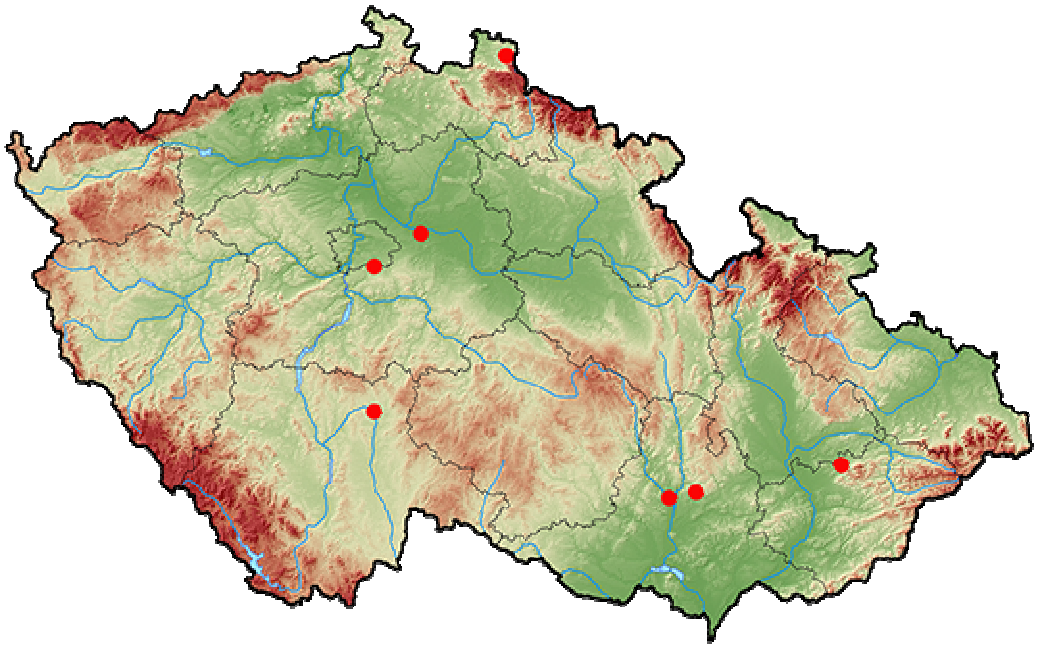


Fig. 3. Distribution of *P. cactorum* is restricted to nurseries, gardening centres, ornamental plantings (red points) and urban greenery (black points). Apparently, the pathogen is naturalised in anthropogenous areas.

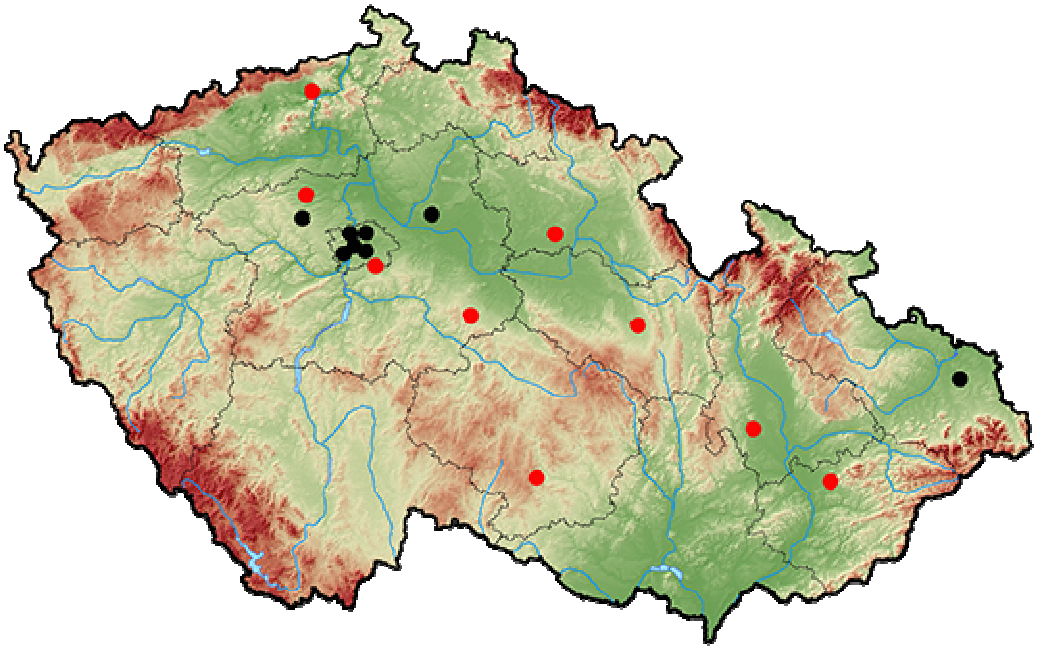


Fig. 4. Distribution of *P. plurivora*. The pathogen is distributed in ornamental stands, nurseries, etc. (red points), urban greenery (black points), riparian (blue) and forest stands (green points). Apparently, the pathogen was introduced a long time ago and invaded the natural environments.

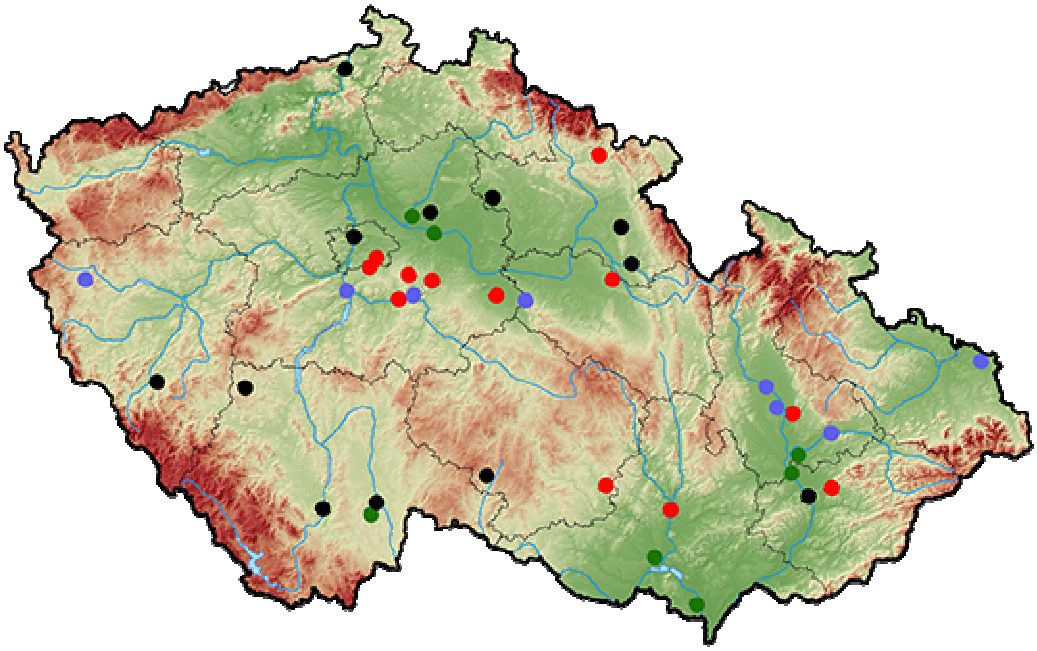
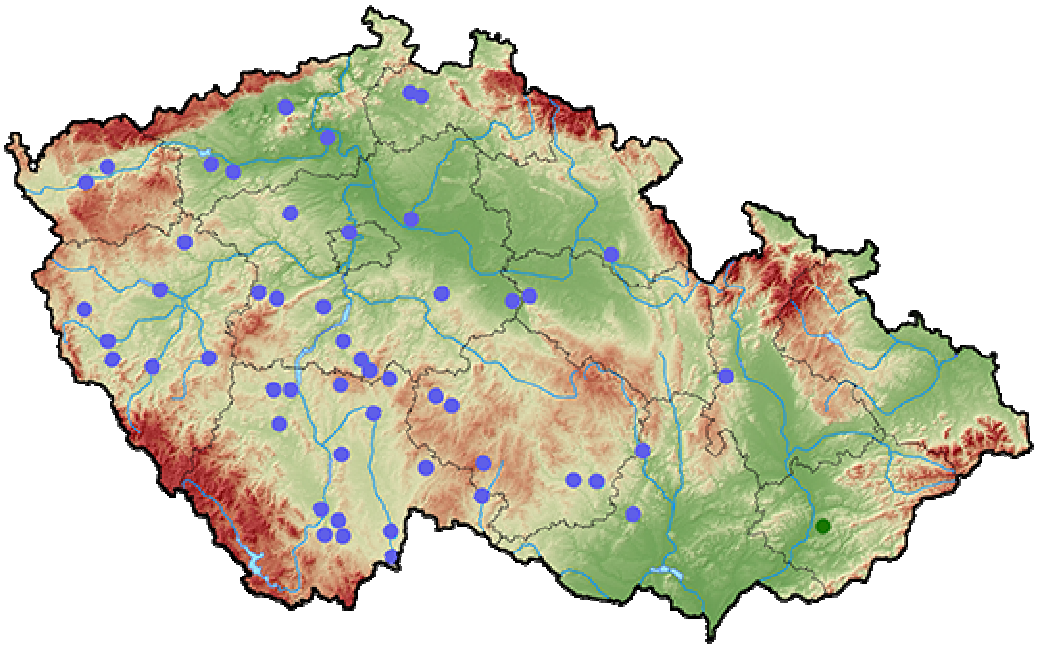


Fig. 5. Distribution of *P. alni alni*. The pathogen spread effectively and settled a large area during 1 – 2 last decades.



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