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The invasion history of Microsphaera palczewskii (Erysiphales) in Finland

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The invasion of *Microsphaera palczewskii* Jacz. – an Asian-origin parasitic fungus of *Caragana* Fabr. – in Finland is reported. The first specimen was collected in South Finland in 1981 and now the species is distributed throughout the country to all areas where *Caragana arborescens* Lam. is cultivated. The epidemic spread caused a total decline of the occurrence of *M. trifolii* (Grev.) U. Braun on *Caragana*. The last record of *M. trifolii* dates back to year 1987. Mature cleistothecia of *M. palczewskii* can be found from mid-July onwards, conidial stage from the beginning of June. Specimens showing conidial stage only can be observed even in September and October, which indicates a continuous infection activity. Recent field observations do not support the reported overwintering in wooden parts. The source of infection is most probably fallen leaves with plenty of cleistothecia.

Keywords: *Microsphaera*, *Caragana*, Finland, invasion history

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Introduction

The characteristics, occurrence and epidemic spread of *Microsphaera palczewskii* Jacz. (Erysiphales) have recently been quite well documented. The species originates in Asia (Russian Far East and China to Kazakhstan) and has since 1975 also been known in Europe. Much has been written on its invasion history and to the list provided by Braun (1995) and Scholler (1994a, 1994b) the following new treatises can be added: Eriksson (1992), Gjærum (1994), Kreisel & Scholler (1994), Karis (1995), Gelyuta (1997), Tikhomirova & Tobias (1999). As summarized by Scholler (1994a), the species was first discovered in Europe in 1975. The first collection originates from Belarus. The next finds were made in all directions from this area. The distribution map published by Scholler (1994a, 1994b) contained many records from Finland provided by Prof. Teuvo Ahti. According to the map *M. palczewskii* appeared to be most abundant in Finland. The expansion pattern led Scholler (1994b) to the conclusion that *M. palczewskii* did not gradually widen its area westward from its original area, but was sporadically first introduced to Europe in some places in Belarus or in the Baltic Republics. Since the mid-seventies, the species gradually moved to all areas where its hosts – species of the genus *Caragana* Fabr. (Fabaceae) – are cultivated as ornamental plants. Its northern limit has now reached 68th parallel in Finland. The spread appears irreversable and the species is a typical neomycete (Kreisel & Scholler 1994) in Europe.

Materials and methods

All the Finnish specimens of powdery mildews on *Caragana* in the major Finnish herbaria (H, OULU, TUR) were checked. Also the sheets of *Caragana* in the phanerogamic collections of H and TUR were checked. Determinations are almost exclusively based on the presence of mature or nearly mature cleistothecia, bearing in mind also *Microsphaera coluteae* Komarov (Braun 1987). Due to the reported difficulty of separating the different species by their anamorph (Scholler 1994a), collections showing only conidial formation are cited with an asterisk in the list of studied material. Due to the overall efficiency of the invasion of *M. palczewskii*, they most probably also represent this species, being mostly collected well after the last definite records of *M. trifolii*.

Phenology

The first specimens of *M. palczewskii* that show only surface mycelium and conidial formation have been collected during the first week of June in South Finland. Immature specimens dominate to the middle of July. Cleistothecia begin to mature towards the end of July in South and Central Finland. In August and September the species is easily visible; hence the peak of collections occurs during these two months (Fig. 1). There seems to be no greater difference in phenology between South and North Finland, except that there are no collections after mid-September from the North. Specimens with only the conidial stage have occasionally been collected also in September and October. This parallels the observations by Scholler (1994a), who reported juvenile asci also in material collected at the end of October (in N Germany).

The spread

Before the arrival of *M. palczewskii* in Finland, *Caragana arborescens* was practically free of heavy infections by powdery mildews. However, the polyphagous *M. trifolii* (Grev.) U. Braun (syn. *Erysiphe trifolii* Grev.) was occasionally found on this host. The arrival of another species, specialized on this host, changed this situation drastically. The first specimen of *M. palczewskii* was collected in Helsinki in 1981. The species was first reported in Finland by Hämet-Ahti et. al. (1992). By the end of year 1981 *M. trifolii* had been observed eleven times, at seven localities in South Finland (Fig. 2). By 1983 two new localities for *M. palczewskii* were observed, both still in South Finland. *M. trifolii* was still collect-

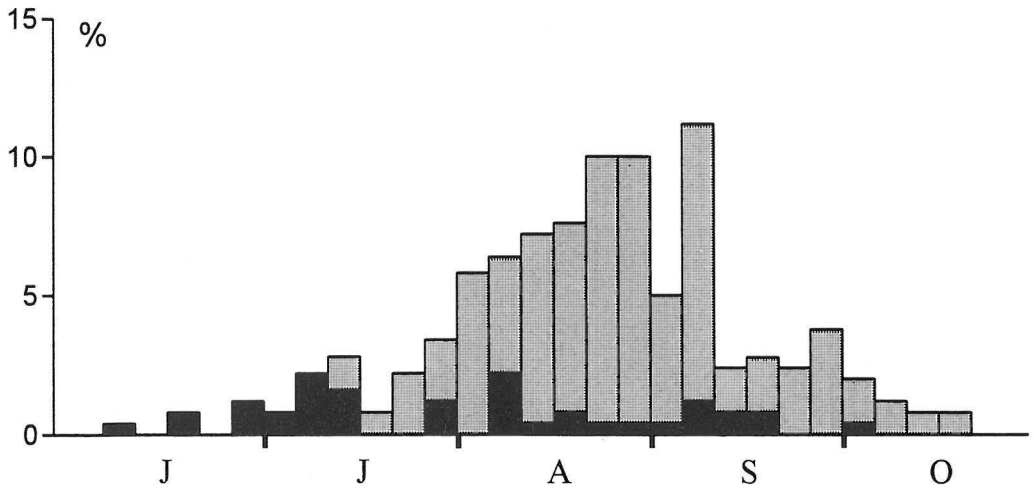
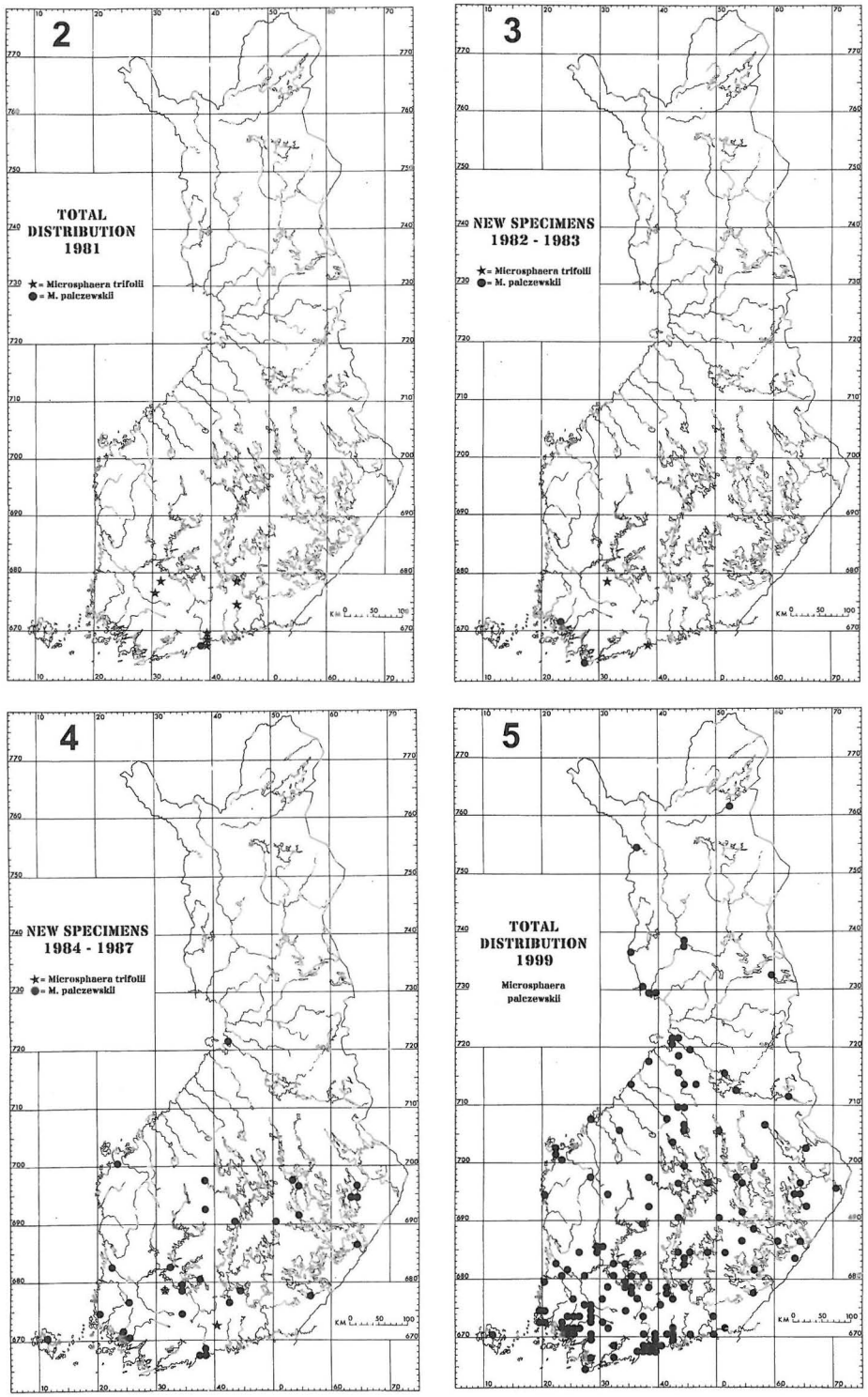


Fig. 1. The percentual distribution of 240 Finnish collections of *Microsphaera palczewskii* according to collection dates from June to October, divided in pentads. Blackened part indicates juvenile specimens (with conidia).



Figs. 2–5. The invasion of *Microsphaera palczewskii* into Finland and the simultaneous decline of *M. trifolii* from the same host.

ed twice on *Caragana*; one locality being a new find (Fig. 3). By 1985 14 new collections of *M. palczewskii* were made and the species had now spread to Central Finland. At the same time only one specimen of *M. trifolii* was found in Hattula; a site where the species had persisted on *Caragana* from the year 1965. By 1987 17 new specimens of *M. palczewskii* had been collected and the species had now reached Oulu in northern Finland (Fig. 4). The year 1987 marked also the last collection of *M. trifolii* on *Caragana*. By the end of 1998 *M. palczewskii* had reached Ivalo and Muonio in Lapland.The present distribution is shown in Fig. 5. The fast invasion is explained by the unusual abundance of *C. arborescens* as an ornamental plant in Finland (Hämet-Ahti et. al. 1992). *Caragana arborescens* was apparently first introduced to Europe in 1727, when D. Messerschmidt brought seeds to St. Petersburg from his expedition to Yenisey River, Siberia (Buligin & Firsov 1998). According to Parvela (1930) seeds of Caragana were brought from St. Petersburg to Turku, Finland, in 1744, where the plants produced their first flowers in 1748 (Bjelke 1750). *C. arborescens* was similarly introduced to many other countries in Europe from Russia. *C. frutex* was brought into cultivation in St. Petersburg in 1736 through seeds collected by I. Heintzelmann (Buligin & Firsov 1998), probably along the Volga River in SE Russia. It never became as widespread in Finland and elsewhere in Europe as *C. arborescens*.

A search for *M. trifolii* in 1998 from the same shrubs on which it had occurred for 17 (Helsinki, Malmi) and 20 (Hattula, Lepaa) years showed that the species could not be found any more (observations by P.A.). Leaves from basal shoots were especially observed, because on these the more massive infection of *M. palczewskii* was not as likely to mask the occurrence of *M. trifolii*. It is likely that *M. palczewskii*, being a newly arrived specialist on this genus, has actually ousted the other species with weaker and more occasional infection on *Caragana*.

M. palczewskii often causes so heavy infections that even free-growing shrubs of *Caragana* become conspicuously white. Especially severe infections can be observed in hosts grown in hedges, which are regularly cut and thus develop a continuous dense "monoculture" of even-aged shoots. Due to this fact, some gardeners have replaced hedges of *C. arborescens* with other species. As to be expected, the fungus seems to make no difference between different cultivars of *Caragana*. Twenty specimens of *C. arborescens* 'Lorbergii' and 'Pendula' have been collected from mid-August to the end of September, their phenology apparently reflecting overall collection activity. Only one specimen originates from *C. frutex*, on which species *M. palczewskii* has not been previously reported (cf. Karis 1995).

Scholler (1994a) reported that *M. palczewskii* most likely overwinters as mycelium inside wooden parts of the host. To support this he had a series of *in situ* observations where the first signs of surface mycelium developed at the basal parts of the leaflets. A study of 30 juvenile specimens from Finnish herbaria showed no support for this idea. Also field observations verified that the first mycelial patches may develop to any part of the leaf and leaflet. In one collection mycelium and cleistothecia developed on empty pods of *C. arborescens*.

Material studied

Microsphaera trifolii
Uusimaa: Artjärvi, 1981 *Haikonen 1674* (H), Helsinki, 1966, 1971 *Savas 4, 879* (H), 1972, 1983 *Alanko 23144, 23308, 23326, 44996* (H, 23144 also in OULU, TUR). Mäntsälä, 1987 *Haikonen 8864* (H); Vantaa, 1966, 1971 *Savas, 101, 963* (H). **Etelä-Häme**: Hattula, 1965, 1976 , 1982, 1985 *Alanko 32792, 43774, 53602* (H), *67835, 410-65* (OULU). Heinola, 1954 *Rauhala* (H). Humppila, 1972 *Alanko 21929* (H).

M. palczewskii (those showing only conidia marked with *)
Ahvenanmaa: Sund, 1984 *Mäkinen 84-874* (TUR). **Varsinais-Suomi**: Aura, 1989 *Mäkinen 89-1212* (TUR). Halikko, 1998 *Kapanen & Kosonen** (TUR). Kaarina, 1989, 1993 *Mäkinen 89-863**, *93-1527* (TUR). Karinainen, 1997 *Huhtinen* (TUR). Karjalohja, 1999 *Alanko 104045* (H). Karkkila, 1997 *Alanko 94089* (H). Kiikala, 1995 *Kapanen & Kosonen* (TUR). Koski, 1991 *Kapanen*; 1996, *Mäkinen & Heinonen & Heinonen 44-96**; 1998 *Kapanen & Kosonen** (TUR). Kustavi, 1999 *Kallio* (TUR). Marttila, 1998 *Kapanen & Kosonen* * (TUR). Paimio, 1991 *Kapanen* (TUR); 1998 *Kapanen & Kosonen** (TUR). Perniö, 1994 *Kapanen & Kosonen* (TUR). Piikkiö, 1986 *Alanko 57110* (H); 1998 *Kapanen & Kosonen* (TUR). Raisio, 1998 *Kapanen & Kosonen* (TUR); 1999 *Kallio* (TUR). Rusko, 1998 *Kapanen & Kosonen* (TUR). Salo, 1994, 1997 *Kapanen & Kosonen* (TUR). Taivassalo, 1989 *Laine* (TUR). Tammisaari, 1998 *Alanko 99212* (H). Turku, *Kallio* 1999 (TUR); 1983, 1986, 1989, 1993, *1996 Alanko 46783, 57243, 66437, 76389, 90061, 90079* (H); 1983*; 1984, 1994 *Mäkinen 83-1475**, *84-1425, 88-754**, *94-503, 94-532, 94-1010* (TUR); 1993, 1994 *Kapanen*, 1996*, 1998* *Kapanen & Koso-*

nen (TUR). Vahto, 1998 *Kapanen & Kosonen* (TUR). Vehmaa, 1984 *Mäkinen 84-1222* (TUR). Uusikaupunki, 1993 *Mäkinen 93-1161* (TUR). Västanfjärd, 1998 *Alanko 97857* (H). **Uusimaa**: Askola, 1996 *Höijer 2021* (TUR). Espoo, 1984, *Ahti 41887* (H); 1990, 1994, 1996, 1998 *Alanko 68349, 80247, 89930, 98858* (H). Hanko, 1983 *Alanko 46965* (H); 1991 *Kapanen & Kosonen* (TUR). Helsinki, 1981, 1984, 1989, 1993, 1994, 1995, 1996, 1997, 1999 *Alanko 41916, 49549, 49590, 49593, 50378, 65826, 76772, 79421, 79649, 83493, 89192, 90965, 93874, 94441- 94444, 100720* (H); 1991 *Ahti 50940* (H); 1993 *Harju* (H); 1995 *Mäkinen 95-389* (TUR); 1995 *Gustafsson* (H); 1996 *Höijer 2020* (TUR); 1997 *Saari* (TUR). Järvenpää, 1992 *Höijer 882* (TUR). Kerava, 1996 *Höijer 1952* (TUR). Kärkölä, 1997 *Alanko 94629* (H). Loviisa, 1996 *Höijer 2014* (TUR). Nurmijärvi, 1989 *Askola 2654* (H). Pornainen, 1996 *Kapanen & Kosonen* (TUR). Porvoo, 1996 *Höijer 1935* (TUR); 1997 *Alanko 93930* (H). Sipoo, 1996 *Höijer 2019* (TUR). Vantaa, 1991 *Joutsenlahti 189** (TUR). **Etelä-Karjala**: Anjalankoski, 1994 *Kapanen & Kosonen* (TUR). Hamina, 1997 *Alanko 94181* (H). Kotka, 1998 *Höijer 2628* (TUR). **Satakunta**: Harjavalta, 1984 *Mäkinen 84-1138** (TUR). Hämeenkyrö, 1992 *Alanko 73130* (H). Ikaalinen, 1993*, 1996 *Kapanen & Kosonen* (TUR). Kiukainen, 1996 *Kapanen & Kosonen* (TUR). Lavia, 1998 *Kapanen & Kosonen* (TUR). Loimaa, 1991 *Kapanen* (TUR). Loimaan mlk, 1993 *Kapanen* (TUR). Mellilä, 1998 *Kapanen & Kosonen** (TUR). Pori, 1985 *Alanko 53849, 53870* (H). Rauma, 1992 *Ahti 51338* (H). Yläne, 1984 *Mäkinen 84-1105* (TUR). Äetsä, 1996 *Kapanen & Kosonen* (TUR). **Etelä-Häme**: Asikkala, 1984, 1989 *Haikonen 4789, 10985* (H). Hartola, 1993 *Alanko 75529* (H); 1994 *Haikonen 16588* (H); 1997 *Höijer 2265* (TUR). Hattula, 1984, 1996, 1997 *Alanko 49047, 90880, 94047 - 94051* (H); 1997 *Höijer 2262* (TUR). Heinola, 1986 *Alanko 57330* (H). Hollola, 1989 *Alanko 66482* (H); 1991 *Haikonen 13303* (H); 1995 *Kapanen & Kosonen** (TUR). Hämeenlinna, 1990 *Ahti 49083* (H). Iitti, 1984 *Haikonen 5067* (H). Kangasala, 1995 *Mäkinen 95-347* (TUR). Lahti, 1986 *Alanko 57316* (H); 1995, *Kapanen & Kosonen** (TUR). Lempäälä, 1993, *Alanko 76108* (H); 1996 *Söderholm 2544* (TUR); 1998 *Nummela-Salo & Salo 6543* (H, TUR). Luopioinen, 1984 *Alanko 49035* (H). Orivesi, 1995 *Kosonen* (TUR). Pälkäne, 1988 *Haikonen 9815* (H). Riihimäki,1995 *Ahti 52634* (H). Somero, 1993 *Kapanen* (TUR), 1997 *Alanko 94654* (H). Tampere, 1986, 1996 *Alanko 57501, 90850* (H); 1994 *Mäkinen 94-475* (TUR); 1998 *Kapanen & Kosonen* (TUR). Tuulos, 1998 *Alanko 98914* (H). Valkeakoski, 1986 *Alanko 57059* (H). Vilppula, 1998 *Järvinen & Järvinen 98-566* (TUR). **Etelä-Savo**:Hartola, 1999 *Alanko 102316* (H). Hirvensalmi, 1992 *Alanko 73191* (H). Joutsa, 1997 *Höijer 2266* (TUR). Juva, 1988 *Alanko 63506* (H). Lappeenranta, 1987, 1993 *Alanko 60888, 76585* (H). Mikkeli, 1988 *Alanko 62558* (H). Puumala, 1992 *Alanko 73053* (H). Rantasalmi, 1998 *Kapanen & Kosonen* (TUR). Savonlinna, 1998 *Kapanen & Kosonen* (TUR). **Laatokan Karjala**: Parikkala, 1989 *Kapanen* (TUR). **Etelä-Pohjanmaa**: Alavus, 1996 *Alanko 89435* (H). Närpiö, 1993 *Kapanen* (TUR). Seinäjoki, 1996*, 1998 *Kapanen & Kosonen* (TUR). Vaasa, 1986 *Piispala 823* (H); 1991 *Kapanen* (TUR); 1991 *Ahti 50151* (H). **Pohjois-Häme**: Jyväskylä, 1986 *Alanko 57596* (H); 1997 *Höijer 2268* (TUR). Jyväskylän mlk, 1997 *Höijer 2267* (TUR). Karstula, 1986 *Alanko 57669*. Konginkangas, 1994 *Kapanen & Kosonen* (TUR). Multia, 1985 *Alanko 53834* (H). Pihtipudas, 1997 *Höijer 2272* (TUR). Rautalampi, 1995 *Alanko 83519* (H). Viitasaari, 1997 *Höijer 2271* (TUR). **Pohjois-Savo**: Iisalmi, 1994 *Alanko 79717* (H). Muuruvesi, 1988 *Ahti 47619* (H). Kuopio, 1984 *Koskela* (H, OULU);1998, *Alanko 99650* (H). 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Oulu, 1989 *Salo 7757* (OULU); 1986, 1989, 1991, 1992, 1995 *Alanko 56427, 65893, 70596, 72944, 76389, 84735, 84737* (H); 1986, 1991 *Väre* (H, OULU); 1996 *Kulju 72/96 - 79/96* (OULU). Tyrnävä, 1996 *Kulju 86/96* (OULU); 1997 *Höijer 2276* (TUR). **Kainuu**: Kajaani, 1997 *Kosonen & Rautiainen 97-129*.(TUR). Kuhmo, 1995 *Alanko 84264* (H). Vaala, 1999 *Alanko 101930* (H). **Perä-Pohjanmaa**: Kemi, 1991, *anonymous* (OULU); 1997 *Höijer 2287* (TUR). Rovaniemi, 1995 *Kapanen & Kosonen** (TUR); 1995, 1996 *Alanko 84409, 84430, 90388, 90488* (H). Tornio, 1997 *Höijer 2290* (TUR). Ylitornio, 1998 *Höijer 2594* (TUR). **Koillismaa**: Kuusamo, 1989 *Ahti 48488* (H); 1996 *Alanko 90471, 90475* (H). **Kittilän Lappi**: Muonio, 1998 *Höijer 2600* (TUR). **Inarin Lappi**: Ivalo, 1998 *Mäkinen 98-911** (TUR).

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