

First records of gall-inducing aphid *Pemphigus populi* (Hemiptera: Aphidoidea, Eriosomatidae) in Poland with gall-based key to Central and North European species of the genus

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Osiadacz, B. & Hałaj, R. 2014: First records of gall-inducing aphid *Pemphigus populi* (Hemiptera: Aphidoidea, Eriosomatidae) in Poland with gall-based key to Central and North European species of the genus. — Entomol. Fennica 25: 16–26.

The paper presents first records of *Pemphigus populi* Couchet, 1879 (Hemiptera, Aphidoidea, Eriosomatidae) from Poland with a short description of the morphological characteristics of its fundatrix and fundatrigenia. Special attention is paid to the characteristics which distinguish this species from other Polish as well as the Central and North European representatives of this genus on poplars (*Populus* spp.). Information on the biology and distribution of *P. populi* in the world are given. A key to Central and North European species of *Pemphigus*, based on their galls formed on the primary host plants is also provided.

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Received 25 April 2013, accepted 18 October 2013

1. Introduction

The world's aphid fauna of *Pemphigus* Hartig, 1839 includes over 70 species (Remaudière & Remaudière 1997, Blackman & Eastop 2006, Holman 2009), out of which 20 have been recorded in Europe (Nieto Nafria *et al.* 2012). So far 9 species have been reported from Poland (Barczak 1987, Osiadacz & Hałaj 2009, 2010). Here we present the first records of *Pemphigus populi* Couchet, 1879 from Poland, thus introducing the 10th species of this aphid genus in the country, with a short description of morphological characteristics of the fundatrix and fundatrigenia as well as notes on the biology and distribution of the species.

Pemphigus spp. includes both holocyclic (with full developmental cycle) and heteroecious species (which in their seasonal cycle change the host) and anholocyclic (breeding only by parthenogenesis) monoecious ones (Zwölfer 1958, Lampel 1960, Heie 1980, Nieto Nafria *et al.* 2002, Stroyan 2009) (Fig. 1), an exception being the holocyclic and at the same time monoecious *P. spyrothecae* Passerini, 1856 (Urban 2002, Osiadacz & Hałaj 2011). All the holocyclic *Pemphigus* spp. induce galls on their primary hosts [*Populus* L. subgenus *Eupopulus* Dode, especially of the section 'black' *Aigeiros* Duby (Figaj & Stecki 1979)] (e.g. Dunn 1960, Shaposhnikov 1964, Whitham 1978, Smith 1985, Wool 2004, Pike *et al.* 2007). Both the gall shape and location

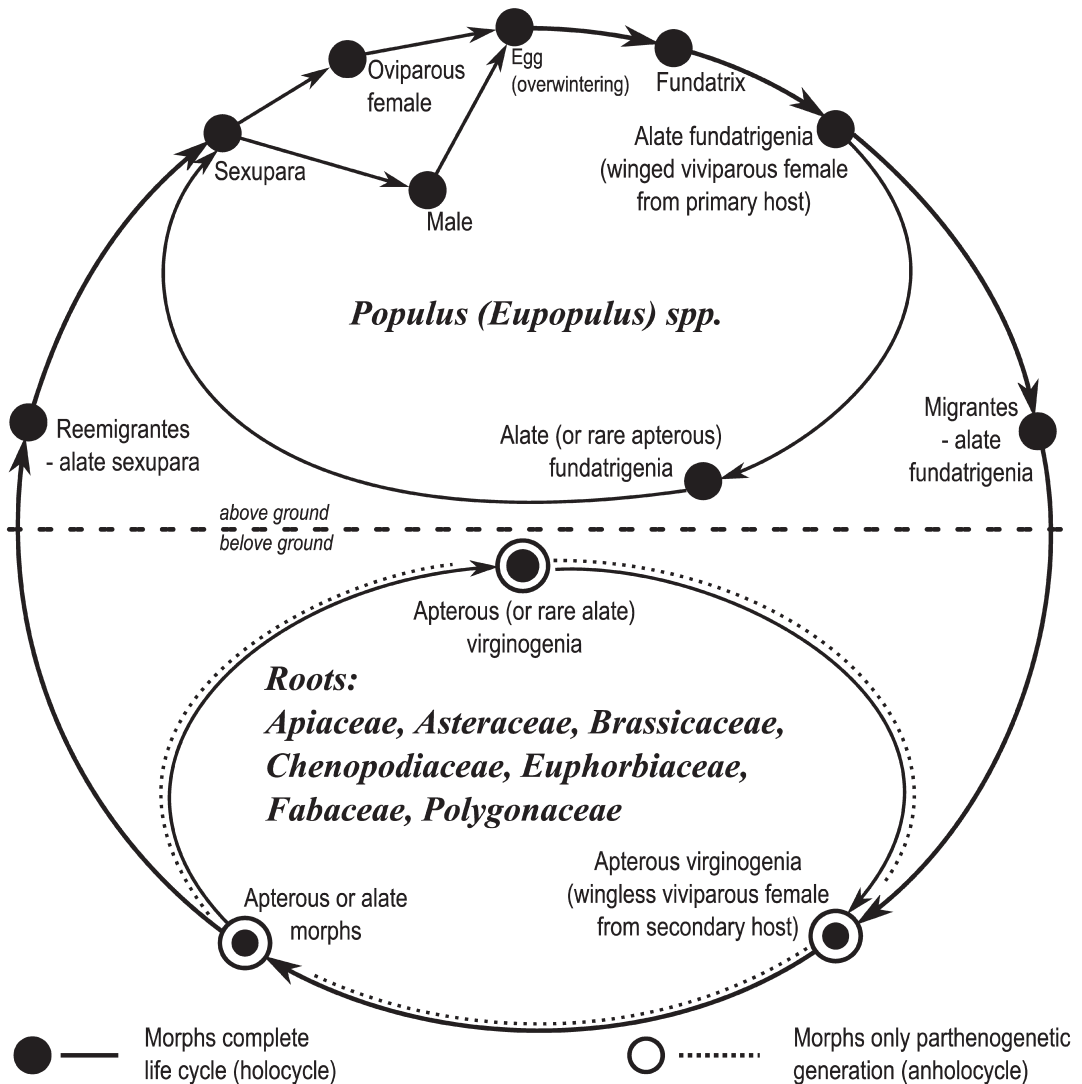


Fig. 1. Life cycles of Central and North European *Pemphigus* spp.

on the plant (Fig. 2) are characteristic enough to enable to differentiate particular species of *Pemphigus* spp. Accordingly, an original identification key of North and Central European *Pemphigus* species is presented on this basis.

2. Material examined

The material consists of numerous fundatrices as well as numerous alate fundatrigeniae and nymphs which are all greyish green and highly wax powdered in galls on leaves of black poplar

Populus nigra L. (Fig. 3). They were recorded at four localities (Fig. 4) as follows: 15.V. (fundatrices and nymphs) and 8.VI.1996 (alatae fundatrigeniae and nymphs), and 14.V.2011 (fundatrices and nymphs), Ruda Śląska-Bykowina (Silesian Upland) UTM: CA47; 08.VI.2012 (alatae fundatrigeniae and nymphs), Górk near Wiślica (Nida Basin), UTM: DA87; 24.VI.2012 (alatae fundatrigeniae and nymphs), Gruczno (Lower Vistula Valley), UTM: CE21; 17.VI.2012 (alatae fundatrigeniae and nymphs), Ligota Dolna-Kamieniołom (Silesian Upland) UTM: BA99.

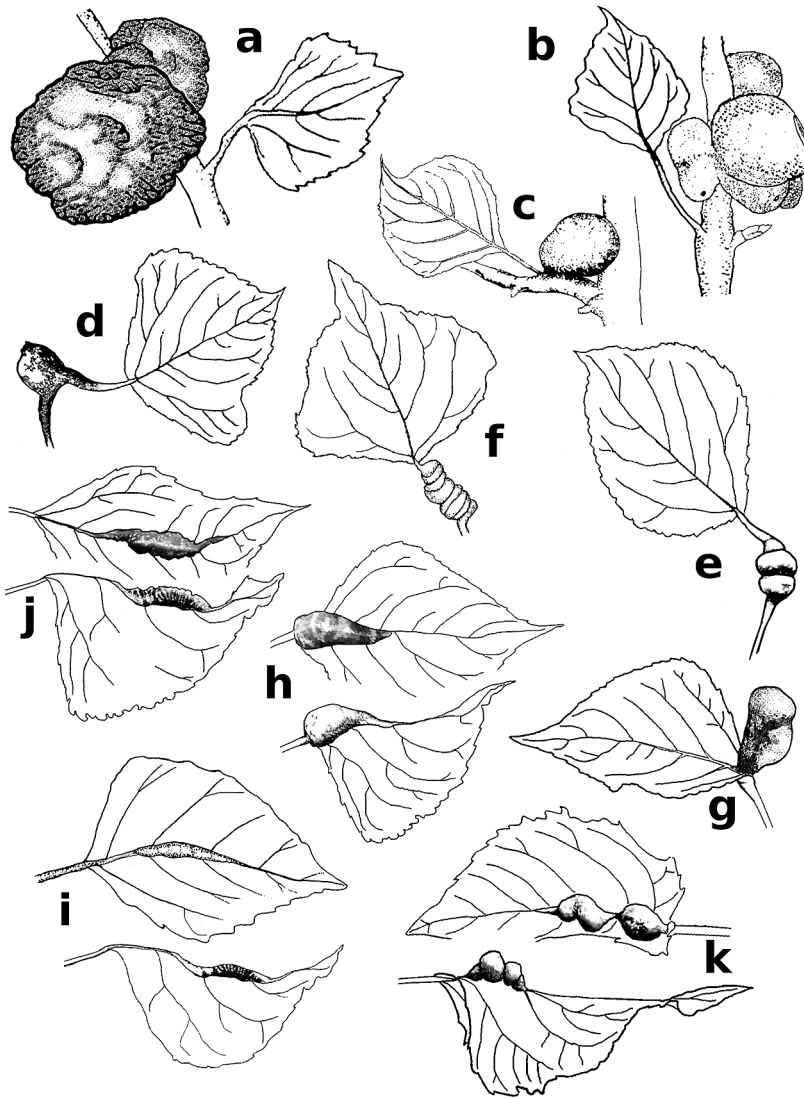


Fig. 2. Gall-inducing *Pemphigus* spp. – a. *P. immunis*. – b. *P. borealis*. – c. *P. trehermei* (modified draft based on Heie (1980)). – d. *P. bursarius*. – e. *P. spyrothecae*. – f. *P. protospirae*. – g. *P. populi*. – h. *P. passeki* (modified draft based on Prinsen (1990)). – i. *P. gairi*. – j. *P. phenax*. – k. *P. populinigrae*.

3. Main morphological characters

Fundatrix. Body 2.4–2.7 mm, abdominal wax gland plates (secrete wax substances) consisting of a few and rather large facets; antennae 4-segmented, about 0.17 times body length; antenna segment III 0.7–0.95 times the length of segment IV.

Fundatrigenia (Fig. 5). Body 1.5–2.4 mm, abdomen with small but distinct marginal wax gland plates; apical segment of rostrum pointed (Fig. 5b), about 0.1–0.12 mm and 0.5–0.7 times as long as the 2 segment of the hind tarsus; antenna segment III 0.9–2.4 times the length of segment IV; antenna segment V nearly the same

length as IV; processus terminalis (VIb) 0.25–0.4 times as long as basal part (VIa) of antenna segment VI; secondary rhinaria on antenna segments IV and V rather oval and wide – greater than rhinaria on antenna segment III (Fig. 5a); the number of secondary rhinaria on segment V are 1 or 2; siphunculi pores absent (Fig. 5c).

The latter two traits are basic morphological hints which help quickly differentiate winged viviparous females (fundatrigenia) of this species (subgenus *Pemphiginus* Börner, 1930 (e.g. Börner 1952, Barbagallo *et al.* 1995, Nieto Nafria *et al.* 2002) from other species of *Pemphigus* infesting poplars, belonging to *Pemphigus* s. str.



Fig. 3. Gall-inducing *Pemphigus populi*.

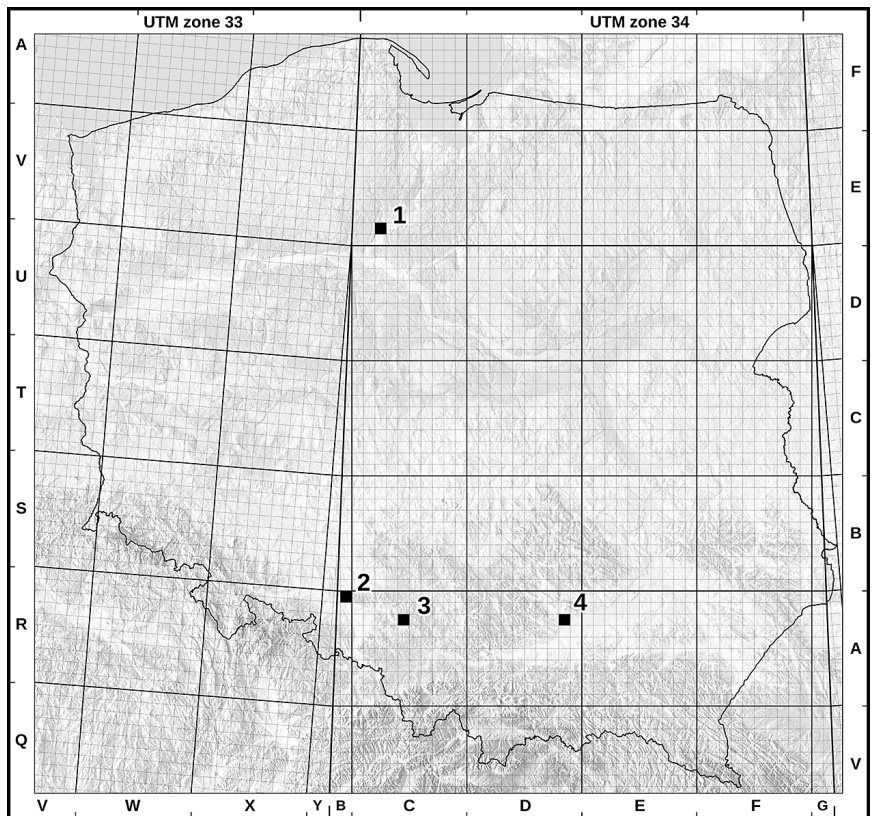


Fig. 4. Distribution of *Pemphigus populi* in Poland. 1: Gruczno, 2: Ligota Dolna, 3: Ruda Śląska, 4: Górki.

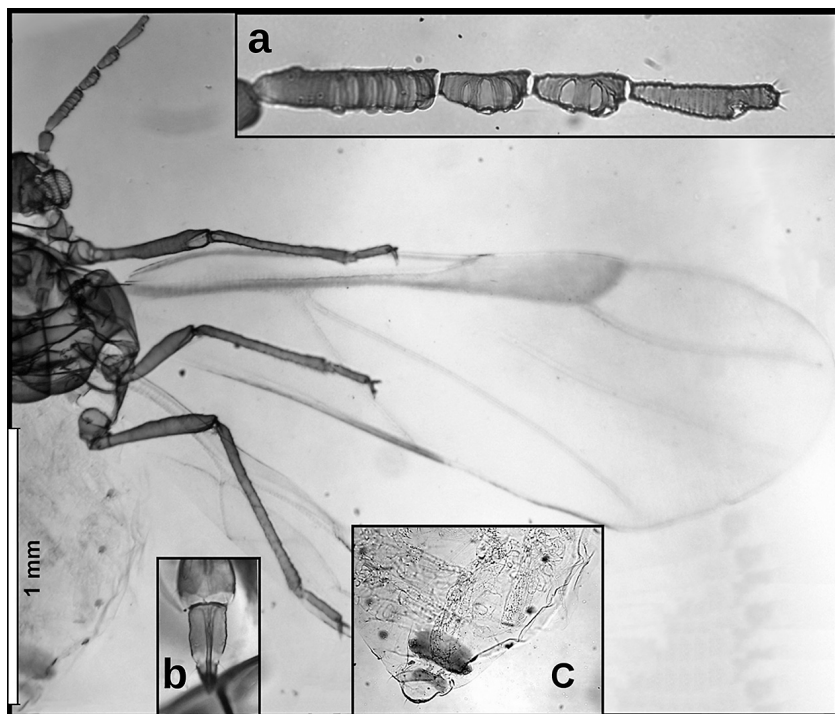


Fig. 5. Alate fundatrigenia of *Pemphigus populi*. – a. Flagellum. – b. Ultimate rostral segment. – c. Tip of abdomen.

4. Biology

Pemphigus populi is a holocyclic and heterocyclic species (see Fig. 1). Its primary host plants are various poplar species of *Eupopulus* subgenus, mainly the black poplar (*Populus nigra*) and its Italian variety (*P. nigra* 'Italica'). The infestation causes characteristic galls (Fig. 2g, 3). They are induced by fundatrices, which hatch from fertilised overwintering eggs on the break of April and May. The first young galls in Poland were observed in the first half of May (15.V.1996, 14.V.2011) and mature ones were seen already at the beginning of June (08.VI.2012) with numerous alate fundatrigeniae feeding inside. The opening of the galls and the flowing out of the migrants were noted in the second half of June (17 and 24.VI.2012).

Secondary host plants for *P. populi* are various species of Fabaceae (e.g. *Lathyrus pratensis* L., *Medicago lupulina* L., *Melilotus altissimus* Thuill.) and the infested place most often include ground and underground plant parts, particularly small roots (Danielsson 1976). Here the large generation of wingless viviparous females (apterous virginogenia) develops and on the

break of September and October, reemigrantes (alate sexuparae) come back to the primary host plants (Furk & Prior 1975) and breed the sexual generation (oviparous females and males). The life cycle ends with laying eggs on poplar twigs (Fig. 1).

5. Zoogeography

Pemphigus populi has been reported on vast areas of the Palaearctic from the British Isles (Stroyan 1957) to Western Siberia (Ivanovskaja 1977) (Fig. 6). A more detailed analysis shows that most locations form a belt approximately along the 40th parallel of north latitude from the Iberian Peninsula (e.g. González Funes & Michelena Saval 1988, Pérez Hidalgo & Nieto Nafria 2003) and other regions of the northern Mediterranean coast: Croatia, France-Corsica, Slovenia, Turkey, Italy (Couchet 1879, Çanakçıoğlu 1966, 1972, Janežič, 1978, 1981, 1989, Roberti 1993, Lampel 2001) through the Caucasus (Dzhibladze 1968) to Central Asia (Narzikulov 1953, 1968, Juchnevitch 1968, Bozhko 1976, Mukhamediev 1979, Gabrid 1989). In some regions of the belt, a clear shift of locations towards the 50th parallel is

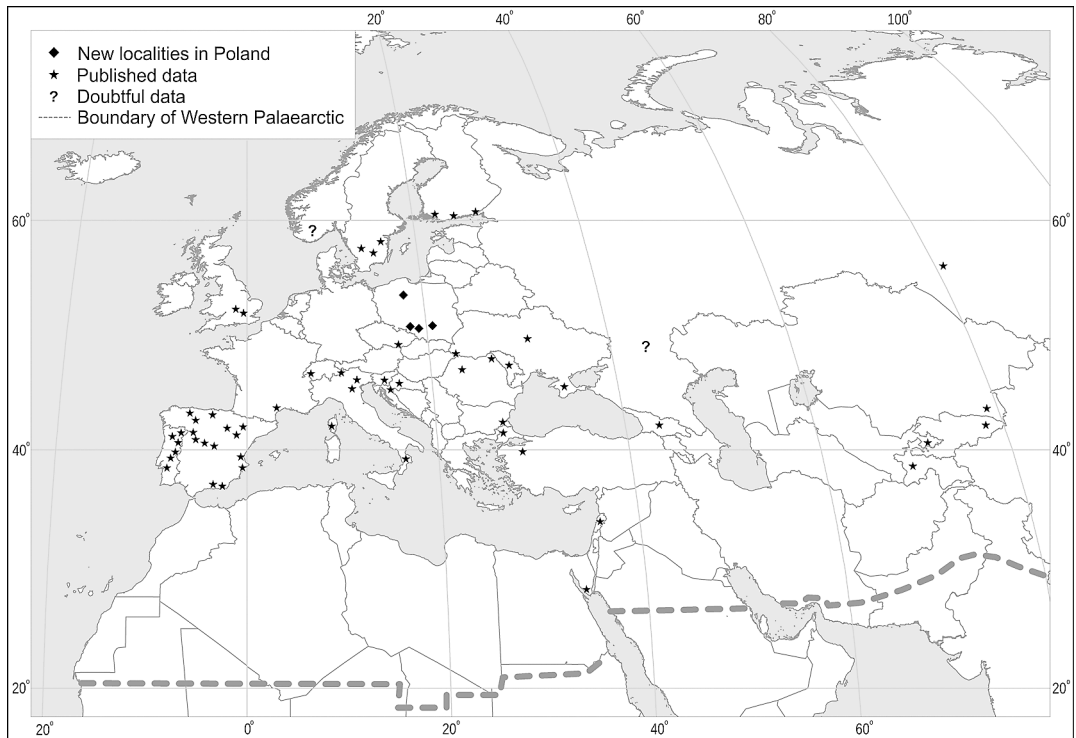


Fig. 6. Occurrence of *Pemphigus populi* in Western Palearctic.

obvious, particularly between 25th and 35th meridian of eastern longitude, as the localities from Bulgaria, Romania, Moldova and southern Ukraine (including Crimea) (e.g. Mamontova 1949, 1955, Bozhko 1957, 1971, 1976, Vereshchagin & Vereshchagina 1962, Holman & Pintera 1981, Vereshchagin *et al.* 1985, Tashev 1985, Gabrid 1989, Chumak 2004) are in those areas.

Therefore, *P. populi* is a species of western Palearctic range and more exactly of a Mediterranean-Pannonian-Pontian-Central Asian element. Some single reports from those centres of occurrence, e.g. Lebanon (Bodenheimer & Swirski 1957) or the Sinai Peninsula in Egypt (El-Akkad & Zalut 2004), seem to corroborate the species character (i.e. Mediterranean).

On the other hand, less numerous reports from other areas, e.g. from the Czech Republic (Lampel 1988, Holman 1995, Lampel & Meier 2003), Switzerland (Lampel, 1988, Lampel & Meier

2003), Sweden (Danielsson 1976), and Finland (Albrecht 2013), may indicate that it is increasing its range. The thesis seems to be supported by finding its new localities in Poland. In spite of rather detailed aphidological research conducted in the previous century in Silesian Upland, Wielokopolsko-Kujawska Lowland or Nida Basin on Małopolska Upland (Krzywiec 1970, 1982, Olesinski & Szelegiewicz 1974, Achremowicz 1972, 1975, Klimaszewski *et al.* 1980, Szelegiewicz 1981, Czylok 1983, Czylok & Wojciechowski 1987, Czylok *et al.* 1991, Karwańska 1991, Hałaj 1996, 1998, Hałaj & Węgierek 1998, Osiadacz & Wiczorek 2003, Wiczorek & Osiadacz 2005) and finding many aphid taxa there (Szelegiewicz 1968, Osiadacz & Hałaj 2009), the species in question was not found then. It seems impossible that *P. populi*, with such characteristic galls, had been overlooked. Therefore, at the moment, the species is quickly (almost invasively) expanding its range.

6. Key to central and north European species of *Pemphigus*, with additional notes on their biology and distribution

The key is based on the galls formed by the aphids on their primary hosts of *Populus* L. (subgenus *Eupopulus*). Below, migrating refers to the host alternation between the primary and secondary host plants of the aphids.

1. Galls on twigs 2
- Galls on the petiole or lamina 4
2. Galls small, maximum diameter 2.5 cm 3
- Galls clearly longer, of walnut size (about 4 cm in diameter), more or less spherical, with thick walls and uneven, wrinkled and often cracked surface, usually occurring individually, less often in small groups (1–4) but always separated from one another (Fig. 2a)

P. immunitus Buckton, 1896
(syn.: *P. lichtensteini* Tullgren, 1909)

The species is holocyclic and heteroecious, migrating to the roots of *Euphorbia* spp. (especially *E. helioscopia* L. and *E. peplus* L.). It is common in the Palaearctic region, occurring also in the Oriental region. However, its occurrence is rarely reported. In Central Europe, it is known from almost all countries, but it has not been listed in Denmark, Norway, Sweden, Finland, Estonia, Latvia and Lithuania.

3. Galls more or less oval in shape and with a rather smooth surface, often merged into groups of 4–6 at the base (even up to 10), but with separate fly-out zones for migrants (Fig. 2b)

P. borealis Tullgren, 1909

The species is holocyclic and heteroecious, migrating between *Populus* and underground parts of *Bidens* spp. (*B. tripartita* L., *B. cernua* L.). It occurs in the Palaearctic region, especially its northern part. It is known in Europe from Sweden and Finland, Estonia, Latvia, and Kaliningrad Region (Russia) and from a few localities in the other parts of the Europe.

- Galls single, rather round and smooth on the surface (Fig. 2c), green with reddish edge around the inlet *P. trehernei* Foster, 1975

The species is holocyclic and also anholo-

cyclic on the secondary hosts (*Aster tripolium* L., *Solidago virgaurea* L.). It is known from southern and western Europe (Ireland, France, United Kingdom). So far it has not been found in Central and Northern Europe.

4. Galls on the petiole 5
- Galls on the lamina 7
5. Galls more or less spherical, pear-shaped or pouch-like (Fig. 2d), green, yellow-green, sometimes red-brown in colour

P. bursarius (Linnaeus, 1758)

The species is holocyclic and heteroecious, migrating to the roots of Asteraceae (mainly *Crepis* spp., *Lactuca* spp., *Lapsana* spp., *Taraxacum* spp., *Tussilago* spp.). It is cosmopolitan.

- Galls of other shapes, mainly spiral 6
- 6. Galls in the form of flattened and spirally twisted petiole, with the number of twists not exceeding 5 (usually 3–4) (Fig. 2e). Galls green, yellow-green to red-brown, open at the end of summer and the beginning of autumn, often only in November

P. spyrothecae Passerini, 1856

The species is holocyclic and monoecious, occurring in Europe (recorded in all countries in Central and North Europe), Western Siberia, Northern Africa and the Middle East. It has been introduced to Canada.

- Galls flattened and strongly spirally twisted, the twists are smaller and more numerous (more than 5) than those formed by *P. spyrothecae*. Galls very often on all the petiole and the base of the lamina (Fig. 2f), shiny, green or green with red spots, opening from the beginning of summer until midsummer

P. protospirae Lichtenstein, 1884, 1885

The species is holocyclic and heteroecious, migrating to the plants of Apiaceae, especially those growing in water (e.g. *Apium* spp., *Berula* spp., *Sium* spp.). It occurs in Europe, Western Siberia and Central Asia. In Central and Northern Europe, it is known from few single localities in several countries (Denmark, Germany, Poland, Sweden, Slovakia, Belarus, Kaliningrad Region – Russia).

7. Galls more or less spherical or oval, more or less irregularly blobbed, almost always narrower at the base than at the top, pear-shaped or even slenderer (baseball bat-shaped),

placed on the upper side of the lamina on the main nerve usually close to its base (Fig. 2g, 3), size of a hazelnut, most often green in colour
P. populi Courchet, 1879

- Galls elongated and running along the main nerve 8
- 8. Galls at the base of the lamina, widest at base, then distinctly tapering (Fig. 2h)

P. passeki Börner, 1952

The species is holocyclic and heteroecious, migrating to the basal parts and roots of *Carum carvi* L. It is so far known from North-Western Europe as well as Finland and Ukraine.

- Galls of other shape, but never commencing at base of leaf lamina, never widened at base 9
- 9. Galls elongated and very narrow, their width at most 3–4 times the width of the main nerve, formed most often in the middle of the lamina (Fig. 2i), rather thin-walled and always slightly shining, green-yellow in colour, rarely slightly reddish *P. gairi* Stroyan, 1964

The species is holocyclic and heteroecious, migrating to the roots of *Aethusa cynapium* L. It is known from England, Czech Republic and Ukraine.

- Galls of other shape, but always much wider (minimum of 5 times the width of the main nerve) than in the previous species 10
- 10. Galls spindle-like, with slightly wrinkled surface (Fig. 2j), more or less red in colour, often with yellow sides and open all along from the bottom side of the lamina

P. phenax Börner & Blunck, 1916

The species is holocyclic and heteroecious, migrating to the roots of carrots (*Daucus carota* L.). It occurs in the Palaearctic region but it is rare or local. In Central and Northern Europe, it is known from most countries except Estonia, Finland, Latvia and Lithuania.

- Galls elongated and running along the main nerve, but much wider than those formed by *P. phenax*, blisterous, hazelnut size (but not larger) (Fig. 2k), rather smooth, in their majority bright reddish (rarely greenish) and rather without yellowish tint, only partly open from the bottom side of the lamina

P. populinigrae (Schrank, 1801)
(syn.: *P. filaginis* Boyer de Fonscolombe, 1841)

The species is holocyclic and heteroecious, migrating to the basal parts and leaves of *Filago* L. and *Gnaphalium* L. it is cosmopolitan.

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