

## Distribution, host plants and life cycle of *Porphyrophora polonica* (L.) (Hemiptera: Margarodidae) in Poland\*

B Łagowska<sup>1</sup>, K Golan<sup>2</sup> & K Stepaniuk<sup>3</sup>

<sup>1</sup>Faculty of Tourism and Environmental Promotion, Pultusk Academy of Humanities, ul. 17 Stycznia 56A, 06-100 Ciechanów, Poland (E-mail: [lagowskab@poczta.onet.pl](mailto:lagowskab@poczta.onet.pl)); <sup>2</sup>Depart. of Entomology, University of Agriculture, ul. K. Leszczyńskiego 7, 20-069 Lublin, Poland; <sup>3</sup>Department of Tourism and Recreation, Technical University of Białystok, ul. Ojca Stefana Tarasiuka 2, 16-001 Kleosin, Poland.

**Abstract:** *Porphyrophora polonica* (L.) has been recorded from 32 localities in 10 regions of Poland. The greatest number of localities with this scale insect were found at Sandomierska Lowland (6 localities) and Roztocze (5 localities). In total, 655 colonies of *P. polonica* were detected, with more than 100 colonies being found at two localities. *P. polonica* occurs in psammophilous vegetation, most often on the waste areas formerly used for agriculture, which constitute an element of the agricultural landscape. Its presence was observed on four plant species, but mainly on *Scleranthus perennis* and *Hieracium pilosella*. *P. polonica* has one generation per year both in the field and under laboratory conditions. Four nymphal stages occur in the male development and three in the female development.

The progressive disappearance of *P. polonica* in Poland has been observed and this species should be considered as an extremely endangered species. Some threats to Polish cochineal have been identified, namely secondary succession of psammophilous vegetation and human pressure. The strategy for the protection of *P. polonica* should be directed at habitat protection. Among the observed localities of *P. polonica*, four potential localities in three regions in Poland are suggested for protection.

**Key words:** *Porphyrophora polonica*, Polish cochineal, distribution, life cycle, threats, conservation.

### Introduction

*Porphyrophora polonica* (L.) is a Palaearctic species. The range of this scale insect includes the steppe and forest-steppe zones of the Eurasian continent from the south of France to eastern Mongolia (Jashenko, 1990).

In Poland, the Polish cochineal was very common in the 15<sup>th</sup> and 16<sup>th</sup> centuries. As a species providing natural dye, it was the object of organized export from Poland to Italy, the Netherlands, France, England, Turkey and Armenia (Jakubski, 1934). Vast areas of waste land, pastures and fallow land were used as pasturage for sheep, which provided wool, and, at the same time, was the natural habitat of *P. polonica*, which was used to dye the wool.

However, the supplies of Polish cochineal in Poland and worldwide started to be gradually exhausted, due to excessive exploitation and to the reduction and degradation of its natural habitat. The phenomenon of disappearance of the Polish cochineal and the need for protection of this valuable species had been noticed already in the 18<sup>th</sup> century. As mentioned by Jakubski (1934), as early as 1731, Breynius wrote: "Punishment {...} should be inflicted upon those who neglect the treasure that nature graciously gifts us".

In Poland, *P. polonica* was considered to be a species commonly occurring throughout the country until the end of the 1960's (Wernerówna, 1971; Kawecki, 1985). However, on

---

\* The study was financed by the Ministry of Science and Higher Education, Department of Scientific Research in the years 2004-2007 as a research project.

the basis of recent faunistic studies conducted between 1970 and 2004, *P. polonica* should be regarded as a disappearing species (Łagowska *et al.*, 2006).

In 2004, systematic cataloguing work was begun to estimate the degree of the threat to *P. polonica* in Poland and to verify its progressive disappearance. Initial results of these studies were published in a paper by Łagowska & Golan (2006).

The present paper discusses results of the search for *P. polonica* carried out in the years 2004-2007, gives an estimation of the threat to its existence, and suggests ways of protecting it in Poland. In addition, the life cycle of this species is presented.

## Materials and methods

The study was conducted at 450 localities in 19 regions of Poland in the months between June and September in each of the years 2004 to 2007. Host plants belonging to 10 species and 9 genera were searched for *P. polonica*: *Scleranthus perennis*, *S. annuus*, *Dianthus sp.* (Caryophyllaceae), *Hieracium pilosella* L., *Artemisia sp.*, *Achillea millefolium* L. (Asteraceae), *Thymus serpyllum* (Lamiaceae), *Corynephorus canescens* (L.), *Festuca sp.* and *Agrostis sp.* (Poaceae). The survey involved searching for *P. polonica* by uncovering the root system of the plants by means of a shovel. Each time the examined plants were counted and, in the case of *H. pilosella* which usually forms a compact cover on the occupied area, the number of soil exposures was noted. When the presence of a colony of *P. polonica* was observed, the number of scale insects was noted, a photo was taken and a description of the locality was prepared. A colony was considered to be all specimens living under one plant or found as a result of one soil exposure. Coordinates of the UTM - grid were recorded for the localities to allow plotting on a map.

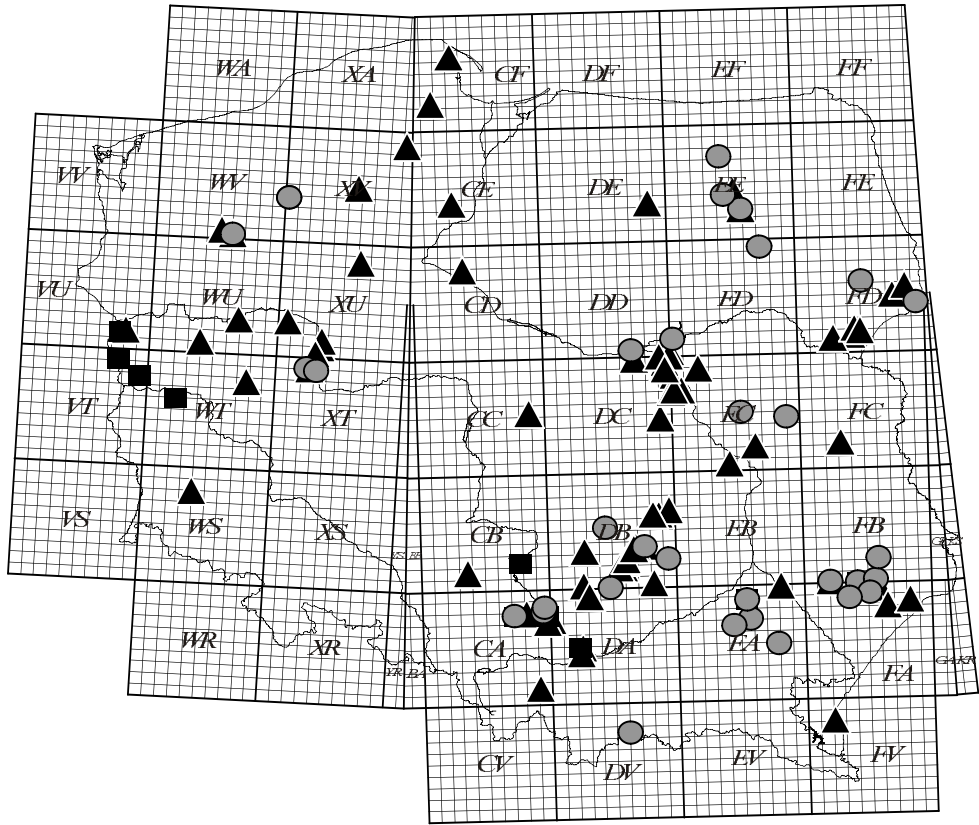
The life cycle of *P. polonica* on *H. pilosella* was investigated between April 2006 and September 2007 under laboratory conditions. Occasional observations also were carried out in their natural environments in different parts of Poland. The first-instar nymphs and cysts were collected between April and early June off *H. pilosella* by cutting the infested rhizomes or roots of the hosts, which were maintained in petri-dishes in the laboratory. Altogether, 41 samples were examined under a binocular microscope every 5 days to establish the dates of the appearance of each developmental stage and the duration of their development. Microscope slide-mounts were made and segregated according to the instar involved.

## Results

### *The occurrence of P. polonica in Poland*

In the last one hundred years, i.e. from 1900 until 2003 (until systematic studies were begun), *P. polonica* was reported from a total at 94 localities in Poland. However, in the years 1900-1970 it had been collected from 84 localities in 16 regions, whereas in the years 1971-2003, it was found in only 10 localities in 5 regions (Fig. 1).

In the period between August 2004 and September 2007, searches were conducted at 450 localities, but the presence of *P. polonica* was recorded from only 32 (Fig. 1; Table 1). Among these 32 sites, single colonies of *P. polonica* were found at 20 localities. The largest number of localities with *P. polonica* were found at Sandomierska Lowland (6 localities) and Roztocze (5 localities). It was there that the greatest number of the colonies of this species were observed; 180 colonies were located in Roztocze and 263 colonies in Sandomierska Lowland. In total, 655 colonies of *P. polonica* were found (Fig. 2; Table 1).



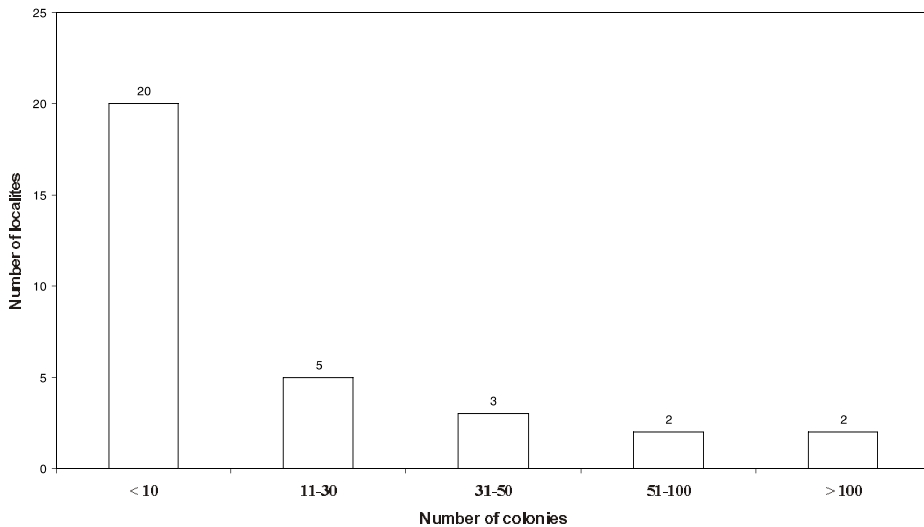
100 km

- ▲ Localities of *P. polonica* in the years 1920 – 1970
- Localities of *P. polonica* in the years 1971 – 2003
- Localities of *P. polonica* in the years 2004 – 2007

Figure 1. Occurrence of *Porphyrophora polonica* in Poland from 1920 to 2007.

**Table 1.** Number and percentage of localities of *Porphyrophora polonica* in the years 2004-2007.

Geographical region	Number of examined localities	Localities of polish cochineal		Number of colonies
		number	%	
Baltic Coast	22	0	0	0
Pomorskie Lakeland	31	3	9.6	70
Mazury Lakeland	13	3	23	17
Wielkopolsko-Kujawska Lowland	25	2	8	15
Podlasie	35	2	5.7	10
Białowieża Forest	18	0	0	0
Mazowsze Lowland	35	3	8.5	41
Lublin Upland	28	0	0.0	0
Roztocze	19	5	26.3	180
Świętokrzyskie Mountains	18	3	16.7	10
Sandomierska Lowland	21	7	33.4	263
Upper Silesia	48	3	13.0	48
Lower Śląsk	29	0	0	0
Pieniny	33	1	3	1
Western Beskidy	32	0	0	0
Eastern Beskidy	6	0	0	0
Małopolska Upland	18	0	0	0
Wzgórza Trzebnickie	15	0	0	0
Kraków-Częstochowa Upland	3	0	0	0
TOTAL	450	32	7.11	655



**Figure 2.** Histogram of the number of *P. polonica* colonies in localities.

### Habitats and host plants

*P. polonica* was found in sandy areas on the outskirts of forests or in waste lands previously used for agriculture. This species occurs in floristically poor psammophilous communities, with the gray *C. canescens* (L.) (Poaceae) dominating, or in clubawn sward in more advanced developmental stages, where the bedding was consolidated and where the following perennial plants already grew: *S. annuus* and *S. perennis*, *H. pilosella*, *Plantago* sp. (Plantaginaceae), *Th. serpyllum*, and rarely *Dianthus deltoides* L. There was a marked dominance of *H. pilosella* and *Pinus silvestris* L. (Pinaceae) in this vegetation.

*P. polonica* was collected on only four plant species, mainly on *S. perennis* and *H. pilosella* (Table 2). But also on *Th. serpyllum* and *C. canescens*.

**Table 2.** Number of localities and frequency of *Porphyrophora polonica* on host plants.

Host	Number of localities with <i>P. polonica</i> on host	Number of examined plants	Frequency [%]
<i>Scleranthus perennis</i>	20	1193	25.8
<i>Hieraceum pilosella</i>	14	1760	14.3
<i>Corynephorus canescens</i>	2	25	44.0
<i>Thymus serpyllum</i>	1	15	20.0

### Life cycle

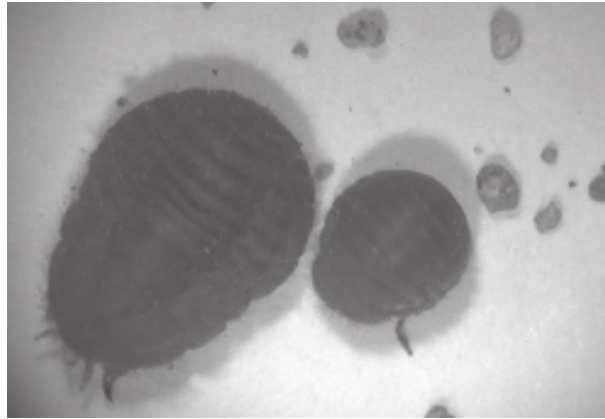
*P. polonica* has one generation per year both in the field and under laboratory conditions. First-instar nymphs (crawlers) overwinter covered by the waxy ovisac, hidden in the soil. This period lasted from the second 10-day period of August to about the end of March (Table 3). By April, the reddish crawlers disperse to hosts and settle on the root-crowns under the leaf-sheath and start to feed (Fig. 3). Soon they become swollen and brilliantly shining. Settled first-instar nymphs were present on the plants until the end of May. At this stage, no gender differences could be detected. The first-instar nymphs moulted during May and the 2<sup>nd</sup>-instar nymphs were present from the second 10-day period of May until the last 10-day period of July. During this stage, the cysts form and the female and male cysts can be distinguished. The two sexes were present on the hosts during the same period, but the male cysts were much smaller (Fig. 4).

During the cyst stage, the life cycle of the female and male diverged. The female life cycle involved three nymphal instars. The female cysts moulted during June and the adult females were present from the second 10-day period of June to the last 10-day period of July. In 2007, the peak emergence of the adult females took place on 25<sup>th</sup> of June.

During the development of the male, in addition to the first-instar nymph and cyst stage, the third nymphal (prepupal) stage and the fourth nymphal (pupal) stage also were detected. The 3<sup>rd</sup>-instar male resembles a small female (Fig. 5) without a vulva; it forms a cocoon and then moults to the pupa and then to the adult male. The adult males emerged between the second half of June and the end of July. In 2007, the peak emergence of the adult males took place on 29<sup>th</sup> of June.

Adult females begin to oviposit in the first 10-day period of July and the eggs hatch in the second 10-day period of August. Virgin females do not lay eggs although they sometimes produce an empty eggsac, but many of them die without forming an eggsac.





**Figure 5.** Adult female and male prepupa of *P. polonica*.

## Discussion

On the basis of the source data covering the years 1970-2003 (Łagowska *et al.*, 2006) *P. polonica* should be considered as an extremely endangered species, even though this opinion was not supported by proper studies. The surveying work carried out in the years 2004-2007 covered a considerable part of Poland. The following was observed in relation to earlier data from those areas (Wernerówna, 1971; Kabasa 1972; Radkiewicz, 1981; Łagowska *et al.*, 2006):

- the presence of *P. polonica* in 10 regions at 32 localities, which constitutes 34% of the localities reported earlier from those regions;
- the occurrence of *P. polonica* was not confirmed in 7 geographical regions (Baltic Coast, Białowieża Forest, Lower Silesia, Eastern Beskidy, Western Beskidy, Małopolska Upland, Kraków-Częstochowa Upland);
- this species was not found in the Lublin Upland and Wzgórza Trzebnickie; the same result had been earlier found by Wernerówna (1971);
- in 3 regions (Podlasie, Mazowsze Lowland, Roztocze), *P. polonica* was recorded in a smaller number of localities in relation to earlier data, with a particular decrease in the number of localities (from 20 to 3) in Mazowsze Lowland;
- the search for *P. polonica* in earlier reported localities was impossible in many cases because of the increasing anthropogenic development and, as a consequence, the disappearance of earlier mentioned localities of the occurrence of *P. polonica*;
- among the recorded localities, those with a small number of *P. polonica* colonies prevailed.

According to Pullin (2004), an estimation of the disappearance of a species may be based on its distribution at two time points, and the species may be regarded as disappearing if it has disappeared from half of the area it earlier occupied. On the basis of the presented data, one can speak of the progressive disappearance of *P. polonica* in Poland. Such a tendency has also been observed in neighbouring countries. Nowadays, in a few countries, *P. polonica* has gained the status of an endangered species and it was included in the Red Book of the former Soviet Union, Kazakhstan, Ukraine and Belarus (Łagowska *et al.*, 2006).

Considering the habitat requirements of *P. polonica* and the rapid rate of disappearance of the biotopes occupied by it, this species will die out also in Poland if no protective activities are undertaken. This species occurs in psammophilous vegetation, most often on the waste areas formerly used for agriculture, which constitute an element of the agricultural landscape. *P. polonica* is endangered wherever this type of plant community is endangered. The main danger to the existence and functioning of psammophilous vegetation is secondary succession. Psammophilous vegetation is stabilized, and to a large extent, shaped as a result of extensive pasturage. After the swards stop being grazed, they transform by way of secondary succession into brushwood, and then into forest (most frequently, poor pine wood). The second source of danger is human activity. The areas where *P. polonica* occurs are privately owned. The farmers usually intend them for building, forestation, or as a place for exploiting sand and gravel.

Out of the five forms of insect protection (Pawłowski & Witkowski, 2000), two should be considered in relation to *P. polonica*: i. protection of the species through protecting its habitats and ii. direct protection of the species. In the case of *P. polonica*, at the present state of knowledge, the first type of protection seems the most reasonable and effective. *P. polonica* does not fulfill all the criteria that insects classified for species protection should fulfill. They should first of all be easy to obtain and commonly recognizable. However *P. polonica* is a species of a very small size: the size of the cyst ranges from 3 to 4 mm, the females from 5.0 to 6.5 mm, the males from 2.2 to 3.5 mm, whereas the size of the crawlers does not even exceed 1 mm.

In addition, finding and identifying *P. polonica* requires specialist knowledge. Therefore, the strategy for its protection should be directed at habitat protection. The act of 16 April 2004, concerning nature conservation (Journal of Laws No. 92, item 880) (Articles 6 and 42), introducing ecological arable lands as an individual form of nature conservation, is conducive to habitat protection. This form of protection is of special importance in the preservation of biological diversity in the agricultural landscape in Poland.

Among the observed localities of the occurrence of *P. polonica*, potential sites can be suggested for protection of *P. polonica*, particularly in Sandomierz Lowland (in Mechowiec and Nowa Dęba) and one locality in each of Roztocze (in Sól) and Pomorskie Lakeland (in Borne Sulinowo). These are the areas with greatest populations of *P. polonica* and should be subject to active protection to inhibit succession (removing trees and bushes, continuing or ensuring extensive pasturage, controlling wilting) and to protect them from human pressure.

Not only ecological but also historical reasons speak in favour of the protection of *P. polonica*. *P. polonica* is an almost historical species, "meritous" for Poland. At the turn of the 15<sup>th</sup> and 16<sup>th</sup> centuries, it was one of the most important economic factors of the national economy, contributing to the splendour of the country and the welfare of the society. However, despite its "historical merits", it is not included in either the red list of threatened and endangered animals in Poland nor in the red book of animals.

At the examined localities, *P. polonica* was mainly reported on *S. perennis* and *H. pilosella*. Its presence was noted for the first time on *Th. serpyllum* and *C. canescens*. At some localities, it occurred more often on *H. pilosella* than on *S. perennis*. In Poland, *H. pilosella* has previously been considered to be a sporadic host to *P. polonica* (Kawecki, 1985).

The life cycle of *P. polonica* was described for the first time by Breynius as early as the 18<sup>th</sup> C. (Kawecki & Wernerówna, 1969). Information on the development of this species also can be found in Jakubski (1965), who distinguished five nymphal stages in the male life

cycle: first-instar nymph, 2<sup>nd</sup> instar nymph (cyst stage), 3<sup>rd</sup> instar nymph, prepupa and pupa. In contrast, our observations showed the presence of four nymphal stages in the male development, which is consistent with the general scheme of the life cycle of species from the genus of *Porphyrophora*, as described by Vahedi & Hodgson (2007). Also we found out that the cysts became enclosed in membranous layers of glassy wax, which were described as exuviae by Jakubski (1965).

## References

- Jakubski, A.W. 1934. Czerwiec polski (*Porphyrophora polonica* (L.). Studium historyczne ze szczególnym uwzględnieniem roli czerwca w historii kultury. Wyd. Kasy im. Mianowskiego-Institutu Popierania Nauki, Warszawa-Pałac Staszica.
- Jashenko, R.V. 1990. Distribution and host-plants of *Porphyrophora polonica* (Homoptera: Coccoinea: Margarodidae). Proceedings of the Sixth International Symposium of Scale Insects Studies, Kraków, part II, pp. 119-122.
- Kabasa, T. 1972. O występowaniu na nowym żywicielu czerwca polskiego *Porphyrophora polonica* (L.) i o jego stanowiskach z powiatu grójeckiego. Przegląd zoologiczny 16:207-209.
- Kawecki, Z. 1985. Czerwce Coccoidea. Katalog Fauny Polski, PWN Warszawa, XXI, 5:1-107.
- Kawecki, Z. & Wernerówna, H. 1969. Johannes Philippus Breynius. Prace o czerwcu polskim De Coco polonico opera 1731-1733-1750 życiorysem J.F. Breynie'a i komentarzem opatrzyli Z. Kawecki i H. Wernerówna. Memorabilia Zoologica 20:1-148.
- Łagowska, B. & Golan, K. 2006. Wstępna ocena zagrożenia *Porphyrophora polonica* (L.) (Hemiptera: Margarodidae) w Polsce i możliwości jego ochrony w świetle istniejących regulacji prawnych. Wiadomości entomologiczne 25, Supl.2:135-145.
- Łagowska, B., Golan, K. & Stepaniuk, K. 2006. Występowanie czerwca polskiego - *Porphyrophora polonica* (L.) (Hemiptera: Margarodidae) w Polsce oraz uwagi o jego cyklu życiowym. Wiadomości entomologiczne 25(1):5-14.
- Pawłowski, J. & Witkowski, Z.J. 2000. Formy ochrony owadów w Polsce w świetle doświadczeń innych krajów i zaleceń Unii Europejskiej. Wiadomości entomologiczne 18, Supl. 2:15-26.
- Pullin, A.S. 2004. Biologiczne podstawy ochrony przyrody. PWN, Warszawa.
- Radkiewicz, J. 1981. *Porphyrophora polonica* (L.) (Hom. Coccoidea) na zachodnich krańcach Polski. Przegląd zoologiczny 25:265-266.
- Wernerówna, H. 1971. Rozmieszczenie czerwca polskiego *Porphyrophora polonica* (L.) (Homoptera, Coccoidea) w Polsce i krajach ościennych. Przegląd zoologiczny 15:287-291.
- Vahedi, H.A. & Hodgson, C.J. 2007. Some species of the hypogeal scale insect *Porphyrophora* Brandt (Hemiptera: Sternorrhyncha: Coccoidea: Margarodidae) from Europe, the Middle East and North Africa. Systematic and Biodiversity 5(1):23-122.