

The species of *Pulvinaria* in The Netherlands (Hemiptera: Coccidae)

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Abstract: The occurrence of the species of the soft scale genus *Pulvinaria* in The Netherlands is discussed. Four species occur in the open, one is native (*Pulvinaria betulae*) and three are introduced and established (*P. floccifera*, *P. hydrangeae* and *P. regalis*). Two species are only known from interceptions during import inspections and from greenhouses (*P. mesembryanthemi* and *P. psidii*). A key to the species is given.

Samenvatting: Het voorkomen van de soorten van het dopluizengeslacht *Pulvinaria* in Nederland wordt besproken. Vier soorten komen buiten voor, waarvan één soort inheems is (*Pulvinaria betulae*) en drie geïntroduceerd en ingeburgerd zijn (*P. floccifera*, *P. hydrangeae* en *P. regalis*). Twee soorten zijn alleen bekend van importintercepties en uit kassen (*P. mesembryanthemi* en *P. psidii*). Een determinatietabel voor de vrouwtjes van deze soorten is opgenomen.

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Introduction

During the last decade, several exotic species of the genus *Pulvinaria* Targioni Tozzetti have established themselves in The Netherlands after introduction as a result of international trade. Some of the introduced species have been previously reported by Moraal (1988, 1989) and in the annual reports of the Plant Protection Service. No comprehensive review of the Dutch species exists. The literature on the species concerned is dispersed and often not easy to obtain.

The genus *Pulvinaria* comprises worldwide 139 species (Ben-Dov, 1993) and six of them have been found in The Netherlands. *Pulvinaria betulae* (Linnaeus) (= *P. vitis* (Linnaeus), see Kozár, 1998) is the only species that can be regarded as native. *Pulvinaria floccifera* (Westwood), *P. hydrangeae* Steinweden and *P. regalis* Canard are introduced species, established well in the public green. *Pulvinaria mesembryanthemi* (Vallot) and *P. psidii* Maskell are imported, but not yet established. *Pulvinaria mesembryanthemi* is described by Qin & Gullan (1992) and has been found in many subtropical regions. In Europe it reaches England and in The Netherlands it occasionally has been found on its hostplant

Mesembryanthemum in living rooms and on plants imported from Spain and France (Jansen, 1995). The tropical *P. psidii* was only found at import inspections (Jansen, 1994). Williams & Watson (1990) and Qin & Gullan (1992) describe this polyphagous species.

This paper is mainly based on samples taken by inspectors of the Plant Protection Service at their regular visits to growers for phytosanitary and quarantine inspections. Furthermore the Service regularly received insects for identification and advice from private persons. Data from the Institute for Forestry and Nature Research (IBN-DLO) are also included. Life cycles are compiled from both Dutch field observations and literature data (Canard, 1965b; Van Frankenhuyzen, 1980; Malumphy, 1991; Schmutterer, 1952; Speight, 1991). Slide material is deposited in the collection of the Plant Protection Service. The material used for this study also includes the collection of A. Reyne kept at the Zoological Museum, Amsterdam. The terminology for morphological structures is after Hodgson (1994).

Identification

Pulvinaria species can be distinguished from

other West-European soft scale genera by a combination of characters: teneral females are less than twice as long as wide and the tibia and tarsus usually are freely articulating. They produce a characteristic elongate, white, cottony ovisac under the body. Members of other genera, however, may have a similar ovisac. Length and shape of the ovisac provide additional diagnostic field characters. Microscopic characters are the three spiracular setae of which the medial one is larger than the other two and the latter differ in shape from the marginal setae.

Females of most *Pulvinaria* species are more or less oval-shaped, rather flat, wrinkly and chestnut-brown to more or less greyish. The adult female (fig. 11) of *P. regalis* possesses yellowish spots and the stigmatic grooves, anal cleft and anal plates are yellowish.

The four Dutch species occurring in the open can be distinguished by a combination of the following characters: the hostplant, the site on the host, the shape and length of the adult female and the shape, length and width of the ovisac (table 1). These characters are useful for practical purposes if critically used on a fair sample of the population. However, a fully reliable identification of scale insects can only be carried out if young females are mounted properly and studied microscopically. Good slide material can only be made during a short period of the year when young adult females are available. *Pulvinaria hydrangeae* and *P. regalis*, however, are easy to distinguish from each other by their external

appearance, but mounted specimens of these species share a lot of microscopic characters.

Hodgson (1994) gave a key to subfamilies, tribes and genera following the generic concept of Borchsenius (1952, 1953, 1957), who distinguished eight genera. *Chloropulvinaria* Borchsenius (with *C. floccifera* and *C. psidii*), *Eupulvinaria* Borchsenius (with *E. hydrangeae*), *Pulvinaria* Targioni Tozzetti (with *P. regalis* and *P. betulae*) and *Pulvinariella* Borchsenius (with *P. mesembryanthemi*) are of interest for the Dutch situation.

Many specimens of the Dutch species don't agree with the genera definitions sensu Hodgson (1994). Therefore the species concept of Ben-Dov (1993) is followed here.

Some commonly used microscopic characters are variable within Dutch populations and therefore a key to the females of the Dutch species is presented in the following lines.

Key to adult females of Dutch *Pulvinaria* species

1. Marginal setae spine-like, blunt apically, with a well-developed, broad basal socket and almost parallel sides
..... *mesembryanthemi*
- Marginal setae spine-like, with acute, expanded or fimbriate apices 2
2. All abdominal segments ventrally with long paired setae in the median region ... 3
- Long paired or pregenital setae only present in the median region of the three posterior abdominal segments 4

Table 1. Field characters of adult females of *Pulvinaria* species occurring in the open in The Netherlands.

	<i>floccifera</i>	<i>hydrangeae</i>	<i>regalis</i>	<i>betulae</i>
hostplant	polyphagous: especially on <i>Euonymus</i> , <i>Ilex</i> , <i>Taxus</i> , <i>Vaccinium</i>	polyphagous: (Table 2); not on <i>Ilex</i> , seldom on <i>Taxus</i>	polyphagous: (Table 3); seldom on <i>Ilex</i> , not on <i>Taxus</i>	polyphagous: seldom on <i>Ilex</i> , not on <i>Taxus</i>
site on host	leaves (also in winter) and branches	trees: leaves; shrubs: leaves + branches	trunk	branches
body length	2-6 mm	2.5-4.6 mm	3.2-8 mm	1-8.5 mm
body width	2-3 mm	2.1-3.9 mm	3.8-6 mm	1-7 mm
shape ovisac	elongate, furrows if present indistinct	with three distinct furrows	short, greatest part hidden under the body	strongly convex
width ovisac	1.5-3.5 mm	3-4.5 mm	6.5-8 mm	1.5-6.5 mm
length ovisac	4-9 mm	4.5-10 (max. 17) mm	2-4 mm	2.5-10 mm



Fig. 1. *Pulvinaria betulae*, adult females with ovisac (Photo: A. van Frankenhuyzen).

- 3. Length of longest posterior marginal setae 55-85 μm long; length of longest pregenital setae 160-180 μm long; number of marginal setae with expanded or fringed tip 2 or more *hydrangeae*
- Length of longest posterior marginal setae 30-50 μm ; length of longest pregenital setae 200-260 μm ; number of marginal setae with expanded or fringed tip 0-14, usually 0-5 *regalis*
- 4. A few or all marginal setae with expanded and fringed apices 5
- Marginal setae with pointed apices, never expanded or fringed *betulae*
- 5. Spiracles surrounded by a sclerotized oval plate, occasionally faint and difficult to observe; marginal setae stout, 12-40 μm long; median seta of spiracular setae 40-60 μm long; dorsum with cell-like clear areas; multilocular pores with 9-12 loculi *psidii*
- Spiracles without a sclerotized oval plate; marginal setae slender, 60-88 μm long; dorsum without cell-like clear areas; multi-

locular pores with 5-10 (mostly 7) loculi *floccifera*

***Pulvinaria betulae* (Linnaeus)**
 (= *P. vitis* (Linnaeus))

Adults (fig. 1) are extremely variable in size in response to host and climate, even within populations (Kosztarab & Kozár, 1988; Malumphy, 1991).

Malumphy (1991), who demonstrated the extreme variability of this species and established several synonyms, described microscopic characters and the habitus of female adults. The dorsal side of the anal plate possesses three to four apical setae and the ventral side three subapical setae. The distribution of *Pulvinaria betulae* comprises the whole Palaearctic Region. It has been introduced in parts of the Neotropical and the Nearctic Region, and New Zealand. Malumphy (1991) recorded world-wide 94 host-plant species in 18 families the majority belonging to the Rosaceae, Salicaceae and Betulaceae.

The life cycle (fig. 2) of *P. betulae* is described by Malumphy (1991) and appears to vary in response to environmental conditions, such as climate and hostplant. Contrary to the other Dutch *Pulvinaria* species occurring in the open, the adult females overwinter. They begin feeding again in the following spring, becoming more convex and darker brown, and start to produce an egg sac of white wax threads in May. Depending on temperature and hostplant, eggs are laid into the ovisac over a period of two or three weeks. Phillips

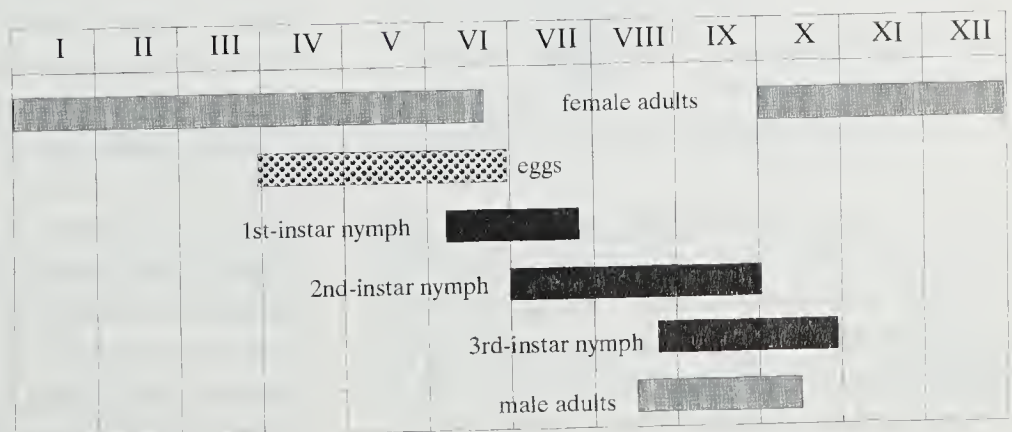


Fig. 2. Life cycle of *Pulvinaria betulae* (after Malumphy (1991), changed).



Fig. 3. Distribution map of *Pulvinaria betulae*.



Fig. 4. Distribution map of *Pulvinaria floccifera*.

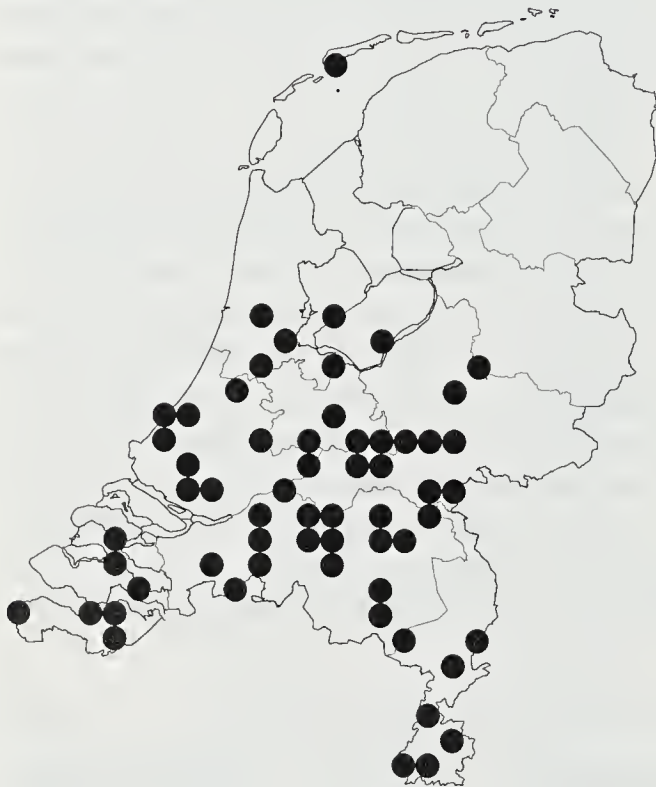


Fig. 5. Distribution map of *Pulvinaria hydrangeae*.



Fig. 6. Distribution map of *Pulvinaria regalis*.

(1963) reported a highest number of 4000 eggs on peach. Adult soft scales appear again in September and October. Malumphy (1991) reported one generation in England, but indicated that a second generation might develop in warm summers.

The glassy tests of male larvae that are described by Řeháček (1960); can be found in clusters on smaller twigs and branches but are usually only found in dense populations. In most outdoor and indoor populations they are absent (Malumphy, 1991).

Pulvinaria betulae is the only native Dutch species, found all over the country (fig. 3). In The Netherlands *P. betulae* has occasionally been noxious in nurseries in the open on *Ribes rubrum* L., *R. nigrum* L., *R. uva-crispa* L. and *Malus*. Occasionally, *Betula*, *Evonymus*, *Fagus*, *Alnus*, *Pyracantha*, *Pyrus* and *Salix* become infested. Van Frankenhuyzen (1980) observed wind dispersal of crawlers from *Alnus* hedgerows to adjacent apple and pear trees. In the past *P. betulae* was regularly found in greenhouses on grapevine, where, in the absence of natural enemies, it developed into a serious pest.

Malumphy (1991) listed the natural enemies of *P. betulae* world-wide and found 28 parasitoids and 16 predator species. Among the latter were representatives of Lepidoptera, Coleoptera, Diptera, Hemiptera, Neuroptera and Thysanoptera.

Pulvinaria floccifera (Westwood)

In comparison with the ovisac of *Pulvinaria hydrangeae* the three longitudinal furrows on the ovisac are very shallow and often hardly visible. Qin & Gullan (1992) and Hodgson (1994) give detailed descriptions of microscopic characters of adult females of *Pulvinaria floccifera* (fig. 7). Canard (1965b) discussed the differences with *P. hydrangeae*. The dorsal side of the anal plate possesses four apical setae and the ventral side two subapical setae. Steinweden (1946) noted considerable variation in the number of fringed or bifid marginal setae in specimens of *P. floccifera*, these varying from two to 30, even in specimens from the same sample.

Kosztarab & Kozár (1988) briefly describe the life cycle of *Pulvinaria floccifera* (fig. 8). Overwintering takes place on the leaves of the hostplant. Males are rare. The test (pupa) of the fourth instar male is described by Řeháček (1960). Although this species is extremely polyphagous as it is known from 27 plant families (Ben-Dov, 1993), it is confined to evergreen shrubs. The species is found in Australia, South Africa, the United States of America, Vietnam and many West-Palaeartic

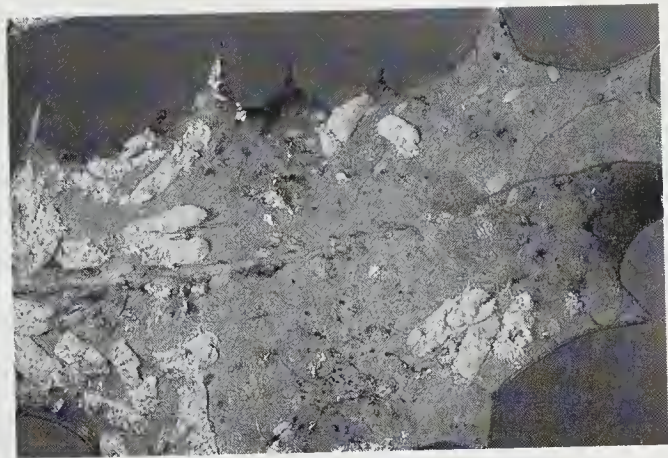


Fig. 7. *Pulvinaria floccifera*, adult females with ovisac and nymphs (Photo: A. van Frankenhuyzen).

countries including The Netherlands (Ben-Dov, 1993).

Pulvinaria floccifera was found for the first time in The Netherlands by J. O. Westwood in a greenhouse at Amersfoort on *Camellia* in 1869 (Verloren, 1870), a few months after its description from England. Reyne (1957) recorded it also from greenhouses and occasionally from the open on *Taxus baccata* L. Nowadays *P. floccifera* is a common species and an important pest in the public green in many towns and villages (fig. 4). Its incidence is still increasing. Outdoors it is especially found on *T. baccata* and *Ilex*, occasionally on *Camellia*, and rarely on *Berberis*, *Euonymus*, *Gaultheria*, *Hedera* and *Mahonia* (Burger, 1981). In 1996 *P. floccifera* was found on *Vaccinium* in woods near Ede and Wolfheze (province of Gelderland) and Oisterwijk (De Kampina) (province of Noord-Brabant).

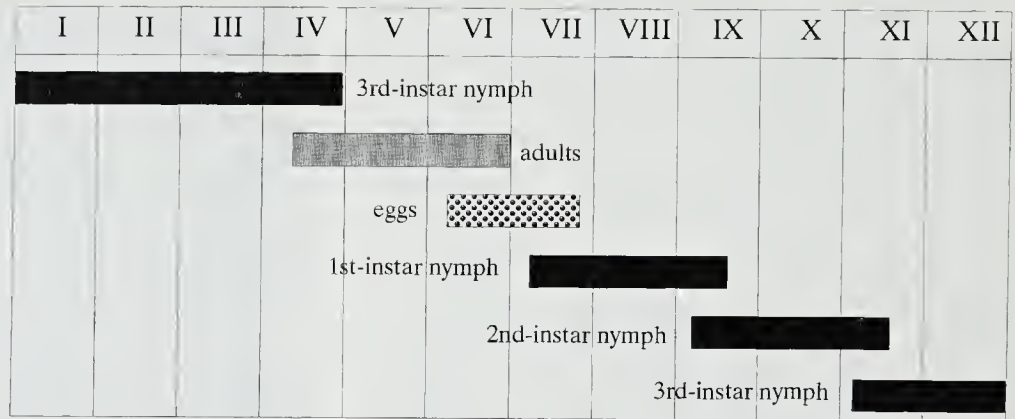
Although Van Rossem et al. (1964) recorded it as regularly found in greenhouses and living rooms, slide-material is only available from *Vaccinium*. Records of *Anthurium* and *Citrus* need confirmation.

The coccinellid *Exochomus quadripustulatus* (Linnaeus) is a common predator, which can partly reduce scale populations.

Pulvinaria hydrangeae Steinweden

The most recent description of the adult female of *Pulvinaria hydrangeae* (fig. 9) is given by Qin & Gullan (1992), and Canard (1965b) discussed the differences with *P. floc-*

Fig. 8. Life cycle of *Pulvinaria floccifera*.



cifera. Contrary to the genus definition sensu Hodgson (1994), Dutch and Australian populations (Qin & Gullan, 1992) possess preopercular pores. The dorsal side of the anal plate has four setae (three apical ones and a subdisical one), and the ventral side bears three subapical setae. Rarely a few straight, bluntly tipped marginal setae were found, which in literature (Qin & Gullan, 1992) are supposed to be typical for *P. mesembryanthemi*. The adult male is described by Canard (1969).

Merlin (1993) and Merlin et al. (1988) describe the life cycle of *P. hydrangeae* (fig. 10). Overwintering takes place on young twigs where nymphs continue to feed, showing reduced growth. Adult males are rare and their role remains uncertain because parthenogenetic reproduction is the rule (Nur, 1963).

Pulvinaria hydrangeae has been recorded by Ben-Dov (1993) from Japan, Australia, New Zealand, the United States of America, Belgium, France and Italy. In addition to Ben-Dov (1993), *P. hydrangeae* has been recorded from England (Malumphy, 1991), Germany (Kreul, 1996), Switzerland (Kozár et al., 1994) and Tasmania (Merlin, 1993). In Europe it is spreading eastwards. It is a common species in The Netherlands, but almost absent in the northern provinces.

In August 1983 a female of *P. hydrangeae* was found on *Prunus* at Zundert near the Belgian border. Later on Burger (1988) recorded it from *Viburnum opulus* L. in a private garden at Renkum in 1987 and by Moraal (1989) from Breda, Maastricht, Den Bosch, Vught and Weert on many different hostplants. World-wide it has been reported from

about 100 plant species in 28 families. In The Netherlands it has been found on 38 hostplant species of 22 families (table 2).

The females are usually living on leaves of their hosts, but occasionally they are found on small branches as is generally the case on *Rosa rugosa* Thunb. *Pulvinaria hydrangeae* is very common in The Netherlands and a pest in the public green of many towns and villages (fig. 5) causing severe damage to various amenity trees. *Acer* and *Tilia* trees of 10-15 m high were almost dying after several years of infestation, while *Hydrangea* shows already a decline in vitality within a few years.

Since a few years the species is also seen in natural habitats, notably on *Tilia* in woodland edges. Until 1997 *P. hydrangeae* populations were increasing on most sites, but showed a sharp decline after the winter of 1997. Like *P. floccifera*, *P. hydrangeae* is of subtropical origin but at present well established in The Netherlands, surviving both the humid winters and the cool summers typical for the maritime climate. The frequently hot summers of the last decade may have promoted population growth and the expansion of both species.

In The Netherlands the coccinellid beetles *Exochomus quadripustulatus* and *Adalia bipunctata* (Linnaeus) are predators of *Pulvinaria hydrangeae*.

Pulvinaria regalis Canard

Characters of the female adult of *Pulvinaria regalis* (fig. 11) are given by Canard (1968). The lengths of the marginal abdominal setae on the venter are very variable, even within a

Table 2. List of hostplants of *Pulvinaria hydrangeae* based on records of Merlin (1993) (1), Ben-Dov (1993) (2) and Dutch records (3).

Family	species
Aceraceae	<i>Acer capillipes</i> (1), <i>A. circinatum</i> (1), <i>A. grosseri</i> (1), <i>A. japonicum</i> (1), <i>A. negundo</i> (1, 2, 3), <i>A. oliverarum</i> (1), <i>A. palmatum</i> (3), <i>A. platanoides</i> (1, 2, 3), <i>A. pseudoplatanus</i> (1, 3), <i>A. saccharinum</i> (1, 3), <i>A. spicatum</i> (1)
Actinidiaceae	<i>Actinidia arguta</i> (1)
Anacardiaceae	<i>Rhus typhina</i> (3)
Araliaceae	<i>Aralia elata</i> (1, 3)
Betulaceae	<i>Carpinus</i> sp. (3), <i>Corylus colurna</i> (3)
Caprifoliaceae	<i>Lonicera</i> sp. (3), <i>Viburnum fragrans</i> (1), <i>V. henryi</i> (1), <i>V. opulus</i> (1, 3), <i>V. rhytidophyllum</i> (1)
Celastraceae	<i>Celastrus</i> sp. (3), <i>Evonymus</i> sp. (3)
Cornaceae	<i>Cornus</i> sp. (2), <i>C. alba</i> (1), <i>C. controversa</i> (1), <i>C. florida</i> (1), <i>C. mas</i> (1), <i>C. nuttallii</i> (1), <i>C. sanguinea</i> (1)
Ebenaceae	<i>Diospyros kaki</i> (2), <i>D. lotus</i> (1)
Eucommiaceae	<i>Platanus x hispanica</i> (1)
Fagaceae	<i>Fagus sylvatica</i> (3)
Hippocastanaceae	<i>Aesculus x carnea</i> (3), <i>A. glaucescens</i> (1), <i>A. hippocastanum</i> (1), <i>A. octandra</i> (1), <i>A. pavia</i> (1), <i>A. shinensis</i> (1), <i>A. turbinata</i> (1)
Hydrangeaceae	<i>Hydrangea hortensis</i> (1, 2), <i>H. macrophylla</i> (2, 3)
Juglandaceae	<i>Pterocarya</i> sp. (3)
Leguminosae	<i>Sophora japonica</i> (3; Moraal, 1988)
Malaceae	<i>Amelanchier confusa</i> (1), <i>A. lamarckii</i> (3), <i>Malus cf. floribunda</i> (1; Malumphy, 1991)
Magnoliaceae	<i>Magnolia</i> sp. (3), <i>Magnolia nicholsoniana</i> (1), <i>Magnolia x loebneri</i> (1)
Moraceae	<i>Morus</i> sp. (3), <i>Morus australis</i> (1), <i>Broussonetia papyrifera</i> (1)
Oleaceae	<i>Fraxinus</i> sp. (3)
Philadelphaceae	<i>Deutzia</i> sp. (1, 2), <i>D. scabra</i> (1)
Platanaceae	<i>Platanus</i> sp. (3)
Rosaceae	<i>Cotoneaster horizontalis</i> (3), <i>Crataemespilus grandiflora</i> (1), <i>Crataegus</i> sp. (2), <i>C. monogyna</i> (1, 3), <i>Maddenia hypoleuca</i> (1), <i>Malus floribunda</i> (3), <i>Photinia beauverdiana</i> (1), <i>Prunus avium</i> (1), <i>P. serrulata</i> (1), <i>P. serrata</i> (3), <i>P. gondoumii</i> (3), <i>P. subhirtella</i> (1), <i>Pyracantha coccinea</i> (1, 3), <i>Pyronia veitchii</i> (1), <i>Pyrus calleryana</i> (3), <i>Rosa canina</i> (1), <i>R. rugosa</i> (1, 3), <i>Rubus</i> sp. (1)
Rutaceae	<i>Euodia daniellii</i> (1), <i>Phellodendron</i> sp. (3), <i>P. amurense</i> (1), <i>P. canadensis</i> (1)
Salicaceae	<i>Populus</i> sp. (3), <i>P. balsamifera</i> (1), <i>Salix alba</i> (1), <i>S. caprea</i> (1,3)
Styracaceae	<i>Halesia carolina</i> (1), <i>Pterostyrax hispida</i> (1)
Taxaceae	<i>Taxus</i> sp. (3)
Tiliaceae	<i>Tilia americana</i> (3), <i>T. x vulgaris</i> (3), <i>T. cordata</i> (1), <i>T. euchlora</i> (3), <i>T. japonica</i> (1), <i>T. mongolica</i> (1), <i>T. oliveri</i> (1), <i>T. petiolaris</i> (1), <i>T. platyphyllos</i> (1, 2, 3), <i>T. tomentosa</i> (1)
Ulmaceae	<i>Celtis glabra</i> (1), <i>C. occidentalis</i> (1), <i>Ulmus</i> sp. (3), <i>Zelkova serrata</i> (3)

single specimen. The anal plate possesses three dorsal setae (one apical and two subdiscal), and the ventral side has three subapical setae. Occasionally specimens were found with digitate abdominal setae, digitate interantennal setae and digitate spiracular setae. Rarely a few straight, bluntly tipped marginal setae were found, which in literature (Qin & Gullan, 1992) are supposed to be typical for *P. mesembryanthemi*.

Speight & Nicol (1984), Merlin et al. (1988) and Şengonca & Faber (1995, 1996) describe the life cycle of *P. regalis* (fig. 12). The species

is univoltine and females lay eggs in May-June, which hatch in June-July. The young nymphs spread over the plant and feed predominantly on the under side of leaves, but depending on the plant species occasionally on the upper side (Şengonca & Faber, 1995). Later on they move to the bark of the trunk and larger branches, where they overwinter as third instar (Şengonca & Faber, 1996). Males are rare (Şengonca & Faber, 1995), with sex ratios in the range of 10 to 20 females to one male (Speight & Nicol, 1984). Canard (1968) recorded no other than parthenogenetic reproduction.

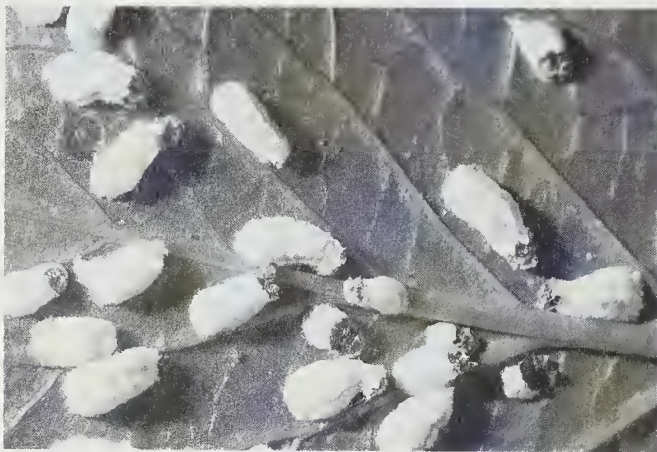


Fig. 9. Adult females with ovisac of *Pulvinaria hydrangeae* (Photo: A. van Frankenhuyzen)

Pulvinaria regalis has been found in Belgium (Merlin et al., 1988), England (Speight, 1984, 1994), France, Germany (Dalchow & Bathon, 1995; Şengonca & Faber, 1995) Switzerland (Hippe, in litt. 1997), and The Netherlands. It seems unlikely that it originates from Europe. It is a rather striking species that, if present, should have been noticed since the soft scale fauna of Europe is relatively well known. Its life-cycle, hostplant range and habitat differ from related native species. Harris (1970), considering its hostplants, suggested Asia as native region. Şengonca & Faber (1996) observed that females only laid eggs at fluctuating moderate temperatures (20/14 °C), while high temperatures hindered juvenile development. Up till now no specific hymenopterous parasitoids are known, but study has been made of *Coccophagus scutellaris* (Dalm.), a polyphagous parasitoid of coccids (Faber & Şengonca, 1997).

Schmitz (1997) reported *Pulvinaria regalis* from 61 plant species in 24 families. In The Netherlands it has been found especially on

Acer sp., *Aesculus* sp., *Tilia* sp. and *Ulmus* sp., whereas *Cornus sanguinea* L., *Fagus sylvatica* L., *Koelreuteria paniculata* Laxm., *Platanus* sp., *Prunus avium* (L.) L., *Sophora* sp. (Moraal, 1988), and *Zelkova serrata* (Thunb. ex Murr.) Mak. are attacked less frequently.

Pulvinaria regalis was first recorded in The Netherlands by Malumphy (1991) and it caused nuisance on various hostplants in Amsterdam in the period 1986-1992 (Anonymous, 1991). During the same period the number of the coccinellid *Exochomus quadripustulatus* increased and the soft scale populations eventually collapsed. Speight & Nicol (1984) recorded also *Chilocorus bipustulatus* (Linnaeus) as predator. At the moment *P. regalis* is still present but on average at a much lower level with fluctuating numbers. In recent years *P. regalis* has been found in the public green of several other towns (fig. 6) but it is still restricted to urban areas.

Speight (1986) showed that *Acer* trees growing in urban areas lodge the largest populations of nymphs of *P. regalis* and suggested low soil oxygen content and drought stress as major causes. Damage by *P. regalis* on *Aesculus hippocastanum* L. is seldom apparent because this tree shows shoot elongation in early summer, before scale nymphs start feeding on the leaves (Speight, 1991). In contrast to many other scale species, including *P. hydrangeae* and *P. floccifera*, the amount of honeydew produced by *P. regalis* is fairly low (Harris, 1970).

Discussion

Synantropic species like *Pulvinaria floccifera*,

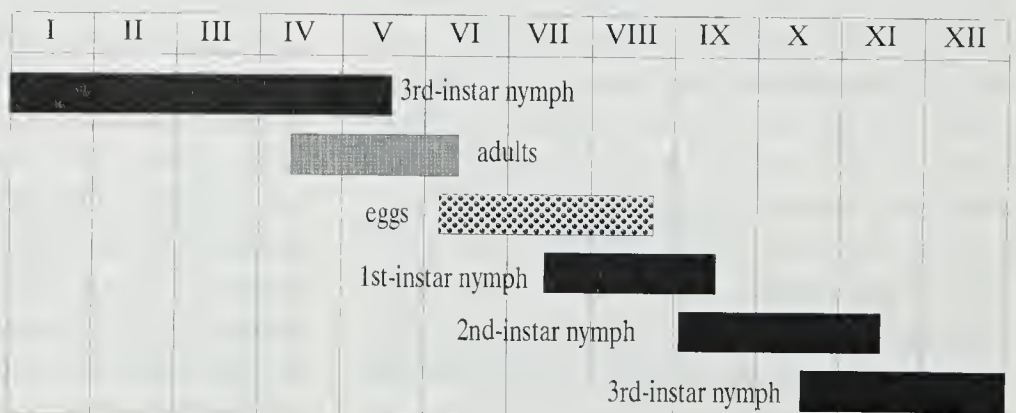


Fig. 10. Life cycle of *Pulvinaria hydrangeae*.

P. hydrangeae and *P. regalis* are species, which are introduced and have established themselves in a certain area. The appearance of these species in The Netherlands is the consequence of two processes: the increasing foreign trade favouring the spreading of species and the increasing urbanisation which has created a habitat in which species with an opportunistic life history are in favour. Such species share traits like polyphagy, a high fecundity, parthenogenesis and lack of diapause. The fecundity of *Pulvinaria* species is large: one female *P. floccifera* may lay 1100 eggs (Canard, 1965a), while *P. hydrangeae* lays up to 2800 eggs (Canard, 1965b) and *P. regalis* up to 3000 eggs (Speight, 1994). On the other hand, Merlin (1993) showed that only 0.08% of *P. hydrangeae* become adult and Speight & Nicol (1984) found an average of 0.001% survival per generation for *P. regalis* populations.

In particular the ability to colonise successfully and to establish large populations in a short time makes several *Pulvinaria* important pest species. The crawlers can bridge large distances passively. The first instars of *Pulvinaria mesembryanthemi* and *P. delottoi* Gill exhibit active aerial dispersal behaviour by standing on their hind legs (Washburn & Washburn, 1984). Direction and distances of dispersal are largely determined by the prevailing winds and the behaviour of birds and insects.

Glick (1939) recorded first instar coccids at 1000 feet in the air. Putnam (1880) observed that honeydew of *Pulvinaria innumerabilis* Rathvon was attractive to flies and bees and that crawlers found their way to the legs and



Fig. 11. *Pulvinaria regalis*, adult female with ovisac (Photo: H. Stigter).

bodies of these insects and were transported this way. Many birds feed on scale insects, so crawlers may be transported over long distances on their beaks and legs.

In general, sooty moulds growing on honeydew produced by *Pulvinaria* reduce the photosynthetic activity of the hostplant. A more severe infestation causes further weakening of the hostplant due to the loss of metabolites, resulting in leaf drop and die back.

No specific parasites of the introduced species are known. The introduced *Pulvinaria* species share predators and parasites with *P. betulae*, but these have only a limited impact suggesting that no native natural enemies accompany their hosts. The low number of natural enemies of the introduced species contributes much to the impact the scales have on their hostplants. Knowledge of potential natural enemies and predators is needed to develop effective biological control.

Although we know that, in general, climatic and biotic factors, aerial pollution and soil

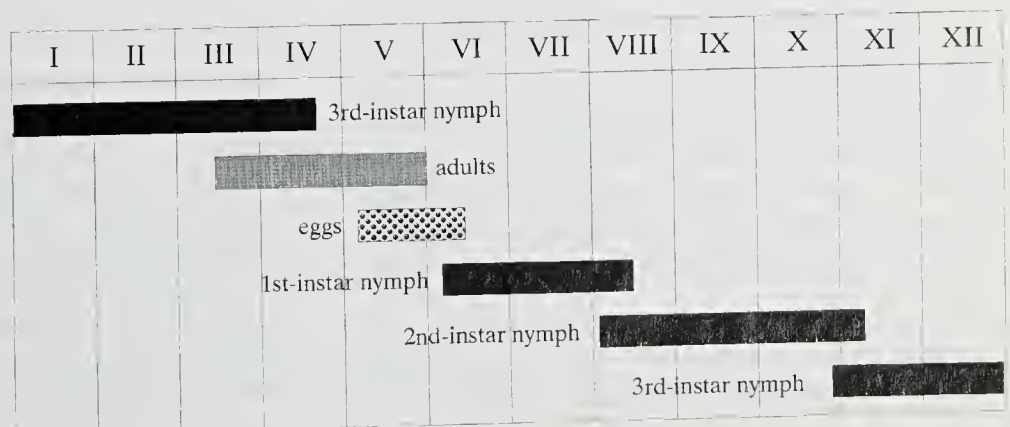


Fig. 12. Life cycle of *Pulvinaria regalis*

conditions affect the frequency and severity of insect attacks, little is known about the mechanisms involved. From the Sternorrhyncha only aphids have been extensively studied in relation to pollution and their numbers often seem to increase when disposed. A better understanding of the interactions involved may contribute to solve the negative effects of introduced pest species.

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