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BIOLOGY OF THE HORSE CHESTNUT SCALE, *PULVINARIA REGALIS* CANARD (HEMIPTERA: COCCOIDEA: COCCIDAE), IN SWITZERLAND.

ABSTRACT

BIOLOGY OF THE HORSE CHESTNUT SCALE, *PULVINARIA REGALIS* CANARD (HEMIPTERA: COCCOIDEA: COCCIDAE), IN SWITZERLAND.

In 1997, many lime (*Tilia* spp.) and horse chestnut (*Aesculus hippocastanum*) trees in the centre of Zurich were found to be heavily infested by the horse chestnut scale, *Pulvinaria regalis* Canard. The biology of this introduced coccid was studied for one year. Crawlers hatched from the end of May and moved to the leaves of their host plants. There the nymphs settled and fed until Sept./Oct., when they migrated to adjacent twigs to overwinter as the 3rd-instar females. After the final nymphal moult in the spring, the adult female went through a period of rapid growth. Adult males appeared for a short period at the beginning of May but were rare. At this time, the females began to move to the main branches and the trunk of the tree, where they secreted a white ovisac consisting of wax filaments. Shortly after oviposition, the females died but remained attached to the ovisac. Two species of aphelinid (*Coccophagus lycimnia* (Walker) and, much less commonly, *C. semicircularis* (Förster)) emerged from parasitised scale nymphs in May (on twigs) and at the beginning of September (on leaves). The average rate of parasitisation of *P. regalis* was low (≤5%). No dipteran and only a few coccinellid predators were found during the sampling period.

Key words: sex ratio, plant stress, *Pseudaulacaspis pentagona*, *Coccophagus obscurus*, *C. scutellaris*, *Exochomus quadripustulatus*, *Leucopis silesiaca*, urban environment, parasitoids.

INTRODUCTION

The horse chestnut scale was recorded for the first time in the Greater London area in 1964 (Harris, 1970). One year later, it was noticed near Paris and described as a new species, *Pulvinaria regalis* (Canard, 1968). Since then, it has spread not only within the United Kingdom and France but has also been reported from Belgium (in 1981; Merlin & Pasteels, 1990), the Netherlands (in 1988; Jansen, 1996), Germany (in 1989; Sengonca & Faber, 1995) and Switzerland (in 1992; Kozár *et al.*, 1994).

P. regalis infests at least 61 plant species belonging to 24 families (Schmitz, 1997). This host range suggests that *P. regalis* might have originated from the Far East (Harris, 1970) but it has only so far been found in Europe. It predominantly infests trees within towns and cities, often along roadsides or in car-parking areas. Trees already suffering from stress symptoms are preferred and show the highest infestation levels (Speight, 1986; Speight *et al.*, 1998).

In the centre of Zurich, heavy infestations on lime (*Tilia* spp) and horse chestnut trees (*Aesculus hippocastanum*) were observed in 1997. Interestingly, an outbreak of another introduced scale insect, *Pseudaulacaspis pentagona* (Targioni-Tozzetti), had occurred there five years previously on *Sophora* sp. (Mani *et al.* 1997). This diaspidid, like *P. regalis*, also seems to thrive in urban environments (Hanks & Denno, 1993).

MATERIALS AND METHODS

Lime and horse chestnut trees infested by *P. regalis* were selected in July 1997 in the centre of Zurich. Samples were collected from these trees at intervals (at least fortnightly) between July 1997 and June 1998, the number of samples on each occasion depending on the level of infestation but sufficient to produce more than 300 scales per visit. In addition, the trunks of the trees were checked for the occurrence of adult females, ovisacs, crawlers and predators.

The collected samples were studied in the laboratory. The average mortality in the overwintering stage of *P. regalis* was established by determining the percentage of dead scales on twig samples between the beginning of March and the beginning of May (seven replicates of 300 scales each). The percentage of males was assessed by counting male developmental stages between the first week of April and the first week of May (four replicates of 300 scales each), while the average rate of parasitisation was evaluated by counting parasitised scales on leaves in September and on twigs between the third week of April and the first week of May (three replicates of 300 scales each).

Parasitised *P. regalis* were isolated from leaf and twig samples in the laboratory to ensure that the adult parasitoids emerged only from this host. Between mid-Sept. and mid-Oct., 177 parasitoids were collected from scales on the leaves while, between the second week of May and the beginning of June, 87 parasitoids were examined from scales on the twigs. Voucher specimens of the parasitoids were deposited in the collection of the Natural History Museum, London.

RESULTS AND DISCUSSION

In Zurich, mainly lime and horse chestnut trees were infested by *P. regalis*. The crawlers hatched from the end of May, left the ovisacs on the trunks and main branches of the host plants and moved to the leaves. There they settled, often on the undersurface next to the leaf veins, feeding until Sept./Oct. Prior

to leaf fall, the nymphs migrated to adjacent twigs on which they overwintered (females as the third-instar (Sengonca & Faber, 1996)). The mean mortality in 1998 during this overwintering stage was 10.0%. In spring, the final moult of the female nymphs was followed by a period of rapid growth, the largest females growing to >6mm. Adult males appeared for a short period at the beginning of May but were rare (2.3% of the total population). At this time, the females began to move from the twigs downwards to the main branches and the trunk of the trees, where white wax filaments were secreted to form the ovisacs. Female *P. regalis* are known to lay up to 3000 eggs (Speight, 1994). Shortly after oviposition, the females died but remained attached to the ovisac, forming a protective cover for the eggs and the offspring. On hatching, the new generation of crawlers dispersed to the leaves again. During this dispersal, the nymphs are easily carried away by the wind and about 99.5% of them die before settling on a leaf (Merlin *et al.*, 1988). However, some crawlers might get blown onto previously uninfested trees and thus spread the infestation.

Although infestations by the horse chestnut scale can have a considerable impact on the growth of the trees (Speight, 1991), the primary "damage" caused by the coccid seems to be of a cosmetic nature. The conspicuous white ovisacs of the adult females cover the trunks and main branches of the trees and are often mistaken for a fungal disease. Amenity trees in towns are supposed to look nice, and infested trees apparently do not fulfil these requirements. The use of insecticides in urban areas, however, is problematic and usually unwanted. In Zurich, therefore, an environmentally harmless method was tested on selected trees: the unsightly ovisacs on the trunks and main branches were washed off with water using a high-pressure cleaner. When carried out just before egg hatch, this washing should also control the pest. Although the washing procedure proved to be difficult and time consuming when the trees were high, it may be an interesting approach especially for younger trees.

Heavy infestations in other cities are known to have subsided after some years but the reasons for this decline are not understood. Native natural enemies do not seem to have a decisive impact on the populations of *P. regalis* in urban areas, maybe because of a low abundance of parasitoids and predators in this environment. Two aphelinid species belonging to the genus *Coccophagus* have previously been described as parasitoids of the horse chestnut scale: *C. obscurus* Westwood in England (Speight & Nicol, 1984) and *C. scutellaris* (Dalman) in Germany (Faber & Sengonca, 1997). In Zurich, however, two other species in this genus were found: *C. lycimnia*

(Walker) and *C. semicircularis* (Förster), which started to emerge from the scales in May (on twigs) and at the beginning of September (on leaves). Of the parasitoids collected, 97.3% were *C. lycimnia*.

According to Speight & Nicol (1984), the parasitoids overwinter as pupae in their hosts fixed to the leaves, so that the parasitoids end up on the ground after leaf fall. As the fallen leaves get removed by the local street cleaners in towns, this would prevent a build-up of the parasitoid population in the following year. However, in Zurich, only a few parasitoid pupae were found in scales on leaves in late October and it is thought that these had probably failed to emerge and died later on. The remaining parasitoids overwintered in an early developmental stage in their hosts on the twigs, indicating that the migration of the parasitised nymphs from the leaves in the autumn had not been suppressed.

All those parasitoids collected from the overwintering scales in the spring were females but 22.9% of the adult *C. lycimnia* in the autumn were males. Blahutiak (1972) found a similar phenomenon in a population of *C. lycimnia* parasitising the European fruit scale, *Parthenolecanium corni* (Bouché), which also occurs in small numbers on the trees in central Zurich. Since *P. corni* is known to be a host of both *C. lycimnia* and *C. semicircularis* (Hayat, 1997), these aphelinids were probably already present when the trees became infested with the horse chestnut scale. However, the rate of parasitisation of *P. regalis* on the leaf and twig samples was low (≤5%).

Coccinellid predators (e.g., *Exochomus quadripustulatus* Linnaeus) were also rare and no potential dipteran predators (e.g., the chamaemyiid *Leucopis silesiaca* Egger) were encountered in the scales' ovisacs.

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REFERENCES

Blahutiak, A., 1972 - Die Parasiten der Zwetschenschildlaus (*Parthenolecanium corni* Bouché) in der CSSR (Hom., Coccidae). *Folia Entomologica Hungarica*, 25: 279-289.

Canard, M., 1968 - Un nouveau *Pulvinaria* (Hom. Coccoidea) nuisible aux arbres d'alignement dans la région parisienne. *Annales de la Société Entomologique de France (N.S.)*, 4: 951-958.

Faber, T., Sengonca, C., 1997 - Laboruntersuchungen zur Lebensdauer und Fruchtbarkeit von *Coccophagus scutellaris* (Dalm.) (Hym., Aphelinidae) als

Parasitoid der Wolligen Napfschildlaus *Pulvinaria regalis* Canard (Hom., Coccidae). *Gesunde Pflanzen*, 49: 84-88.

HANKS, L. M., DENNO, R. F., 1993 - Natural enemies and plant water relations influence the distribution of an armored scale insect. *Ecology*, 74: 1081-1091.

HARRIS, K. M., 1970 - Horse chestnut scale. *Arboricultural Association Journal*, 1: 257-262.

HAYAT, M., 1997 - Aphelinidae. Pp 111-145, *in* Ben-Dov, Y. & Hodgson, C.J. (eds.). Soft scale insects. Their biology, natural enemies and control. World crop pests, 7B. Elsevier, Amsterdam. 442pp.

JANSEN, M., 1996 - The genus *Pulvinaria* in the Netherlands (Coccinea: Coccidae). Pp. 59-63 in: Narkiewicz-Jodke, J., Cichocka, E., Nawrocka, B., Goszczynski (eds): Aphids and other Homopterous Insects, 5. Polish Acadamy of Sciences (PAS), Skierniewice. 105pp.

KOZÁR, F., GUIGNARD, E., BACHMANN, F., MANI, E., HIPPE, C., 1994 - The scale insect and whitefly species of Switzerland (Homoptera: Coccoidea and Aleyrodoidea). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft,* 67: 151-161.

MANI, E, KOZÁR, F., SCHWALLER, F., HIPPE, C., 1997 - Auftreten und Biologie der Maulbeerschildlaus *Pseudaulacaspis pentagona* (Targioni-Tozzetti) in der Schweiz (Homoptera: Diaspididae). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft,* 70: 399-408.

MERLIN, J., GREGOIRE, J.-C., DOLMANS, M., SPEIGHT, M. R., PASTEELS, J. M., VERSTRAETEN, C., 1988 - Preliminary comparison of two scale insect species on broad-leaved trees in western-Europe. Pp 1153-1158, *in* 40th International Symposium on Crop Protection, Mededelingen Faculteit Landbouwwetenschappen Rijksuniversiteit Gent 53/3a.

MERLIN, J., PASTEELS, J.-M., 1990 - La pullulation des cochenilles pulvinaires en milieu urbain: état de la situation et moyens de lutte. Actes du colloque "Gérer la Nature?", Travaux Conservation de la Nature, 15: 607-618 .

SCHMITZ, G., 1997 - Zum Wirtspflanzenspektrum von *Pulvinaria regalis* Canard (Hom., Coccidae). *Gesunde Pflanzen,* 49: 43-46.

SENGONCA, C., FABER, T., 1995 - Beobachtungen über die neu eingeschleppte Schildlausart *Pulvinaria regalis* Canard an Park - und Alleebäumen in einigen Stadtgebieten im nördlichen Rheinland. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz*, 102: 121-127.

SENGONCA, C., FABER, T., 1996 - Studies on developmental stages of the horse chestnut scale insect, *Pulvinaria regalis* Canard (Hom., Coccidae), in the open land and in the laboratory. *Anzeiger für Schädlingskunde, Pflanzenschutz, Umweltschutz*, 69: 59-63.

SPEIGHT, M. R., 1986 - Environmental influences on host plant susceptibility to insect attack. Pp 309-316, *in* Juniper, B., and Southwood, Sir R. (eds.). Insects and the plant surface. Edward Arnold, London. 360pp.

SPEIGHT, M. R., 1991 - The impact of leaf-feeding by nymphs of the horse chestnut scale, *Pulvinaria regalis* Canard (Hem., Coccidae), on young host trees. *Journal of Applied Entomology*, 112: 389-399.

SPEIGHT, M. R., 1994 - Reproductive capacity of the horse chestnut scale insect, *Pulvinaria regalis* Canard (Hom., Coccidae). *Journal of Applied Entomology*, 118: 59-67.

SPEIGHT, M. R., HAILS, R. S., GILBERT, M., FOGGO, A., 1998 - Horse chestnut scale (*Pulvinaria regalis*) (Homoptera: Coccidae) and urban host tree environment. *Ecology*, 79: 1503-1513.

SPEIGHT, M., NICOL, M., 1984 - Horse chestnut scale - a new urban menace? *New Scientist*, 101 (1404): 40-42.