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THE BIOLOGY OF *PHENACOCCUS AZALEAE* KUWANA, A PEST OF BUNGE PRICKLY ASH (*ZANTHOXYLUM BUNGEANUM* MAXIM) FOREST IN NORTHERN CHINA.

ABSTRACT

THE BIOLOGY OF *PHENACOCCUS AZALEAE* KUWANA, A PEST OF BUNGE PRICKLY ASH (*ZANTHOXYLUM BUNGEANUM* MAXIM) FOREST IN NORTHERN CHINA.

Phenacoccus azaleae Kuwana (Hemiptera: Coccoidea: Pseudococcidae) is a major new pest of bunge prickly ash forest in northern China, where it causes high tree mortality when present for two consecutive years. This paper reports on the biology of this pest in northern China, where it has been studied since 1995. The life cycle can be divided into eight phases, two of which cause severe injury to the host plant, through the feeding of: (a) the 3rd-instar nymphs and adult females between late March and mid-May, and (b) the young nymphs which are present on the leaves between late June and October. The adult sex ratio was 6-7♀:1♂. The various development stages are described. Of the natural enemies, ladybirds (Coccinellidae) and lacewings (Neuroptera) were the major predators, but they were not abundant in the newly-infested areas. In addition, a few parasitic Hymenoptera were recorded but appeared to be ineffective.

Key words: *Aphis gossypii*, *Papilio xuthus*, *Podagri comeiashirahatai, Calloides magnificus*, *Agrilus zanthoxylumi*, plum, elm, *Azalea*, Japan, Korea, voltinism, development, population dynamics, damage, *Lasius fuliginosus*, *L. niger*, sex ratio, growth rate, *Harmonia axyridis*, *Coccinella septempunctata*, *Chrysopa.*

INTRODUCTION

Bunge prickly ash, *Zanthoxylum bungeanum* Maxim, is one of the most important economic plants in northern China, where it is planted on a large scale as its fruit is used as a condiment and because natural oils can be extracted from its seeds. It has several pests, of which the most important are *Aphis gossypii* Glover, the butterfly *Papilio xuthus* L. and the leaf-eating beetle *Podagri comeiashirahatai* (Chujo), all of which attack the leaves, and also the two bark-boring beetles *Calloides magnificus* (Pic.) and *Agrilus zanthoxylumi* Hou. Until 1994, few scale insects had been recorded on bunge prickly ash but in that year outbreaks of *Phenacoccus azaleae* Kuwana (Coccoidea: Pseudococcidae) occurred in several areas in northern China.

When the trees were attacked for two consecutive years, most plants died and, prior to 1996, there had been a major reduction in yield, with about a third of the trees being killed by the mealybug.

Previously, *P. azaleae* had been restricted to *Azalea* species in Japan and Korea but, in 1988, it was collected on plum and elm in Inner Mongolia, although it was not considered to be an important pest there (Tang Fangde & Li Jie, 1988; Tang Fangde, 1992). Since it was originally discovered on *Z. bungeanum* in 1994 in Shanxi Province and in Yu xian, Li cheng and Rui cheng counties, it has also been recorded on bunge prickly ash in Shandong and Gansu Provinces. The biology of this pest on *Z. bungeanum* has been studied since 1995 (see Xie Yingping *et al*., 1997) and this paper presents further data on this pest.

MATERIALS AND METHODS

Study site: the ash forests on the mountains and along the Hutuo River in Yu xian county, where it was originally discovered and where the populations of *P. azaleae* are dense.

Study methods:

1. *The sex ratio*: during March in 1996 and 1997, 25 twigs with mealybug populations were selected from the forest and the numbers of males and females counted under a microscope in the laboratory.

2. *Female development*: in the Spring, the number and size of the 3rd-instar nymphs and adult females was monitored as they spread from their overwintering sites and settled on the twigs.

3. *Male development*: from the end of March until late April, 1996, the male cocoons were collected and dissected to determine development.

4. *Oviposition*: once oviposition had commenced, the proportion of adult females with an egg sac was recorded, while the number of eggs was estimated in June by collecting the egg sacs off the leaves and counting the eggs.

5. *Natural enemies*: samples were taken from 20 trees between March and May, 1997, when four twigs, each from a different sector of the tree, were removed. Predators: these were mostly Coccinellidae and Chrysopidae, which were mainly recorded in May, when they were in their immature stages; adults predators were counted *in situ* prior to twig removal. Parasitoids were much scarcer and were mainly present in March and April. These were counted in the laboratory by removing the woolly cocoons from the mealybugs. Generally, the parasitised mealybugs had a different body colour and the larva or pupa of the parasitoid could be easily located in the host.

RESULTS

Development, population dynamics and host plant damage:

P. azaleae has one generation a year, the females typically passing through four instars and the males through five. The life history of this pest can be divided into eight stages, depending on behaviour and feeding habits.

1. Egg stage: the adult females secrete their ovisac beneath the leaves in late April or early May. The egg stage lasts about a month and has a very low mortality, with about 93% hatching.

2. Crawler stage: this stage disperses to the leaves, were they settle on the leaf veins. This stage is easily attacked by ladybirds (Coccinellidae) and lacewings (Neuroptera) as it has very little protective wax. In addition, there may be some mortality due to natural factors such as wind, rain and low humidity. Mortality may be around 15-20%.

3. Young nymphal instars: between the middle of June and the end of October, the nymphs feed on the leaves and develop through to the 2nd instar. This stage is covered in wax which protects them from natural factors, so that mortality appears to be quite low. Due to their high population density, they cause serious damage at this stage.

4. Migration to twigs: in October, when the weather gets colder and the plants start to senesce, the 2nd-instar nymphs disperse back to the twigs. There is some mortality at this time due to such environmental factors as wind and rain.

5. Overwintering stage: the nymphs settle at the base of the twigs and buds, and in the seams and cracks in the bark, where they secrete a wax cocoon which resembles a rice grain and go into diapause. The nymphs spend the entire winter in the cocoon, from October through to March, during which time the female nymphs moult to the 3rd instar, while the male nymphs moult first to the prepupa and then the pupal stage. Mortality is very low during the winter, less than 15%. Few parasitoids were found.

6. Dispersal phase: in late March, the 3rd-instar female nymphs emerge from the cocoons and disperse to the young shoots of the ash trees. At this time, the weather in northern China is usually dry and windy and there is little mortality due to environmental factors, although a few are eaten by ladybirds that have also just emerged from dormancy.

7. Feeding stage: as the young shoots elongate, the female nymphs congregate on the twigs and grow fast, feeding in the phloem of the young tissues (Table 1). About the middle of April, they finally moult to become adult and swell to resemble a large bean grain. During this time, their mean

length increases from 0.9 to 3.4mm and their width from 0.6 to 2.1mm. Many eggs are present in their abdomens.

8. Mating and oviposition: as the 3rd-instar female nymphs moult to become adult, the adult males emerge. The adult males only live for a few days, during which time they can fly and locate the females, which they fertilize. The females continue feeding on the leaves until May when, with the expansion of the leaves, they commence ovisac production and egg laying.

There are two main injurious stages. The first is in the late spring and early summer, when the 3rd-instar nymphs and adult females are growing fast on the young leaves. This feeding causes a serious weakening of the trees, slows leaf growth and can prevent flower and fruit formation. The second important phase is in late summer and early autumn, when the crawlers and 2nd-instar nymphs are feeding in preparation for overwintering and this also weakens the trees. In addition to this direct damage due to sap-sucking, much honeydew is produced on which sooty moulds develop, covering the trees in a black mat and further reducing photosynthesis. Honeydew is particularly abundant during the 3rd instar and early adult stages between March and May. At this time a few ants (*Lasius fuliginosus* Latr. and *Lasius niger* (L.)) are present. Along with the feeding damage, the presence of sooty moulds causes early senescence and leaf fall. This usually occurs in late August, when the temperature is still high. However, the trees may still produce further leaves which leads to a major loss of nutrition for the following year. In addition, the weakened twigs die from the dry air and cold. In our sample of 2000 trees, 300 died after being infected for two consecutive years.

Sex ratio: this was 7.3♀:1♂ in 1996 (488 ♀♀: 67 ♂♂ on 25 twigs) and 6.1♀:1♂ in 1997 (429♀♀: 70 ♂♂ on 20 twigs).

Female growth rate after overwintering: the growth rate of *P. azaleae* during the period late March to early May is summarised in Table 1 and it is clear that growth is very rapid during this period.

Male development and emergence: this is summarised in Table 2. Most males were in the pupal stage in late March although a few were still 2nd-instar nymphs, suggesting that the winter was spent as the 2nd-instar nymph and that pupation mainly occurred in early Spring. The first adult males inside the cocoons were found on the 12th April and all were adult by the 19th April. The first emerging males were seen on the 13th April and all had emerged by the 25th April.

Table 1. Mean body size (mm) of *P. azaleae* on four dates between late March and early May on bunge prickly ash in northern China in 1996 (n = 11).

Parameter	31st March	6th April	26th April	6th May
Length	0.9	1.4	2.32	3.4
range	0.5-1.1	1.3-1.5	1.59-4.00	2.8-4.1
Width	0.6	0.9	1.4	2.1
range	0.5-0.7	0.8-1.1	0.9-2.5	1.5-2.5

Table 2. Stage of development of male *P. azaleae* on bunge prickly ash in northern China between late March and April, 1996.

Date	n	nymph n %	prepupa n %	pupa n %	adult in cocoon n %	adult emerging from cocoon n %
30th March-2nd April	113	10 8.8	14 12.4	89 78.8		
3rd- 8th April	159	1 0.6	5 3.1	153 96.2		
12th-18th April	115			81 70.4	28 24.3	6 5.2
19th-22nd April	240				141 58.8	99 41.3
23rd-25th April	184				7 3.8	177 96.2

where n = number in sample.

Table 3. The timing of ovisac and egg production of *P. azaleae* on bunge prickly ash leaves in northern China in 1996.

	April	May				
	26th	6th	9th	11th	13th	15th
n	100	50	47	201	110	92
% ♀ with ovisac	1	6	89	59	99	100
% ♀ with eggs	1	6	63	59	99	100

Ovisac development and oviposition: on maturity, adult female *P. azaleae* move onto the lower leaf surface and commence ovisac production. This occurred over a short period at the end of April and in early May (Table 3).

Although ovisac production began on about the 26th April, the ovisacs where quite small and they continued to elongate until at least the last week of May. Thus, the ovisacs had a mean length of about 4.9mm and a width of about 2.3mm on the 7th May but had extended to a mean of 7.9mm and a width of 2.6mm by the 27th (max. length 8.2mm, width 2.8mm). The mean number of eggs per egg sac was 446 (range 206-842).

Natural enemies: because *P. azaleae* is a recently established pest, rather few predators or parasitoids were recorded during the first two years and they were ineffective in controlling the mealybug. Thus, in 1995 and 1996, a few ladybirds and lacewings were noted and a few hymenopterous parasitoids were found in the cocoons. However, the populations of two ladybirds (*Harmonia axyridis* (Pallas) and *Coccinella septempunctata* L.) and the lacewing *Chrysopa septempunctata* Wesmael, built up quite fast in both the forest areas studied.

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