OBSERVATIONS ON THE BIOLOGY AND CONTROL OF THE HAWTHORN (TWO-CIRCULI) MEALYBUG, *PHENACOCCUS DEARNESSI* (KING)

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Abstract. The hawthorn (two-circuli) mealybug, *Phenacoccus dearnessi* (King), is a serious woody plant pest of hawthorn, *Crataegus* spp.) in Colorado. With the expanded use of this plant in landscape settings, *P. dearnessi* has become of more economic importance. Studies were conducted to better understand its biology and to evaluate management strategies. In the area of Fort Collins, Colorado, nymphs emerged from overwintering sites on trunks and began spring activity on 20 March 1998. Migration to twigs was first noted on 14 April, peaking in early May and ceasing at the end of the month. Adult females first produced living young on 27 May and continued to reproduce until 14 October. Three species of predaceous lady beetles—*Adalia bipunctata* (L.), *Coccinella septempunctata* (L.), and *Hippodamia convergens* (Guerin-Meneville)—were observed feeding on *P. dearnessi* nymphs as they emerged from overwintering sites, but predation of mature females was not observed; no parasitoids have been observed. There is a range of susceptibility to this insect among *Crataegus* spp.: *Crataegus phaenopyrum* 'Cordata' has remained highly resistant to infestation throughout this study; *Crataegus* × *mordenensis* 'Snowbird', *C. succulenta macracantha*, and *C. ambigua* also showed substantial levels of resistance. A wide range of insecticides has been evaluated for control, with imidacloprid (Merit) and permethrin (Astro) among the most effective. In addition, the use of horticultural oil consistently improved performance. However, timing of application seems to be critical; applications coinciding with migration of the overwintered nymphs to the twigs being particularly effective.

Key Words. Mealybug; hawthorn; *Phenacoccus dearnessi*; insect management.

The hawthorn mealybug (two-circuli mealybug), *Phenacoccus dearnessi* (King) (Homoptera: Pseudococcidae), is widely distributed through the U.S. Midwest, North Atlantic, and some western states. The species is restricted to rosaceous hosts including *Amelanchier* spp., *Cotoneaster* spp., *Cydonia oblonga*, and certain *Prunus* spp. (USDA-FS 1985; McKenzie 1967). It is most commonly associated, however, with hawthorn (*Crataegus* spp. and cultivars), and in Colorado has been reported from this host only.

In Colorado, hawthorn mealybug has proved to be very damaging and difficult to manage. High populations of the insect commonly occur on cultivated *Crataegus*, and feeding can produce conspicuous accumulation of excreted sugary honeydew, subsequent promotion of sooty molds, and sometimes dieback or even death of trees. Natural enemies are not reported for this insect, and effective chemical control measures have not been identified.

With the expanded use of hawthorn in landscape settings in Colorado, *P. dearnessi* is increasingly important. Therefore, studies were conducted to better understand its biology and to evaluate strategies for management of this insect.

MATERIALS AND METHODS

Life History Observations

All reported studies were made at the Plant Environmental Research Center (PERC) on the campus of Colorado State University (CSU) in Fort Collins in a planting of mixed *Crataegus* cultivars that have been established at the site since the early 1980s. The most complete life history observations were made during 1998, at approximately weekly intervals, beginning on 16 March 1998 and continuing until 15 November 1998. Supplementary observations have been made annually from 1994 through 1999.

All insects found feeding on hawthorn mealybug were noted and, if immature, were reared to the adult stage for identification. Also, samples of infested twigs were periodically removed to the lab to determine if any parasitoids were present.

Evaluations of Cultivar Susceptibility

During three years (2 June 1994, 3 June 1997, and 28 May 1998), observations were made on the relative infestation of 14 hawthorn species and cultivars at the PERC site. Evaluations were made by assessing

the average number of adult females established on the terminal 45 cm (18 in.) of hawthorn branches. A 0-to-4 scale rating the intensity of infestation was used in all evaluations (0 = no mealybugs present, 4 = 200 or more mealybugs per branch present).

Insecticide Control Trials

Since 1994, insecticide evaluations have been conducted, of which only 3 of the most recent are described in this paper. Standard methodology involved use of individual branches as the experimental unit. Plot design was a randomized complete block (RCB) with 4 or 5 replications. Individual branches were sprayed to point of run-off and in 1998 and 1999 additional trials examined the effect of treatment timing. Evaluations were done by counting all mealybugs on the terminal 30 cm (12 in.) of the treated branch.

RESULTS AND DISCUSSION

Life History Observations

Hawthorn mealybug in Colorado has 1 generation per year and overwinters as nymphs. Wintering sites are concentrated almost entirely in bark crevices of the trunk, with a small percentage on larger branches. Approximately 10% of the overwintered females were observed to have begun first spring activity on 20 March 1998. This spring activity was correlated with onset of bud swell.

The life cycle is somewhat complex because a series of migrations occurs on its host to feeding sites on either foliage and twigs at different times, oversummering diapause sites, and overwintering sites (Miller and Appleby 1971, Kosztarab and Kozar 1988). In 1998, first migration from overwintering sites on trunks and branches was observed on 14 April. Migration to the ultimate feeding sites at the bases of buds and in twig crotches gradually increased with warmer temperature and bud development. Peak migration was observed in the beginning of May and ceased at the end of the month.

Adult males, which are winged, were first observed in 1998 on 8 April among females still remaining on the overwintering sites of the trunk; subsequent mating extended over the next month. Instar 1 stages ("crawlers") of this ovoviviparous species were first observed on 27 May. Peak egg production occurred around 10 June, at which time females were observed to average 180 maturing eggs. However, egg production and crawler emergence was very extended with a few new crawlers observed 14 October.

Throughout June, crawlers were plentiful on leaves. Beginning on 25 June, some were observed to migrate to cracks in the bark of twigs and small branches and go through a summer diapause. During early fall, beginning 8 September, crawlers returned to the leaves to feed. Subsequently, migration to overwintering sites on trunks was first noted 9 November. After settling into overwintering sites, nymphs produced a small amount of a mealy secretion, giving infested trunk surfaces a speckled appearance.

Notes on Biological Controls

Three species of predaceous lady beetles—*Adalia bipunctata* (L.), *Coccinella septempunctata* (L.), and *Hippodamia convergens* (Guerin-Meneville)—were observed to feed heavily on the overwintered stages of hawthorn mealybug as they emerged from overwintering sites and migrated to twigs. Feeding was observed to begin by late March and peaked during early May, in association with peak migrations. All 3 species of lady beetle, as well as larvae of the green lacewing, *Chrysoperla carnea* (Stephens), readily fed on *P. dearnessi* crawlers when specimens were provided in the lab, but feeding by the later was not observed in the field. In the field, predation by lady beetles ceased on 20 May, when the settled *P. dearnessi* females began to swell with eggs. Predation of adult females with maturing eggs has not been observed.

A pilot study in 1995, involving releases of the mealybug destroyer (*Cryptolaemus montrouzieri*) was not successful. Although there was limited feeding on hawthorn mealybug in the laboratory, there was no observed reduction of hawthorn mealybug numbers on plants where adults were released.

No parasitoids have ever been observed to attack hawthorn mealybug, although efforts have been made annually to attempt to identify their presence.

Evaluations of Cultivar Susceptibility

Hawthorn species and cultivars appeared to show differences in susceptibility to *P. dearnessi* (Table 1).

Table 1. Observations on the relative severity of hawthorn mealybug *(Pseudococcus dearnessi)* infestations on various *Crataegus* cultivars. Plant Environmental Research Center (PERC), Colorado State University, 1994, 1995, and 1997.

Botanic name	Common name	Infestation level[z] 1994	1995	1997
Crataegus arnoldiana	Arnold hawthorn	3.0	2.7	2.7
Crataegus crus-galli inermis	Thornless cockspur hawthorn	3.0	3.0	3.0
Crataegus douglasii	Black hawthorn	3.0	1.5	2.0
Crataegus laevigata 'Toba'	'Toba' English hawthorn	3.0	3.5	3.5
Crataegus laevigata 'Paul's Scarlet'	'Paul's Scarlet' English hawthorn	3.0	3.0	3.0
Crataegus laevigata 'Crimson Cloud'	'Crimson Cloud' English hawthorn	3.0	2.5	2.5
Crataegus monogyna stricta	'Upright Singleseed' hawthorn	2.0	2.3	2.5
Crataegus pedicellata		2.0	3.0	2.0
Crataegus spp.		2.0	2.0	2.0
Crataegus rivularis		2.0	2.0	2.0
Crataegus × *mordenensis* 'Snowbird'	'Snowbird' hawthorn	1.5	2.0	1.5
Crataegus succulenta macracantha	Macracantha hawthorn	1.0	2.0	1.0
Crataegus ambigua	Russian hawthorn	1.0	2.0	1.0
Crataegus phaenopyrum 'Cordata'	'Cordata' Washington hawthorn	0.0	0.0	0.0

[z]Average infestation. Evaluations were typically made on 2trees per cultivar. Scale: 0 = no mealybugs present, 1 = 1–10 mealybugs per branch present, 2 = 11–50 mealybugs per branch present, 3 = 51–200 mealybugs per branch present, 4 = 200+ mealybugs per branch present.

All *C. laevigata* (English hawthorn) cultivars were highly susceptible, and 1 cultivar ('Toba') died and had to be removed during the study, following consistently high annual levels of infestation. *C. phaenopyrum* 'Cordata' remained nonsusceptible to infestation throughout this study. *Crataegus* × *mordenensis* 'Snowbird', *C. succulenta macracantha*, and *C. ambigua* also showed substantial levels of resistance.

Insecticide Trials

Some insecticides—permethrin (Astro), imidacloprid (Merit), the related Novartis compound 293,343 (thiomethoxam), and abamectin—appeared to perform better than others (Table 2, Table 3, and Table 4). The addition of horticultural oil (SunSpray) seemed consistently to improve control. Pymetrozine (Relay, Fulfill) provided only modest control.

Most important, however was proper timing of treatments. Applications made after females have migrated to twigs and have begun to produce eggs can be expected to provide poor control, regardless of the insecticide used. This was indicated in the 1998 trial (Table 3) in which there was a fourfold decline in control when Merit applications were delayed 12 days. Furthermore, in a 1999 trial (Table 4), control with Astro declined as applications were delayed from 15 May to 1 June. It is therefore recommended that applications be made to coincide with the period when overwintering stages move from trunks and larger branches to the twigs.

Table 2. Hawthorn mealybug control trial, 1999.

Treatment[z] and rate	Mealybugs/terminal[y]
Avid 0.15EC 4.0 oz + SunSpray ultra-fine spray oil 2 qt/100 gal	0.25 c
SunSpray ultra-fine spray oil 2 gal/100 gal	1.33 c
293,343 25G 4.0 oz/100 gal	1.75 c
Astro 6.0 fl oz	3.00 c
293,343 25G 2.0 oz/100 gal	3.25 bc
293,343 25G 6.0 oz/100 gal	3.25 bc
Orthene TTO 0.5 lb/100 gal	12.00 b
Fulfill 50WG 2.5 oz/100 gal	12.00 b
Untreated check	30.00 a

[z]Treatments applied 21 May, 1999. Evaluations were made 15 July by counting all mealybugs on the terminal 12 inches of four branches per treatment.

[y]Numbers not followed by the same letter are significantly different ($P = 0.05$) by SNK.

Table 3. Hawthorn mealybug control trial, 1998.

Treatment and rate	Treatment date	Mealybugs/ terminal[z]
Untreated check		58.75 a
Relay 50WG 5.0 oz/100 gal	15 May	18.50 bc
Relay 50WG 2.5 oz/100 gal	15 May	14.75 ab
Relay 50WG 2.5 oz/100 gal + SunSpray 2 gal/100	15 May	18.75 ab
Merit 75W 0.52 oz/100 gal	15 May	5.75 cd
Merit 75W 0.52 oz/100 gal	27 May	21.50 ab
Astro 8 fl oz/100 gal	15 May	1.00 d

[z]Original data; data log transformed for analysis. Numbers not followed by the same letter are significantly different ($P = 0.05$) by LSD. Evaluations were made 10 June by counting all mealybugs on the terminal 30 cm (12 in.) of 4 branches per treatment.

Table 4. Effect of treatment timing on hawthorn mealybug control, 1999.

Treatment and rate	Treatment date	Mealybugs/ terminal[z]
Astro 6.0 fl oz/100 gal	15 May	1.2 c
Astro 6.0 fl oz/100 gal	22 May	2.4 c
Astro 6.0 fl oz/100 gal	1 June	12.6 b
Untreated check		46.4 a

[z]Original data; data log transformed for analysis. Numbers not followed by the same letter are significantly different ($P = 0.05$) by LSD. Evaluations were made 10 June by counting all mealybugs on the terminal 30 cm (12 in.) of 5 branches per treatment.

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Acknowledgments. We would like to acknowledge the assistance provided by Dr. James Klett of the Department of Horticulture and Landscape Design at Colorado State University for assisting with identifying and maintaining sites used during this study. Dr. Klett and Dr. Bill Jacobi of the Department of Bioagricultural Sciences and Pest Management also assisted with reviews of this research. Early work on this insect involved Tom Eckberg, currently with TruGreen/Chemlawn in Douglasville, Georgia. Assistance with being able to work on this, and many other regional problems associated with insect pest management on woody plants, has been provided by the Rocky Mountain Chapter of the International Society of Arboriculture and the Colorado State University Agricultural Experiment Station.

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Résumé. La cochenille de l'aubépine, *Phenacoccus dearnessi* (King), est un insecte parasite sérieux des aubépines (Crataegus spp.) au Colorado. Avec l'utilisation accrue de cet arbre dans les aménagements, *P. dearnessi* a pris une importance économique plus grande. Des études ont été menées afin de mieux comprendre sa biologie et d'évaluer des stratégies de gestion. Dans la région de Fort Collins au Colorado, les femelles adultes produisent leur premiers rejetons le 27 mai et continuent à se reproduire jusqu'au 14 octobre. Sur le terrain, trois espèces de prédateurs-parasites ont été observés se nourrissant de nymphes de *P. dearnessi* lorsqu'elles émergeaient de leur sites d'hibernation, mais aucune prédation n'était observée sur les femelles adultes; aucun parasitoïde n'a pu être observé. Il y a divers degré de susceptibilité à cet insecte parmi le genre *Crataegus*: *Crataegus phaenopyrum* 'Cordata' s'est avéré immunisé contre les infestations tout au cours de cette étude; *Crataegus* × *mordenensis* 'Snowbird', *C. succulenta macracantha* et *C. ambigua* ont eux aussi démontré certains degrés de résistance. Une vaste gamme d'insecticides ont été évalués pour le contrôle; l'imidacloprid (Merit) et le permethrin (Astro) ont été parmi les plus efficaces. De même, l'emploi d'huile de dormance a considérablement amélioré le résultat. Par contre, la période d'application semble être primordiale ; les applications coïncidant avec la migration des nymphes qui avaient hiberné vers les tiges ont été particulièrement efficaces.

Zusammenfassung. Der Schädling *Phenacoccus dearnessi* (King) (Wirtspflanze: Zweigriffeliger Weißdorn) ist eine ernste Plage für die Weißdornbestände in Colorado. Mit dem ausgedehnten Einsatz dieser Pflanzen in landschaftlichen Pflanzungen wurde dieser Schädling eine große wirtschaftliche Plage. Es wurden Studien durchgeführt, um die Biologie besser zu verstehen und Strategien zur Kontrolle zu entwickeln. In der Gegend von Fort Collins, Colorado, produzierten erwachsene Weibchen zum erstem Mal am 27. Mai lebende Junge und fuhren mit der Produktion bis zum 14. Oktober fort. Im Feld wurden drei Arten von räuberischen Käfern beobachtet, die sich von den gerade geschlüpften Nymphen der *Ph. dearnessi* ernährten, aber ein Auffressen der Weibchen wurde nicht beobachtet. Es gibt eine Spannweite von Anfälligkeit für dieses Insekt bei *Crataegus* spp.: *Cratagus phaenopyrum* 'Cordata' blieb währen der Studie unbefallen; *Cr.* × *mordenensis* 'Snowbird', *Cr. Succulenta macracantha* und *Cr. ambigua* zeigten auch einige Resistenz. Es wurde auch eine Vielzahl an Insektiziden, die Imidacloprid (Merit) und Permethrin (Astro) enthielten, getestet, wobei sich genannte als wirksam erwiesen. Zusätzlich verbesserte der Einsatz von Öl die Wirksamkeit. Dennoch scheint der genaue Zeitpunkt kritisch zu sein, aber wenn der Anwendungszeitpunkt mit der Migration der überwinterten Nymphen zu den Zweigen übereinstimmte, erwies sich das Verfahren als wirkungsvoll.

Resumen. El chinche *Phenacoccus dearnessi* (King) es una plaga severa de la oxiacanta, *Crataegus* spp, en Colorado. Con el uso extendido de esta planta en arquitectura del paisaje, *P. dearnessi* se ha vuelto de gran importancia económica. Se condujeron estudios para entender mejor su biología y evaluar las estrategias de manejo. En el área de Fort Collins, CO hembras adultas produjeron crías el 27 de Mayo y continuaron reproduciéndose hasta el 14 de Octubre. Fueron observadas en el campo tres especies de escarabajos predadores alimentándose de ninfas de *P. dearnessi* a medida que emergían de los sitios de reposo, pero no se observó predación en las hembras adultas; tampoco se observaron parasitoides. Existe un rango de susceptibilidad a este insecto entre *Crataegus* spp: *Crataegus phaenopyrum* 'Cordata' ha permanecido inmune a la infestación a través de este estudio; *Crategus* × *mordenensis* 'Snowbird', *C. succulenta macracanta*, y *C. ambigua* también mostraron substanciales niveles de resistencia. Un rango amplio de insecticidas ha sido evaluado para el control, con imidacloprid (Merit) y permethrin (Astro) como los más efectivos. Además, el uso de aceite hortícola mejoró consistentemente. Sin embargo, la época de aplicación parece ser crítica; las aplicaciones coincidentes con la migración de las ninfas recién emergidas a las ramas son particularmente efectivas.