Life History of an Exotic Soft Scale Insect Phalacrococcus howertoni (Hemiptera: Coccidae) Found in Florida

Authors: Amarasekare, Kaushalya G., and Mannion, Catharine M.

Source: Florida Entomologist, 94(3) : 588-593

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.094.0324

LIFE HISTORY OF AN EXOTIC SOFT SCALE INSECT *PHALACROCOCCUS HOWERTONI* (HEMIPTERA: COCCIDAE) FOUND IN FLORIDA

KAUSHALYA G. AMARASEKARE[1,2] AND CATHARINE M. MANNION[1]
[1]University of Florida, Institute of Food and Agricultural Sciences, Tropical Research and Education Center, 18905 SW 280th Street, Homestead, FL 33031-3314

[2]Current Affiliation: Oregon State University, Mid-Columbia Agricultural Research and Extension Center, 3005 Experiment Station Drive, Hood River, OR 97031

ABSTRACT

We investigated the life history of an exotic soft scale insect, *Phalacrococcus howertoni* Hodges and Hodgson that damages croton and several other economically important ornamental and fruit plants in Florida. There was no difference in the development, survival, and reproduction of this scale insect species when reared either on croton or on buttonwood at 27 ± 1°C, 12:12 (L:D) h and 65% R. H. The scale insect practiced ovoviviparity. We observed that eggs that came out from vulva hatched to first instars immediately. Newly hatched nymphs had a tendency stay underneath the female body for somewhat less than approximately 24 h and then disperse throughout the leaf area for feeding. Females went through 3 immature stages (first, second, and third-instar) prior to becoming adults, while males had 4 immature stages (first, second, third ('pre-pupa'), and fourth instar ('pupa')). Survival in the first instars was the lowest (50.0-50.9%), while the survivorship of the other instars was as follows: second instars (88.9-90.0%), third instar males (92.9-93.7%), third instar females (92.9-94.8%) and fourth-instar males (96.0-97.6%).Thus, approximately 40% of the first instars survived to adults. The pre-oviposition period was 17.6-19.1 d and the oviposition period was 13.9-15.5 d. Lifetime fertility was in the range of 382.4-394.7 live first instars per female. Intrinsic rate of increase (r^m) was 0.091-0.095. The lifespan of adult males was very short (less than 1 d) at 27 ± 1°C compared to that of adult females (60.3-61.5 d).

Keywords development, insect pest, survival, reproduction, intrinsic rate of increase

RESUMEN

Investigamos la historia de vida de un insecto de escama blanda exótico, *Phalacrococcus howertoni* Hodges y Hodgson que daña croton y otras plantas ornamentales y frutales de importancia económica en la Florida. No hubo diferencias en el desarrollo, la supervivencia y la reproducción de esta especie de escama cuando fue criado sobre croton o mangle botón (*Conocarpus erectus*) a 27 ± 1°C, 12:12 (L: D) horas y 65% RH. La escama presenta ovoviviparidad. Observamos que los huevos que salieron la vulva nacieron inmediatamente como primero estadio. Las ninfas recién eclosionadas tenían una tendencia de mantenerse por debajo del cuerpo de la hembra por aproximadamente algo menos de 24 horas y luego se dispersan por todo el área de la hoja para alimentarse. Las hembras pasan por tres etapas inmaduras (primero, segundo y tercer estadio) antes de convertirse en adultos, mientras que los machos tenían 4 estadios inmaduros (primero, segundo, tercero ("pre-pupa"), y cuarto estadio ("pupa")). La supervivencia en los primeros instares fue la más baja (50.0 a 50.9%), mientras que la supervivencia en los otros estadios fue la siguiente: segundo estadio (88.9 a 90.0%), tercera estadio del macho (92.9-93.7%), tercera estadio de la hembras (92.9-94.8%) y el cuarto estadío de los machos (96.0-97.6%). Por lo tanto, aproximadamente el 40% de los primeros estadios sobrevivieron hasta el estado adulto. El período de pre-oviposición fue 17.6 a 19.1 dias, y el período de oviposición fue 13.9 a 15.5 dias. La fertilidad por toda la vida de la hembra fue de 382.4 a 394.7 para el número de primeros estadios vivos por cada hembra. La tasa intrínseca de crecimiento (r^m) fue 0.091-0.095. La duración de la vida de los machos adultos fue muy corta (menos de 1 dia) a 27 ± 1°C en comparación con la de las hembras adultas (60.3 a 61.5 dias).

A new exotic soft scale insect species, *P. howertoni* Hodges and Hodgson (Hemiptera: Coccidae), was first detected in the United States in Apr 2008 in Marathon (Monroe County), Florida on croton (*Codiaeum variegatum* (L.) 'Blume') (Hodges 2008). The scale was subsequently found in 21 counties in Florida including Broward, Miami-Dade, Palm Beach, Duval, Indian River, Lee, Orange, Pinellas, Putnam, and St. Lucie (Hodges 2008; Hodges & Hodgson 2010). Economically important fruits and ornamental plants such as guava (*Psidium guajava* L.), mango (*Mangifera*

indica L.), croton, buttonwood (*Conocarpus erectus* L.), Mysore fig (*Ficus mysorensis* Roth), and strangler fig (*Ficus aurea* Nutt.) are included in the currently recorded host plant range of this scale; the complete list of known host plant species totals 72 belonging to 34 families (Hodges 2008; Hodges & Hodgson 2010). *P. howertoni* is a new species in a new genus of an unknown origin (Hodges & Hodgson 2010).

Although the economic importance of *P. howertoni* is unknown at present, the scale does build up large populations on croton and could potentially become pest of this and other host plant species from which it has been recorded. Observations on its prolific nature and the high intensity of sooty mold production in affected host plants, suggest that this scale species could become a serious pest to numerous agricultural crops in Florida and elsewhere in the United States. Currently, there is no published information on the biology and life history of this soft scale species.

We investigated the life history of *P. howertoni* on 2 popular ornamental plants in Florida: croton and buttonwood. In addition to its ornamental value, buttonwood is a mangrove species of ecological importance (Gilman & Watson 1993). Information on the development, reproduction and survival of the scale insect species is important in developing control measures for *P. howertoni* to prevent further infestations throughout Florida and in predicting the establishment and spread of this species to the other parts of the United States.

Materials and methods

Insect Rearing

Phalacrococcus howertoni was initially collected (July 2008) from an infested croton plant in Homestead, FL. A scale colony was maintained at 27 ± 1°C in a temperature-regulated greenhouse on 6-mo old container-grown croton plants (*Codiaeum variegatum* (L.) variety '*Mammey*') purchased from a local store (Walmart, Florida City, Florida). The plants were maintained under overhead irrigation and fertilization not exposed to any insecticides. Plants were utilized for colony rearing 1 mo after their purchase.

Development and Survival

We measured the development and survival of *P. howertoni* under controlled conditions (27°C, 65% R. H., and a 12:12 (L:D) h photoperiod). Croton (cuttings) and buttonwood (cuttings and seedlings) with fully expanded leaves were used as the host tissues. (We used both buttonwood seedlings and cuttings with the assumption that if *P. howertoni* could develop and complete its life cycle in seedlings, they would be in great danger of dying because of the prolific nature of the scale species and high density of sooty mold production observed in affected plants). Cuttings were excised from 3-mo old container-grown croton plants maintained outdoors under overhead irrigation and without any pesticide applications. Buttonwood cuttings were obtained from a hedge of buttonwood from University of Florida, Tropical Research and Education Center (TREC) landscape that were maintained without any insecticide applications. Buttonwood seedlings (liners) (15 cm in height) were used 1 mo after purchase (Pat Ford's Nursery Inc., Boynton Beach, FL).

The experimental arena consisted of a 9-cm-diameter petri dish. A 0.6-cm-diameter hole was created in the bottom of the petri dish using a heated cork borer. A seedling or cutting with 2 to 3 newly expanded leaves (5-10 d old and ~6 cm in length) selected from the upper leaf canopy (with 11-cm long stem) was placed in to each petri dish with the stem inserted through the hole at the bottom of the dish. A lid was placed on top to avoid insect escape. Each petri dish containing a cutting was placed on a 296 ml plastic cup so that the stem below the petiole was immersed in water. This arrangement was similar to the set up used by Amarasekare et al. (2008).

Gravid females (kept individually on croton leaves prepared as above) were transferred to environmental growth chambers (Percival I-36LL, Percival Scientific Inc. Perry, North Carolina) 24 h before the experiment. They were acclimatized to experimental conditions of 27± 1°C temperature, 65 ± 2% R.H., and a photoperiod of 12:12 (L:D) h. Each individual female was placed in each experimental arena (croton stem cutting arranged in a petri dish) and allowed to lay eggs. Females were removed after 24 h. Ten first instars emerged from eggs of a single female were kept in each experimental arena. There were 21 females (replicates) with each replicate comprising of the offspring of a single female. The experimental arenas were placed in the environmental chamber set at above-mentioned conditions. Petri dishes were checked daily for shed exuviae to identify eclosion of nymphal instars and adults. The numbers of days to each instar, percentage survival, and numbers of adult males and females were recorded. The crawlers (first instars) of soft scales do not appear to be sexually differentiated morphologically (Marotta 1997). The sexual gender of each individual was determined during the latter part of the second instar when males changed their appearance. At this time, the male nymphs become elongate and show the beginning of eye pigmentation. After this point, males and females held separately and the development times and survival of males and females were recorded separately.

Reproduction and Adult Longevity

Newly emerged virgin females and males (emerged from the above study) were used to determine reproductive capacity. In this experiment, newly eclosed adult females of less than 24 h old were selected from each experimental arena and each female was paired with 2-3 newly emerged adult males. Twenty-five females (replicates) were used in the experiment. The number of days prior to oviposition (number of days from adult emergence to oviposition) and oviposition period (number of days from beginning to end of oviposition), number of eggs laid, and adult mortality were recorded. Sex ratio was calculated as the proportion of females. The intrinsic rate of increase was calculated using the equation $r_m = 0.74 (\ln M_d)/T$ (Wyatt and White 1977), in which T is time from birth to onset of reproduction, M_d is the reproductive output per original female during a period equal to T, and 0.74 is a correction factor.

Statistical Analyses

The experiment involved a completely randomized design. A one-way analysis of variance (ANOVA) was conducted using PROC MIXED (SAS Institute 1999). The mean number of individuals in each petri dish / replicate was used as the dependent variable in the analyses. Treatment means were compared at $P = 0.05$ significance level using the LSMEANS test (SAS Institute 1999). The data on proportion of females (sex ratio) and percentage survival were arcsin square-root transformed to stabilize variances (Zar 1984) prior to ANOVA.

Voucher Specimens

Voucher specimens of the scale species were deposited in the Entomology and Nematology Department insect collection at the Tropical Research and Education Center, University of Florida, Homestead, Florida. For verification of identification, scale samples from each host plant species were sent to the Systematic Entomology Laboratory, USDA-ARS and to the Division of Plant Industry, Florida Department of Agriculture and Consumer Services.

Results

Development

Duration of each developmental stadium of *P. howertoni* was not different between croton and buttonwood (Table 1). We observed that eggs were coming out from vulva and that they would hatch to first instars (crawlers) immediately after oviposition. Newly hatched nymphs had a tendency stay underneath the female body for somewhat less than approximately 24 h and then disperse throughout the leaf area for feeding. First-instar developmental period ranged from 12.4 to 12.6 d. In the latter part of the second-instar development, males changed their appearance. At this time, the developmental period for the second-instar males and females were monitored separately. Females had 3 immature stages (first, second and third nymphal instars) before becoming adults (Table 1). In contrast, males had 4 immature stages before becoming adults (first, second, third ('pre-pupa') and fourth ('pupa') instars) (Table 1). The developmental periods of second, third and fourth- instar males ranged from 9.8-10.4 d, 3.8-3.9 d and 2.8-3.1 d, respectively. The developmental periods of second and third- instar females were 11.6-11.8 d and 6.7-6.9 d, respectively. The overall development periods from first instar to adult male and female were between 29.0-29.7 d and 30.8-31.1 d, respectively (Table 1).

Survival

There was no difference in the survival of developmental stages between croton and buttonwood (Table 2). Percentage of first-instar survival (50.0-50.9%) was the lowest compared to the survival of other developmental stages (Table 2). Second-instar survival (percentage of first instars survived to second instars) was 88.9-90.0%. More than 90% of third-instar males and females and fourth- instar males survived to the next stage (92.9-93.7%, 92.9-94.8% and 96.0-97.6%, respectively). Percentage survival of first instars to adults was lower (39.5-40.9%) than the survival of the other developmental stages on both croton and buttonwood (Table 2). Scale crawlers have a tendency to move away from light (Peña et al. 1987). They are generally the most active stage, and engage in both active and passive dispersal (Marotta 1997). This movement causes the disappearance of some individuals during the experiment. The survival of the crawlers was lower than the other life stages, likely because of the sessile nature of the other stages.

Adult Sex Ratio and Longevity

Adult sex ratio ([females/(males + females)] × 100%) ranged from 49.0-52.3% and was not significantly different between croton and buttonwood (Table 3). The adult males died within 24 h of their emergence so their longevity was not assessed in detail (Table 3). Females lived between 60.3 and 61.5 d with no difference between the host plants tested (Table 3)

Reproduction

Pre-oviposition and oviposition periods did not differ between croton and buttonwood and ranged

TABLE 1. MEAN NUMBER OF DAYS (±SEM) FOR EACH DEVELOPMENTAL STADIUM OF *P. HOWERTONI* REARED ON CROTON (CUTTINGS) AND BUTTONWOOD (CUTTINGS AND SEEDLINGS).

	Stadia							
		Second		Third		Fourth	First to Adult	
Host	First	Male	Female	Male	Female	Male	Male	Female
Croton cuttings	12.6 ± 0.1 a	10.4 ± 0.2 a	11.6 ± 0.2 a	3.9 ± 0.1 a	6.9 ± 0.2 a	2.8 ± 0.2 a	29.7 ± 0.3 a	31.1 ± 0.4 a
Buttonwood cuttings	12.4 ± 0.1 a	9.9 ± 0.2 a	11.7 ± 0.2 a	3.7 ± 0.1 a	6.7 ± 0.2 a	3.1 ± 0.2 a	29.2 ± 0.4 a	30.8 ± 0.3 a
Buttonwood seedlings	12.5 ± 0.2 a	9.8 ± 0.2 a	11.8 ± 0.2 a	3.8 ± 0.1 a	6.8 ± 0.2 a	2.9 ± 0.2 a	29.0 ± 0.4 a	31.0 ± 0.4 a
F	0.41	1.57	0.27	0.25	0.15	0.64	0.73	0.11
d.f.	2, 60	2, 60	2, 60	2, 60	2, 60	2, 60	2, 60	2, 60
p	0.6677	0.2175	0.7651	0.7765	0.8649	0.5327	0.4850	0.8996

n = 21 for each host plant.
Gender could not be determined before the second instar.
Means within a column followed by the same letters are not significantly different at $\alpha = 0.05$ (LSMEANS).

TABLE 2. MEAN (±SEM) PERCENT SURVIVAL (%) DURING EACH DEVELOPMENTAL STADIUM OF *P. HOWERTONI* REARED ON CROTON (CUTTINGS) AND BUTTONWOOD (CUTTINGS AND SEEDLINGS).

	Survival (%)					
			Third		Fourth	Cumulative
Host	First	Second	Male	Female	Male	First to Adult
Croton cuttings	50.9 ± 3.6 a	90.0 ± 2.8 a	93.7 ± 2.9 a	94.8 ± 2.9 a	96.0 ± 2.8 a	40.9 ± 3.0 a
Buttonwood cuttings	50.5 ± 3.3 a	89.1 ± 2.7 a	92.9 ± 4.1 a	94.4 ± 3.1 a	96.0 ± 2.8 a	40.5 ± 2.9 a
Buttonwood seedlings	50.0 ± 3.7 a	88.9 ± 3.4 a	93.3 ± 3.2 a	92.9 ± 4.1 a	97.6 ± 2.4 a	39.5 ± 2.9 a
F	0.01	0.06	0.01	0.03	0.14	0.06
d.f.	2, 60	2, 60	2, 60	2, 60	2, 60	2, 60
P	0.9851	0.9444	0.9890	0.9716	0.8709	0.9426

n = 21 for each host plant.
Means within a column followed by the same letters are not significantly different at $\alpha = 0.05$ (LSMEANS).

TABLE 3. MEAN (±SEM) PROPORTION OF FEMALES, ADULT LONGEVITY, LIFETIME FERTILITY, PRE-OVIPOSITION AND OVIPOSITION PERIODS AND INTRINSIC RATE OF INCREASE (R^M) OF *P. HOWERTONI* REARED ON CROTON (CUTTINGS) AND ON BUTTONWOOD (CUTTINGS AND SEEDLINGS).

Host	Sex Ratio (%) (Proportion of Females)	Adult Longevity (d)	Lifetime Fertility (number)	Pre- oviposition Period (d)	Oviposition Period (d)	Intrinsic Rate of Increase (r^m)
		Female				
Croton cuttings	50.9 ± 0.6	61.5 ± 2.4 a	388.2 ± 25.0 a	17.6 ± 0.7 a	13.9 ± 1.1 a	0.091 ± 0.002 a
Buttonwood cuttings	52.3 ± 2.4	60.3 ± 2.3 a	394.7 ± 29.1 a	18.3 ± 0.6 a	14.7 ± 1.1 a	0.090 ± 0.003 a
Buttonwood seedlings	49.0 ± 2.1	61.1 ± 2.7 a	382.4 ± 27.7 a	19.1 ± 0.9 a	15.5 ± 1.0 a	0.095 ± 0.002 a
F	0.76	0.07	0.05	0.93	0.49	1.07
d.f.	2, 60	2, 60	2, 60	2, 72	2, 72	2, 60
P	0.4709	0.9357	0.9508	0.3998	0.6161	0.3483

n = 21 for each host plant.
Means within a column followed by the same letters are not significantly different at $\alpha = 0.05$ (LSMEANS test).

from 17.6-19.1 d and 13.9-15.5 d, respectively (Table 3). Lifetime fertility of mated females was 382.4-394.7 live first-instars and with no significant difference between croton and buttonwood. Almost all first instars born were alive at the time of birth and zero or negligible numbers of hatching failures were observed. The intrinsic rate of increase (r^m) ranged from 0.091-0.095 (Table 3).

DISCUSSION

The new exotic soft scale species, *P. howertoni,* was able to develop, survive and reproduce equally successful on both croton and buttonwood. This is the first information available on biology and life history of *P. howertoni*. This information on life history of the scale insect species is important and needed to understand its development, reproduction and survival and useful in predicting distribution and abundance and implementing appropriate control measures to prevent further infestations in Florida and the species' spread to other areas in the United States or abroad.

We found that the female *P. howertoni* are neotenic, reaching the adult stage after 3 molts through metamorphosis of the heterometabola-paurametabola type (Marotta 1997). This is a common life history feature in all soft scale species as well as in other families of Coccoidea. On the other hand, adult male *P. howertoni* goes through 2 nymphal instars and sessile pre-pupal and pupal stages before becoming an active adult. This is again a common life history feature of male soft scales (Marotta 1997).

We found that the female has a high fecundity with close to 400 live nymphs per female with 0.091-0.095 intrinsic rate of increase (r^m). This combines with its polyphagous nature suggest that *P. howertoni* could be a threat to other similar crop plants grown in Florida and elsewhere in the United States. In general, fecundity of soft scale species can vary enormously depending on temperature, scale abundance, size of adult females and the condition of the host plant (Marotta, 1997). It is important that future studies investigate factors that affect the fecundity of *P. howertoni*, as fecundity is likely to be a key life history trait that allows the scale to successfully establish and spread.

According to Hodges & Hodgson (2010), this new genus and species of *P. howertoni* show similarities with members of the Eulecaniinae, Paralecaniini, and Coccini but differ significantly from all these taxa with uncertain (unknown) taxonomic relationships. At the time this species was first found in Florida, there was a speculation that this soft scale may be a *Philephedra* sp. (Hodges 2008). Both species are polyphagous and have wide host plant ranges, which include popular fruits and ornamental plants. *P. howertoni*

and *Philephedra* sp. are both green in color but *P. howertoni* does not produce an ovisac as *Philephedra* sp. does (Hodges 2008). We observed that eggs of *P. howertoni* hatched to first instars immediately after oviposition. This feature is also observed in several subfamilies within the Coccidae (Ceroplastinae, Coccinae (tribes Coccini, Paralecaniini and Saissetiini), Eulecaniinae and Myzolecaniinae) (Marotta 1997). There are similarities in the developmental periods of *P. howertoni*'s life stages and those of *Philephedra tuberculosa* (Pena et al. 1987). In general, male soft scales are devoid of mouthparts and may live only for few hours to about a week (Marotta 1997). Males of both species had less than 1 d of longevity, while females of *P. howertoni* and *P. tuberculosa* (Pena et al. 1987) lived 60.3-61.5 d and 59 d, respectively.

The fact that *P. howertoni* successfully completed its life cycle in buttonwood shows that it has the potential to damage native plant species that are ecologically important. It also shows that *P. howertoni* can survive on native host plant species even in the absence of cultivated species such as croton. Its polyphagus nature and high reproductive ability therefore makes *P. howertoni* a potentially serious pest of tropical and subtropical ornamental and fruit plants and ecologically important mangrove plants such as buttonwood. With the interstate plant movement, this pest has the ability to move in to other U.S. states in which similar host plant species occur naturally or are grown commercially. The life history information obtained in this study is likely to be important both in predicting the potential distribution of this species and in implementing appropriate control measures.

Acknowledgments

We thank Douglass R. Miller (Coccidae) of Systematic Entomology Laboratory, USDA-ARS for insect identification (Lot # 0902998), Greg Hodges of Division of Plant Industry, Florida Department of Agriculture and Consumer Services for providing information on soft scale insects similar to this studied species and for insect identification (sample number E2009-1214-1 and E2009-1215-1), and Holly Glenn and Julio Almanza of the University of Florida, Tropical Research and Education Center for their support during this experiment.

References Cited

Amarasekare, K. G., Mannion, C. M., Osborne, L. S., and Epsky N. D. 2008. Life history of *Paracoccus marginatus* (Hemiptera: Pseudococcidae) on 4 host plant species under laboratory conditions. Environ. Entomol. 37: 630-635.

Gilman, E. F., and Watson, D. G. 1993. *Conocarpus erectus*. Fact Sheet. ST-179. Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.

Hodges, G. 2008. A new exotic soft scale insect on croton in South Florida (Hemiptera: Coccoidea: Coccidae). Pest Alert. Florida Department of Agriculture and Consumer Services. Division of Plant Industry. Gainesville, Florida.

Hodges, G., and Hodgson, C. J. 2010. *Phalacrococcus howertoni*, a new genus and species of soft scale (Hemiptera: Coccidae) from Florida. Florida Entomol. 93: 8-23.

Marotta, S. 1997. Chapter 1.2 Biology-1.2.1.1 General Life History, pp. 251-256 *In* Y. Ben-Dov and C. J. Hodgson. [eds.], World Crop Pests, 7A. Soft Scale Insects-Their Biology, Natural Enemies and Control, Elsevier Science B.V., Amsterdam, The Netherlands.

Peña, J. E., Baranowski, R. M. and Litz, R. E. 1987. Life history, behavior and natural enemies of *Philephedra tuberculosa* (Homoptera: Coccidae). Florida Entomol. 70: 423-427.

SAS Institute. 1999. SAS user's guide. Version 9.1. SAS Institute. Cary, North Carolina.

Wyatt, I. J., and White P. F. 1977. Simple estimation of intrinsic increase rates for aphids and tetranychid mites. J. Appl. Ecol. 14:757-766.

Zar, J. H. (1984). Biostatistical Analysis. 2nd ed. Prentice Hall. Englewood Cliffs, New Jersey.