Experimental and Applied Acarology

# Effect of different ornamental pepper pollens on the development and reproduction of Amblyseius swirskii (Acari: Phytoseiidae)

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| **Abstract:** | Chilli thrips, Scirtothrips dorsalis Hood (Thysanoptera: Thripidae), a newly introduced pest in the United States is well known to cause significant economic damage on a variety of crops worldwide. In Florida, it has emerged as a key pest of ornamental and vegetable crops. Chemical control is still considered as a primary mode for its control. The rationale behind the current study was to assess if the phytoseiid mite, Amblyseius swirskii (Athias-Henriot), a commercially available predator of S. dorsalis can survive and reproduce by solely feeding on a variety of ornamental pepper pollens. In order to evaluate nutritional value and the possible impact on longevity, daily rate of oviposition and total egg deposition was assessed. A. swirskii was reared on pollen collected from four ornamental pepper varieties, viz. Red Missile, Masquarade, Black Pearl and Explosive Ember - potential banker plant candidates for ornamental nurseries. A. swirskii was able to survive, develop and oviposit on all the ornamental pepper pollen varieties tested and the two standard controls (commercially available olive pollen and S. dorsalis). No significant differences were observed among the different diet treatments for the following A. swirskii biological parameters: mean longevity (22.7-24.2 d), larvae to eggs (11.8 -12.6 d) and duration of adult stage (12.4-13.2 d). Amongst the pepper pollens, the highest daily rate of oviposition (~1.07 eggs/female/day) and total oviposition (~10.23 eggs/female) was recorded on the Red Missile variety. Results from this study can aide in the selection of suitable pepper varieties as candidate banker plants for establishment of A. swirskii in ornamental nurseries and can boost the management strategies being used against S. dorsalis and other pest species. |

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# Effect of different ornamental pepper pollens on the development and reproduction of *Amblyseius swirskii* (Acari: Phytoseiidae)

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## Abstract

Chilli thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae), a newly introduced pest in the United States is well known to cause significant economic damage on a variety of crops worldwide. In Florida, it has emerged as a key pest of ornamental and vegetable crops. Chemical control is still considered as a primary mode for its control. The rationale behind the current study was to assess if the phytoseiid mite, *Amblyseius swirskii* (Athias-Henriot), a commercially available predator of *S. dorsalis* can survive and reproduce by solely feeding on a variety of ornamental pepper pollens. In order to evaluate nutritional value and the possible impact on longevity, daily rate of oviposition and total egg deposition was assessed. *A. swirskii* was reared on pollen collected from four ornamental pepper varieties, viz. Red Missile, Masquarade, Black Pearl and Explosive Ember - potential banker plant candidates for ornamental nurseries. *A. swirskii* was able to survive, develop and oviposit on all the ornamental pepper pollen varieties tested and the two standard controls (commercially available olive pollen and *S. dorsalis*). No significant differences were observed among the different diet treatments for the following *A. swirskii* biological parameters: mean longevity (22.7-24.2 d), larvae to eggs (11.8 -12.6 d) and duration of adult stage (12.4-13.2 d). Amongst the pepper pollens, the highest daily rate of oviposition (~1.07 eggs/female/day) and total oviposition (~10.23 eggs/female) was recorded on the Red Missile variety. Results from this study can aide in the selection of suitable pepper varieties as candidate banker plants for establishment of *A. swirskii* in ornamental nurseries and can boost the management strategies being used against *S. dorsalis* and other pest species.

**Keywords:** Chilli thrips, banker plants, phytoseiid mites, biological control

## Introduction

In last two decades, biological control has been practiced as an important component of pest management strategies. It is a method of suppressing arthropod pest populations using suitable natural enemies to gain an economic benefit resulting from the integration of various biological control approaches including classical, innundative and conservation (Gurr et al. 1998; Gurr and Wratten 1999). Banker plant systems are examples of an integrated biological control approach which involves combined aspects of augmentative and conservational biological control and habitat manipulation proposed as an efficient alternative to chemical based pest management techniques (Osborne and Barrett 2005; Frank 2010; Huang et al. 2011; Xiao et al. 2011). Success of biological control strategies depends upon several factors: (1) efficacy of natural enemies against the target pest(s), (2) high search ability of natural enemies, (3) seasonal synchronization with host, (4) adaptability to environmental variations and (5) continuous supply of food supporting survival and long-term establishment in the habitat. According to Gurr et al. (2000), success of biological control strategies can be valued by its affordability in bringing a pest population below the economic injury level, as well as the proportion of growers that adopt the technique. Installing banker plants in the agro-ecosystem can provide long-term suppression of pest populations by providing ecological infrastructures required to sustain a reproducing population of natural enemies (Frank 2010; Huang et al. 2011). Such a self-sustaining pest management system can increase reliability of biological control strategies and can reduce overall insecticide use. In addition to providing nutrient supplements in the form of nectar or pollen, important for the natural enemies survival in the absence of prey, banker plants can provide a modified microhabitat (domatia) which can protect them against adverse abiotic conditions, secondary enemies or from an insecticide application (Landis et al. 2000). The intentional provision of food and shelter via banker plants can maximize biocontrol potential of the released biological control agents and favor their survival, fecundity and longevity; thereby supporting the success of biological control agents overall.

Chilli thrips *Scirtothrips dorsalis* Hood is a new invasive thrips species in the United States and an emerging pest of various vegetable, ornamental and tropical fruits in the region (Seal et al. 2006, 2010; Kumar et al. 2012). It is a polyphagous insect with more than 100 reported hosts from 40 different families of plants worldwide (MacLeod and Collins 2006). Since its introduction in the United States in 2005, it has become established in 30 counties of Florida, 8 counties in Texas and with several reports of their invasion in Alabama, Georgia, Louisiana and New York (Kumar et al. 2011). Osborne (2009) recently reported that this pest is responsible for damaging more than 50 ornamental plant species in different parts of Florida. According to an economic analysis by Garrett (2004) on 28 potential hosts in the US, a 5% loss of these crops could lead to a loss value of $3 billion to the USA economy. Thus, there is an urgent challenge for researchers to develop an efficient and long-term management strategy against this pest before it emerges as a serious control problem for vegetable and ornamental industries in the United States.

In a previous study, the efficacy of two phytoseiid mites, *Amblyseius swirskii* (Athias-Henriot) and *Neoseiulus cucumeris* Oudemans, was evaluated (Arthurs et al. 2009) as potential biological control agents of *S. dorsalis*. *A. swirskii* was reported to provide significantly higher suppression of *S. dorsalis* populations compared to *N. cucumeris* and is being considered as a promising tool for their control. Although *A. swirskii* is an aggressive predator and can provide a significant reduction of *S. dorsalis* in a timely fashion, the survival and long-term establishment of the phytoseiid mites can be difficult in the absence of their prey. Scarcity of food may lead to intraguild predation resulting in a population crash of the phytoseiid mites, and the control strategy would no longer be economical if multiple applications of the agents were required. With the aim to develop a long-term management strategy for *S. dorsalis* using phytoseiid mites by employing a banker plant based biological control strategy, we conducted a pilot study to assess the effect of different ornamental pepper pollen on the life parameters of *A. swirskii*. The current study was designed to determine whether *A. swirskii* can develop and reproduce when feeding solely on an ornamental pepper pollen diet. Ornamental pepper cultivars were selected because the original work was aimed to regulate *S. dorsalis* populations on rose nurseries and gardens in the landscape, and the evaluation of different pollen was important for screening a particular ornamental pepper banker plant variety.

## Materials and Methods

### Host plant and pollen collection

The study was conducted at the University of Florida's Indian River Research and Education Center, Fort Pierce, FL (27.42N, 80.40W). The host plants for the study were grown from seed as single plants in Fafard Pro-mix medium (Conrad Fafard, Inc., Agawam, MA) in plastic pots (10.1 cm dia) placed into a homemade plastic screened cage (61 cm x 71 cm x 61 cm). Seeds of the four different ornamental pepper (*Capsicum annum* L.) varieties (Masquerade (MA), Red Missile (RM), Black Pearl (BP) and Explosive Ember (EE)) (Ball Horticultural Co., West Chicago, IL, USA) were sown on different days to synchronize the germination times. Plants were irrigated as needed (~3 times a week) and fertilized with 50 mL/pot of Peters Professional® 20-10-20 (325 ppm) (Scotts Co., Marysville, OH) once a week. Plants selected for the study were healthy, young, vigorous, and free of arthropod pests. Two weeks after flowering, pollen was collected from flowers of each variety by tapping the pollen into small plastics ampoules. The collected pollen was dried in an oven for two days at 37°C before being stored in a refrigerator at 4°C.

### Stock colony of *A. swirskii*

*A. swirskii* population used in the study was collected from a colony which was initially established at Mid-Florida Research and Education Center, Apopka, FL (28.63N, 81.55W) in 2009 from a culture of SWIRSKI-MITE™ (Koppert Biological Systems., Inc. USA Ltd, Howell, MI). The mites were raised following a modified protocol of Carrillo et al. (2010) in plastic trays (14 x 14 cm) filled with water; culture arena consisted of a waxed colored paper (5.5 x 5.5 cm) grooved by a wire mesh (1 $mm^2$) placed on top of 3 stacked cotton pads (75 mm dia) with a few threads of cotton placed on top of the waxed paper simulating leaf trichomes (to facilitate egg oviposition of mites). Small dried apricots infested with all stages of *Carpoglyphus lactis* (Acari: Acaridae) were supplied to *A. swirskii* on plastic arenas as a food source. In order to produce mites of the same age, gravid female *A. swirskii* were kept individually in small Falcon® Petri dishes (4 cm dia) for 12-14 h to oviposit on leaf disks. The eggs were collected and incubated at 25°C. The mites that emerged were considered to be of the same age or at least formed cohorts with a maximum age variation of less than 8 h.

### Feeding experiment with *A. swirskii*

The experimental arena consisted of a small Falcon® Petri dish (4 cm dia) lined with a moist cotton layer and sealed with plastic food wrap. Leaf discs (3 cm dia) of each pepper variety were punched at the center of the leaf blade beginning at the intersection between the petiole and the edge of the leaf with a cork borer and placed on the cotton. About ~13-15 mg of pollen was placed on plastic cover slips and the cover slips were replaced every three days to avoid mold growth. The cover slips were placed at the center of each leaf disk. The ornamental pepper treatments (pollen) evaluated in the study was RM, MA, EE and BP. For comparison, a commercial pollen source from an olive plant (OC) (Pollen Collection and Sales, Inc. Lemon Cove, CA) and *S. dorsalis* (SD) larvae were used as controls; these were put on MA leaves as this variety  was more leafy than other ornamental pepper varieties. A single gravid female mite was gently removed from one of the rearing units using a moistened camel hair brush, and transferred to the center of the leaf disk and allowed to walk off the brush onto the cover slip. Fifteen replicate bioassays were placed on a tray for each treatment and placed on a shelf in the growth chamber held at 25 ±1 °C, 75 ± 5% RH and a 14 h L: 10 h D photoperiod. Egg deposition and hatching of *A. swirskii* for each treatment was assessed using a binocular microscope (40X) every 24 h for two weeks and the study was repeated once.

## Statistical Analysis

Data obtained on *A. swirskii* (egg numbers, motile stages and developmental period) during the study were analyzed independently using the Statistical Analysis System (SAS Institute Inc. 2003). Data were transformed by the square-root of (X + 0.25) to stabilize error variance before analyses. The transformed data were then analyzed using one-way analysis of variance (ANOVA). Differences among the treatment means were tested using the Tukey's honestly significant difference (HSD) at $\alpha = 0.05$. The non-transformed means are presented in the table and figure.

## Results

Data from the two experiments were pooled together because there was no treatment-by-experiment interaction observed. *A. swirskii* was able to survive, develop and oviposit after feeding on either pollen or *S. dorsalis* (SD) only (Table 1). Longevity of *A. swirskii* varied between 22.7-24.2 d when fed on different treatments (SD = 21-26 d; OC = 21-25 d; RM = 21-25 d; MA = 21-25 d; BP = 20-25 d; EE = 22-26 d), however no significant differences (*F* = 2.38; df = 5, 174; *P* = 0.0603) were observed among the means of different treatments for the two replicated experiments. There were no significant differences observed in other life cycle parameters including larvae to first egg stage ~11.5-13.2 d (*F* = 1.57; df = 5, 174; *P* = 0.1707) and duration of adult stage ~12.1-13.5 d (*F* = 2.21; df = 5, 174; *P* = 0.0551) when phytoseiid mites fed on different food sources. However, the type of diet did influence reproductive potential of *A. swirskii*. A significantly higher number of *A. swirskii* eggs was recorded when mites were offered *S. dorsalis* as a food source (7-22 eggs/adult) compared to pollen treatments (*F* = 19.37; df = 5, 174; *P* <.0001), followed by RM (4-18 eggs/adult) and OC pollen (3-15 eggs/adult), respectively. The daily oviposition rate of *A. swirskii* fed on *S. dorsalis* was significantly higher than MA, EE and BP, but not from RM and OC (*F* = 3.60; df = 5, 174; *P* = 0.0040) (Figure 1).

## Discussion

Biological control is an important component of integrated pest management (IPM) for any target pest species. Combining an innundative approach along with conservational biological control can aid the long term survival of biocontrol agents and result in achieving the goal of an IPM program- economically efficient strategy; which in turn can increase the acceptability of the management strategy. According to Osborne and Barrett (2005), the establishment of biological control agents in a new environment is a critical and difficult process. Thus it is essential to develop a banker plant based management strategy which is a self contained tool that is needed to meet the growing demand of sustainable agriculture and help facilitate the establishment of biological control agents during this critical stage. The phytoseiid mite, *A. swirskii* is a generalist predator, both nymphal and adult stages are voracious feeders and well known for their biocontrol potential against whiteflies and many different thrips species in greenhouse and nursery crops (Nomikou et al. 2001; Van Houten et al. 2005; Messelink et al. 2006). However, there is limited information available about their performance in regulating *S. dorsalis* in ornamental nurseries. Results from the current study on biological and reproductive parameters of *A. swirskii* fed on pollen from different ornamental pepper varieties points to the fact that the mite species can successfully survive and establish in nurseries exclusively feeding on pollen produced by the plant. Although, *A. swirskii* was able to survive and reproduce on all the pollen treatments, the highest mean longevity, daily rate of oviposition and total number of eggs was recorded on Red Missile, suggesting that this variety must be subjected to further screening as a potential ornamental banker plant for IPM of *S. dorsalis*. Because implementation and maintenance of the banker plant is easy and economical, and phytoseiid mites are facultative feeders, *A. swirskii* can establish and provide suppression of multiple pests in ornamental nurseries.

Apart from producing pollen or nectar as a nutritional supplement, another factor which is critical for selecting the best candidate as a banker plant is the presence of tuft domatia (domatia with non-glandular trichomes in the vein axils of leaves) (O’ Dowd and Wilson 1991; Walter 1996). There are several reports indicating that the presence of tuft domatia can support the survival and establishment of beneficial mites in a number of ways, such as providing a breeding and development site, protection against adverse climatic condition, protection against natural enemies, etc. (O' Dowd and Wilson 1991; Walter 1996; Roda et al. 2000; Romero and Benson 2005). Lounghner et al. (2008, 2010) showed that the presence of tuft domatia was positively associated with an increased abundance of phytoseiid mites. Thus, presence or absence of tuft domatia on the selected plant variety can be a crucial factor governing the population increase of *A. swirskii* in the new banker plant habitat. Our future studies will focus on evaluating other parameters of a successful banker plant including presence of tuft domatia, and the preference of *A. swirskii* among the four pepper varieties studied here in the presence and absence of prey and pollen.

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## Figure caption

**Figure 1.** Daily oviposition of *Amblyseius swirskii* females fed on either Red Missile, Masquarade, Black Pearl, Explosive Ember, olive pollen or *Scirtothrips dorsalis* (25 ±1 °C, 75 ± 5% RH and a 14 h L: 10 h D). Error bars represent the standard error of the mean (Tukey's HSD, $P < 0.05$).

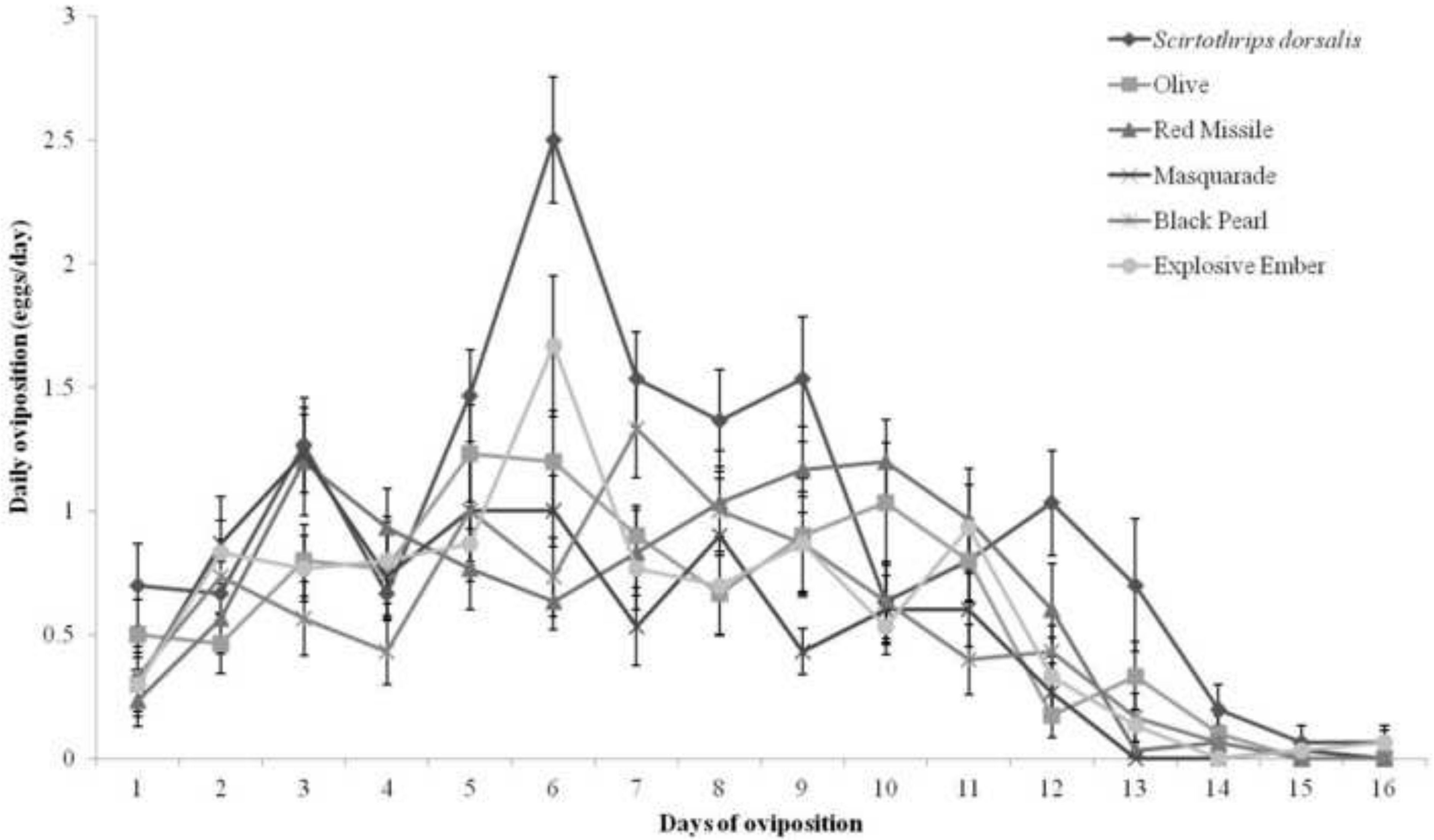
3
2.5
2
1.5
1
0.5
0
Daily oviposition (eggs/day)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Days of oviposition
*Scirtothrips dorsalis*
Olive
Red Missile
Masquarade
Black Pearl
Explosive Ember

Table 1. Biological parameters (development and reproduction) of *Amblyseius swirskii* fed on six different food sources (five pollen types; OC, RM, MA, EE, BP and thrips SD at 25 ±1 °C, 75 ± 5% RH under a 14 h L: 10 h D photoperiod)

|  | *S. dorsalis* (SD) | Olive (OC) | Red Missile (RM) | Masquarade (MA) | Explosive Ember (EE) | Black Pearl (BP) |
|---|---|---|---|---|---|---|
| Longevity (days) | 23.13 ± 0.25a | 22.96 ± 0.26a | 23.63 ± 0.21a | 23.26 ± 0.26a | 23.76 ± 0.24a | 22.83 ± 0.21a |
| Larvae to eggs (days) | 11.80 ± 0.15a | 12.53 ± 0.38a | 12.53 ± 0.18a | 12.10 ± 0.14a | 12.36 ± 0.30a | 12.56 ± 0.24a |
| Duration of adult stage (days) | 13.03 ± 0.24a | 12.46 ± 0.26a | 13.10 ± 0.21a | 12.50 ± 0.26a | 13.16 ± 0.20a | 12.43 ± 0.26a |
| Oviposition period (days) | 11.56 ± 0.33a | 9.70 ± 0.51ab | 9.53 ± 0.29ab | 8.56 ± 0.55b | 9.70 ± 0.44ab | 9.20 ± 0.48b |
| Post oviposition period (days) | 0.73 ± 0.21c | 1.20 ± 0.22bc | 2.03 ± 0.29ab | 2.96 ± 0.53a | 2.10 ± 0.29ab | 1.66 ± 0.28abc |
| Total number of eggs | 15.20 ± 0.66a | 9.86 ± 0.54b | 10.23 ± 0.56b | 8.50 ± 0.51b | 9.60 ± 0.55b | 8.70 ± 0.56b |
| Daily rate of oviposition (eggs/day) | 1.33 ± 0.06 a | 1.10 ± 0.08ab | 1.07 ± 0.04ab | 1.05 ± 05b | 1.01 ± 0.05b | 1.02 ± 0.08b |

Means within a row followed by the same letter are not significantly different (*P* ≥ 0.05, Tukey's HSD).