Differences in Seasonal Variation between Two Biotypes of Megamelus scutellaris (Hemiptera: Delphacidae), a Biological Control Agent for Eichhornia crassipes (Pontederiaceae) in Florida

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Source: Florida Entomologist, 99(3) : 569-571

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.099.0340

Differences in seasonal variation between two biotypes of *Megamelus scutellaris* (Hemiptera: Delphacidae), a biological control agent for *Eichhornia crassipes* (Pontederiaceae) in Florida

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Megamelus scutellaris (Berg) (Hemiptera: Delphacidae) is a classical biological control agent for waterhyacinth, *Eichhornia crassipes* (Mart.) Solms (Pontederiaceae), that was released and established in Florida (Tipping et al. 2014). The original host range testing was carried out on a population of *M. scutellaris* collected from Otamendi, Argentina (GPS: 34.1525°S, 58.8090°W), and this biotype (Argentine) was released in Florida in 2010 (Tipping et al. 2014). *Megamelus scutellaris* densities were consistently lower in the more sub-tropical sites in southern Florida compared with more temperate sites in the northern part of the state (unpublished data).

In 2013, a second population (Paraguay) of *M. scutellaris* was collected from the Manduvira River, in Puerto Tobati-tuya, Cordillera, Paraguay (GPS: 25.0111°S, 57.1256°W). The Paraguay biotype was tested for fidelity to waterhyacinth and released in the field. Colonies of the 2 biotypes were held separately and evaluated for differences in number of progeny, development time, and weight as a function of temperature. Elucidating any biotype differences may help guide their deployment to the most suitable environments, thereby maximizing control.

Eichhornia crassipes used during testing was grown in a greenhouse under ambient light and photoperiod at the United States Department of Agriculture, Agricultural Research Services, Invasive Plant Research Laboratory in Davie, Florida. Fertility in the greenhouse tanks (2.1 × 0.8 × 0.3 m) was supplied by adding 0.31 g/L of 15-9-12 osmocote and 0.02 g/L of 10% iron chelate and replenished every 90 d.

A single *E. crassipes* plant was placed into a 37.8 L octagonal aquarium (width: 37 cm; height: 47 cm) along with 6 L of fertilized water (as described above). Two adults of *M. scutellaris* (1 ♀, 1 ♂) were placed on the plant and removed after 1 wk. The aquarium was covered with a fine mesh screen and placed into a Percival environmental chamber (model #E36L). Temperatures were programmed to change hourly to mirror monthly averages from 2011 to 2012, which were recorded at an on-site weather station (Table 1). The number of F1 nymphs that emerged from each plant was counted every 7 d, and nymphs were left in place until they became adults, whereupon they were removed, frozen for 24 h, counted, and weighed. The experiment ended when no new F1 adults were found after 2 consecutive sample dates. All data were analyzed using R version 3.2.1 (R Core Team 2015). Data were omitted from the analysis if the parental female was not recovered alive after the 1 wk exposure to the plants. A multiple analysis of variance (MANOVA) was used to determine if adult weight, number of F1 adults produced, and adult development time were affected by season or biotype.

Biomass of F1 adults, the number of F1 adults produced, and their development time showed significant differences between biotypes ($F = 3.2717$, df = 3, $P = 0.04036$) and among seasons ($F = 4.7292$, df = 9, $P = 5.997e{-05}$). Further analysis was done by separating the data by season (winter = Dec, Jan, Feb; spring = Mar, Apr, May; summer = Jun, Jul, Aug; and fall = Sep, Oct, Nov). No results are reported for spring, as a malfunction in a set of environmental chambers reduced the number of replicates to 2, which reduced statistical power and disallowed proper inference.

No differences between biotypes were found in either winter or fall. However, there was a significant difference between the biotypes in the summer ($F = 7.2303$, df = 3, $P = 0.02036$). Post-hoc analyses for summer indicated that average weight was the only response variable to show a difference between biotypes ($F = 6.1955$, df = 1, $P = 0.03758$) (Fig. 1). In general, progeny of the Paraguay biotype weighed more than that of the Argentine biotype (1.26 mg and 0.89 mg, respectively) during the summer.

Differences among biotypes of insects used for the biological control of weeds can have important weed-control implications. Morphological differences between ecotypes of *Crytobagous salviniae* Calder and Sands (Coleoptera: Curculionidae), a biological control agent for common (*Salvinia minima* Baker) and giant salvinia (*Salvinia molesta* Mitchell) (Salviniaceae) were shown to be a factor in the effectiveness of control (Tipping et al. 2010). Hoffmann et al. (2002) investigated 2 biotypes of *Dactylopius opuntiae* (Cockerell) (Homoptera: Dactylopiidae) that feed on different species of *Opuntia* (Cactaceae), namely, *Opuntia stricta* (Haw.) and *Opuntia ficus-indica* (L.). The biotypes of *D. opuntiae* can interbreed and produced F1 offspring that can feed on either *Opuntia* species. This ability is sometimes lost in the F2 generation. Interbreeding can, therefore, produce a situation where F2 nymphs may be produced on plants on which they are unable to feed, potentially reducing the control of both *Opuntia* species.

Differences between biotypes of *M. scutellaris*, although small, could have important implications. Insect weight is usually a reliable predictor of reproductive capability (Gilbert & Raworth 1996). Significant differences in adult weight between biotypes existed, without a corresponding response in the number of F1 adults. However, we conducted this experiment across only 1 generation. Had the experi-

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Table 1. Hourly temperature averages (°C) used to program the environmental chambers. Average hourly tempera ture data are based on data pulled from a weather station in Davie, Florida, in 2011 and 2012.

Season	Winter			Spring			Summer			Fall		
Hour	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
0	20.3	16.5	19.8	18.8	21.1	23.3	25.3	25.9	26.2	25.3	23.0	21.3
1	20.3	16.1	19.4	18.4	20.9	23.0	25.1	25.7	25.8	25.1	22.9	21.2
2	20.1	15.8	19.1	18.0	20.5	22.9	24.9	25.6	25.7	24.8	22.8	21.0
3	19.9	15.4	18.9	17.7	20.3	22.8	24.7	25.4	25.5	24.8	22.7	20.6
4	19.8	15.0	18.7	17.4	20.1	22.6	24.3	25.2	25.3	24.7	22.4	20.4
5	19.7	14.7	18.4	17.2	19.7	22.4	24.0	25.1	25.2	24.5	22.4	20.3
6	19.4	14.6	18.2	17.2	19.7	23.1	24.9	25.7	25.5	24.7	22.5	20.2
7	19.5	14.6	18.3	18.6	21.4	24.9	26.7	27.5	27.2	26.5	23.3	20.9
8	20.8	17.3	20.3	21.3	23.3	26.2	28.3	29.1	29.1	28.4	24.7	22.7
9	22.2	20.0	22.1	23.3	24.8	27.3	29.6	30.1	30.2	29.7	26.0	24.1
10	23.2	21.8	23.4	24.5	25.6	28.1	30.6	31.0	31.0	30.5	26.8	25.1
11	24.1	22.9	24.2	25.5	26.3	28.6	31.1	31.4	31.4	30.6	27.3	25.6
12	24.7	23.5	24.8	25.8	26.2	28.7	31.4	31.0	31.4	30.9	27.7	26.0
13	24.8	23.9	25.1	26.1	26.4	28.4	31.0	30.7	31.0	30.7	27.6	26.2
14	24.8	23.8	25.2	26.0	26.6	28.2	30.0	30.7	30.3	30.1	27.5	26.0
15	24.6	23.5	24.8	25.7	26.8	27.8	29.6	30.5	29.5	29.5	27.2	25.7
16	23.9	22.7	24.4	25.1	26.4	26.9	28.6	30.0	28.8	28.9	26.5	25.0
17	22.8	21.5	23.5	24.4	25.5	26.2	28.0	29.5	28.7	28.1	25.7	24.0
18	21.7	20.1	22.5	23.0	24.3	25.3	27.2	28.5	28.1	27.2	24.9	23.2
19	21.1	18.9	21.9	21.9	23.3	24.6	26.4	27.5	27.2	26.7	24.4	22.7
20	20.8	18.2	21.5	21.1	22.8	24.3	26.0	27.0	26.9	26.4	24.2	22.2
22	20.3	17.7	21.2	20.4	22.5	24.0	25.7	26.6	26.7	26.1	23.9	21.9
22	20.3	17.3	20.7	19.9	22.1	23.8	25.6	26.5	26.5	25.9	23.5	21.6
23	20.3	16.9	20.2	19.5	21.5	23.6	25.4	26.2	26.2	25.6	23.2	21.3

ment been conducted on multiple generations, it may have yielded significant results between biotypes in the number of F1 progeny produced. Although speculative at this point, this phenomenon should be investigated further.

Studies should be conducted across multiple generations of these biotypes of *M. scutellaris* to determine if the difference in adult weight seen after 1 season would correspond to higher fecundity over multiple generations, resulting in longer-term, population-level effects.

We would like to thank Brittany Knowles, Eileen Pokorny, and Carlos Zapata for their help in experimental setup and data collection. Partial funding was provided by the Florida Fish and Wildlife Conservation Commission.

Summary

Two biotypes (Paraguay and Argentine) of *Megamelus scutellaris* (Berg) (Hemiptera: Delphacidae), a biological control agent for waterhyacinth, were tested for differences in number of progeny, development time, and weight across average south Florida seasonal tem-

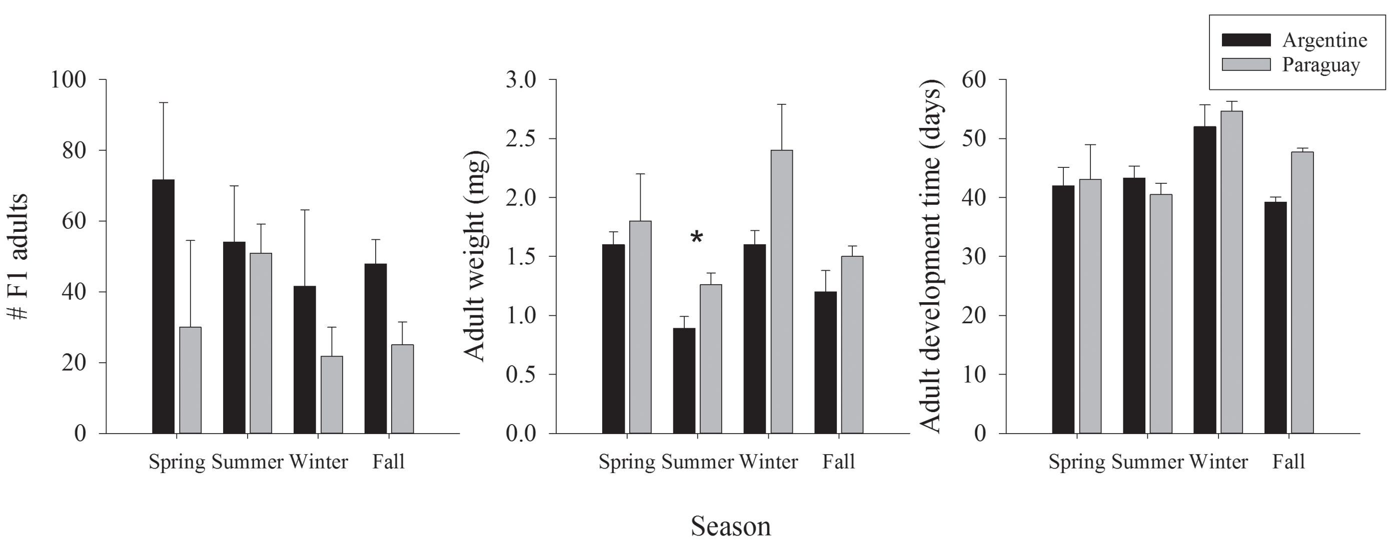

Fig. 1. Average number of F1 adults, average weight, and average development time (+ SE) across typical seasonal temperatures in Davie, Florida. An asterisk (*) indicates significance at the α = 0.05 level.

peratures. Significant differences between the biotypes were found at summer temperatures. In general, progeny of the Paraguay biotype weighed more than those of the Argentine biotype during the summer.

Key Words: waterhyacinth; classical biological control; temperature range; development time

Sumario

Se probaron dos biotipos (Paraguay y Argentina) de *Megamelus scutellaris* (Berg) (Hemiptera: Delphacidae), un agente de control biológico del jacinto de aguas para las diferencias en el número de progenie, el tiempo de desarrollo y el peso a través del promedio de temperatura estacional del sur de la Florida. Se encontraron diferencias significativas entre los biotipos durante las temperaturas del verano. En general, la progenie del biotipo Paraguay pesa más que las del biotipo Argentina durante el verano.

Palabras Clave: jacinto de agua; el control biológico clásico; rango de temperatura; tiempo de desarrollo

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