California Management Implications for Blue Orchard Bees (*Osmia Lignaria*) Adapted to Different Climates

Project No.: **07-POLL6-Cane/Pitts-Singer**

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Interpretive Summary:

This project is working in cooperation with Project 07-Poll5-Pickel. We are contrasting and comparing climatic adaptations of blue orchard bee populations from three geographical sources (California, Utah, Washington), under common California seasonal conditions, both in the laboratory (in ramping incubators set to Stockton, CA temperature records), and out in California almond orchards. To collect progeny for the study, the three populations were successfully flown in three different conventional orchards, and we have begun to monitor immature development. The larval bee progeny have completed feeding but will be continuing through critical life stage

transformations until October, so we are only mid-way in our work. UT and WA populations developed much faster than CA bees under Stockton conditions, from egg hatch to the completion of a cocoon, although egg stages lasted much longer than published values. Simulated record summer heat (Stockton in June 2007), did not kill developing bees, but further accelerated development which may diminish survival of these bees later in life. Without manipulation, UT and WA bees are at risk of late summer starvation under CA conditions because we have also found that, unlike CA bees, they seem unable to arrest their metabolism during the summer months. We currently are tracking development to the pupal and adult stages through fall and winter, when this difference should play out. In the following spring (2009), surviving bees will be incubated to simulate February emergence management for almond pollination; emerged bees will be monitored and compared for survival and longevity. This study is revealing contrasting thermal adaptations of blue orchard bees from different geographical source populations currently used in CA mass-rearing. Left at ambient CA conditions, the UT and WA bees appear at great risk during the late summer months (we will know by September), but we will have specific practical management responses that tailor bee rearing and timely cooling for their use in the CA Central Valley. Importantly, laboratory results are being correlated with observable responses of these populations living in the almond orchards under ambient conditions to assure that our interpretations are based in reality.

Objectives:

Our objectives are to evaluate climatic adaptations of blue orchard bees relevant to their mass management for early spring almond pollination in the CA Central Valley. Trap-nesting of this bee has traditionally been done in colder, more northerly regions, specifically the maritime climates of WA and continental climates of UT. These trapped bees are then sold for use in CA for almond pollination, but how and when to manage these cool-climate bees for sustaining pollinator populations is not well defined. Our experimental research documents how CA temperatures influence the timings and durations of critical bee diapause periods (arrested metabolism to save fat stores), as well as summer heat tolerances, of the offspring of bees from three populations (UT, WA and CA).

Materials and Methods:

With the assistance of collaborators in CA (Project 07-Poll6-Cane/Pitts-Singer, blue orchard bees from UT, WA, and CA were flown concurrently but in isolation in separate almond orchards in 2008 such that the UT bees were flown in Turlock, the UT bees were flown in North Butte, and the WA bees were flown in South Butte. As nests were made by nesting female bees, they were removed and shipped to Logan, UT. Nests were dissected, and the number and position of all nest cells were recorded. Nests were placed into ramping temperature incubators set to mimic the 9-year weekly averages for hourly temperatures at Stockton, CA (rather than simple high-low temperature settings of previous studies). Nests have been and continue to be monitored to determine the dates at which the following developmental stages occur: egg hatch, start of cocoon, cocoon completion, diapause, pupa, and adult. Also, after bees had spun a cocoon, a subset of each population was exposed to above-average temperatures to determine if such an event is fatal at this time. A second exposure to above-average temperatures will occur when the bees pupate. Three separate pre-wintering and overwintering regimens will be examined for their relative successes for managing cocooned adults for subsequent spring emergence and survival.

Results and Discussion:

Populations of blue orchard bees sourced from different climatic regions are found to have different, apparently heritable thermal adaptations for their developmental stages, differences that persist in a common climatic regime. Accommodating these adaptations will be critical to successful management of this bee for almond pollination. For this study, nesting of all the blue orchard bee populations placed in the CA almond orchards was wildly successful, producing many bee cells that were shipped by our collaborators to Logan, UT with little mortality despite shipping delicate eggs on their pollen provisions. Rearing of the eggs in these nest cells began immediately, and results thus far indicate that UT and WA bees develop more quickly and at similar rates through cocoon completion, whereas CA bees are weeks slower to reach this stage (Table 1). For the summer prepupal diapause stage (the period from cocoon completion to pupa), a more dramatic difference between CA bees and the other two sources is becoming evident in our current experiment. Interpreted data on timing, duration, and survival for this prepupal stage and those stages that follow will prove critical for successfully managing bees from various geographical regions. In particular, results from our respirometry trials has just revealed that, after larvae complete their feeding, native CA bees are adapted to endure the long summer months by going into a prolonged metabolic shut-down (diapause), that conserves their fat stores. This stage was brief for WA and UT bees; without intervention, we predict (and will be able to test in the coming months), that this will place them at risk for starvation before winter. We expect to be able to avert the problem by subjecting these northerly populations to an early onset of winter using a simple cooler, providing users with accurate calendar timing to perform this manipulation correctly for CA climatic conditions.

Table 1. To date, the average number of days for time periods critical to the understanding of blue orchard bee development.

Bee Source	Average Day from: Egg Hatch to Cocoon Complete		Average Day from: Cocoon Complete to Pupa*		Dates of 1st/Last Pupation for Population	
	Male (N)	**Female (N)**	**Male (N)**	**Female (N)**	**Male**	**Female**
UT	44.48 (212)	51.52 (111)	11.27 (162)	11.73 (102)	May 23, Jun 10	May 27, Jun 10
WA	46.42 (400)	50.53 (353)	13.15 (397)	12.82 (344)	May 23, Jun 6	May 27, Jun 6
CA	52.88 (225)	56.12 (206)	incomplete	incomplete	incomplete	incomplete

* many CA bees have not yet achieved pupal stage as of mid-June

Recent Publications:

None to date.