N O T E

Predicting Emergence in a Midwestern Population of *Cotinis nitida* (Coleoptera: Scarabaeidae): An Update[1]

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The green June beetle, *Cotinis nitida* (L.), is an important pest of grapes, peaches, blackberries, blueberries, apples, and pears that is native to North America (Johnson et al. 2009, pp. 599–629 *in* Peshin and Dhawan (eds.), Integrated Pest Management: Innovation-Development Process, Springer Science + Business Media). Females of this species oviposit into the soil in the summer of the year preceding the emergence of the adults. The grubs overwinter in the soil and pupate in April to May the next year. In June and July, the adults emerge, dig out to the surface, mate and lay eggs in soil, and begin feeding on ripening or overripe fruit from late June to mid-August (Pontasch and Knutson 2010, Texas A&M System E-Publ. EEE 000044).

Three strategies to minimize damage caused by adults attacking ripe fruit have been proposed: (a) sprays with insecticides with a short preharvest interval (Flanders and Cobbs 2000, Alabama Coop. Ext. Serv. ANR-991; Pontasch and Knutson 2010); (b) timely harvesting of ripe fruit and removal of rotting fruit, which attracts green June beetle adults (Pontasch and Knutson 2010); and (c) using floating row covers or exclusion nets for physical separation of the crop from the beetles (Strang et al. 1992, Hort. Sci. 27: 1169; Lesoing 2011, Univ. Nebraska Coop. Ext., https://extension.unl.edu/statewide/nemaha/Green%20June%20Bugs.pdf). Both the sprays and the cultural control measures require a priori planning and proper timing of operations.

To that end, the number of cumulative degree days (CDDs) that this species requires for outbreak have recently been delineated in preliminary research by Creed at al. (2016, J. Kans. Entomol. Soc. 89: 45–52). In their study, green June beetle populations in Mountain Grove, MO, were monitored for five consecutive years (2009–2013) using traps baited with isopropanol. They showed that a CDD

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calculation with a starting point of 01 March, a single sine method of calculation, and 10°C as the base temperature were useful for forecasting green June beetle population dynamics. The 5-yr mean ± standard error (SE) was 888.96 ± 36.78 CDDs for the first trap catch and 1,237.68 ± 25.31 CDDs for the peak trap catch. To verify the validity of our CDD calculations for 2009–2013, we extended the period of green June beetle monitoring by 7 consecutive years (2014–2020) in the same location, using the same methods as in Creed et al. (2016).

Briefly, traps were made from transparent polyethylene terephthalate 710-ml beverage bottles. The bottom 7 cm of the bottle was cut off, and the bottle was placed bottom up and hung on a harness made of nylon twine. A 125-ml plastic bottle dispenser equipped with an 8-mm-diameter cotton wick was filled with 100 ml of 45.5% isopropanol in water and hung on the harness inside the trap so the lure could be detected and green June beetles could enter the trap. A total of 200 ml of 0.02% Triton X-100 (Sigma-Aldrich Corp., St. Louis, MO) was poured into each bottle to serve as a drowning agent. The remaining details of the trap design are described in Cowell et al. (2012, J. Econ. Entomol. 105: 2076–2084).

Traps were set in a research peach orchard on the experimental farm at the Missouri State University Research Campus in Mountain Grove, MO (N 37°9′11.18″, W 92°16′4.30″). The 1.2-ha orchard was planted with Red Haven peach (*Prunus persica* [L.] Batsch) (Rosaceae).

The traps were washed with water, rinsed with isopropanol, air dried, baited with isopropanol dispensers, and hung on tree branches at heights ranging from 130 to 160 cm above the ground. Seven traps were randomly placed in the plot. After 1 week, the traps were replaced, and green June beetles were removed from each trap and stored for later identification using the key to the subgenera and species of *Cotinis* by Goodrich (1966, Ann. Entomol. Soc. Am. 59: 550–568). The number of *C. nitida* was recorded for each trap. This procedure was repeated every 7 d between 1 May and 1 September from 2014 to 2020.

Weather data (maximum and minimum temperatures) were obtained from a computerized weather station, MMOA15, located approximately 100 m from the peach orchard where the traps were installed. Degree days were accumulated beginning from 1 March (Creed et al. 2016) to first trap catch and to peak trap catch of green June beetles using the Univ. of California Davis CDD calculator (Anonymous 2013, Agric. Nat. Res., Univ. California. http://www.ipm.ucdavis.edu/WEATHER) using the single sine method and 10°C as the base temperature. No upper developmental threshold was used. CDDs were averaged across the 7 yr of trapping records for the first trap catch and for the peak of population density, separately.

An unpaired Student's *t* test ($\alpha = 0.05$) was used for comparison of means. Calculations were made using GraphPad InStat (GraphPad Software Inc., San Diego, CA).

The mean (± SE) number of CDDs at the first flight calculated for 2009–2013 equaled 888.96 ± 36.78, and that recorded for 2014–2020 reached 867.17 ± 11.23 (Table 1). No significant differences were found ($t = 0.6543$, df = 10, $P = 0.5277$). Similarly, there were no differences between mean numbers of CDDs at the peak of green June beetle population density. From 2009 to 2013 the number of CDDs equaled 1,237.68 ± 25.31, whereas in 2014–2020 it reached 1,259.17 ± 36.68. Again, no significant differences were found ($t = 0.4408$, df = 10, $P = 0.6687$). CDDs

Table 1. Dates and cumulative degree days (CDDs) for the first flight and the peak density in Midwestern population of green June beetle, *Cotinis nitida*, 2014–2020, Mountain Grove, MO.*

Year	First Flight Date	First Flight CDD	Peak Date	Peak CDD
Mean 2009–2013**		888.96 ± 36.78 a		1,237.68 ± 25.31 a
2014	01 July	834.9	02 Aug	1,211.2
2015	19 July	908.0	08 Aug	1,447.6
2016	07 July	898.6	22 July	1,217.2
2017	01 July	828.5	01 Aug	1,295.7
2018	28 June	858.4	25 July	1,278.4
2019	07 July	870.9	02 Aug	1,222.9
2020	07 July	870.9	27 July	1,141.2
Mean 2014–2020		867.17 ± 11.23 a		1,259.17 ± 36.68 a

* Columnar mean ± SE values followed by the same letter are not significantly different (Student's *t* test, $P > 0.05$).
** From Creed at al. (2016, J. Kansas Entomol. Soc. 89: 45–52).

averaged across all 12 yr of the monitoring period (2009–2020) equaled 876.25 ± 15.99 for first catch and 1,250.22 ± 23.14 for the peak.

Our findings presented herein validate the method of predicting green June beetle outbreaks proposed by Creed et al. (2016). We postulate that, in spite of its limitations, this method (in combination with weather forecast data available on the worldwide web for many locations) can serve as a useful tool for growers in the midwestern United States by providing an estimate of green June beetle emergence and helping in deciding and planning appropriate management practices. In the future, we intend to develop more sophisticated day-degree modelling to predict green June beetle population dynamics.