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SCIENTIFIC NOTE

Flight Periodicity of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins (Coleoptera: Curculionidae: Scolytinae) in Colorado, U.S.A.

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There are about 500 species of bark beetles (Coleoptera: Curculionidae: Scolytinae) in the United States (Wood 1982). A number of them are important disturbance agents in forested ecosystems, occasionally creating large tracts of dead trees. One eruptive species is the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins, which utilizes Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, as its primary host throughout most of the tree's range. The Douglas-fir beetle is univoltine with brood adults and larvae overwintering (Schmitz and Gibson 1996). The insect prefers to attack large diameter trees in high density stands often exhibiting reduced growth (Furniss *et al.* 1981; Negrón 1998; Negrón *et al.* 1999).

Various authors indicate that emergence from trees is influenced by location and weather, yet state that the majority of attacks occur from April to June, made by overwintered adults. They further state that overwintered larvae completing development and early attacking, re-emerging adults comprise a second emergence and attack period in July and August into September (Furniss and Carolin 1977; Wood 1982; Schmitz and Gibson 1996). However, specific empirical data supporting this information are lacking, suggesting that it is based mostly on observation and anecdotal information.

Apparently the first empirical data on Douglas-fir beetle flight come from a study in Oregon by Ross and Daterman (1997). Flight had already started when they began monitoring, so flight initiation could not be determined, but they present data showing peak trap catches in June and again in August, consistent with previous flight pattern descriptions. Lessard and Schmid (1990) published the only Douglas-fir beetle emergence study on the Colorado Front Range, which was conducted during rising beetle populations that followed an outbreak of western spruce budworm, *Choristoneura occidentalis* Freeman (Lepidoptera: Tortricidae). They attached emergence cages to the boles of Douglas-fir beetle-attacked trees and monitored emergence at three locations in 1986 and four in 1987. Beetle emergence began as early as mid-April, peaked between 10 and 16 June, and was infrequent after 1 July. They reported no second emergence period.

During 1993–1995, a rare outbreak of the Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough) (Lepidoptera: Lymantriidae), occurred in the South Platte Ranger District of the Pike National Forest (USDA Forest Service 2001) on the Colorado Front Range. Following the tussock moth outbreak, Douglas-fir beetle populations increased in defoliated trees and developed into an outbreak that lasted about four years. To evaluate the flight period of Douglas-fir beetle, we used Lindgren funnel traps (Lindgren 1983) with 12 funnels. Each trap contained a commercial formulation of a 3-component Douglas-fir beetle attractant comprised of frontalin, seudenol, and 1-methylcylcohex-2-en-1-ol

(Phero Tech Inc., Delta, BC, Canada [now Contech Enterprises Inc., Victoria, BC, Canada]). Four traps were deployed at each of three locations—Buffalo Creek, Sugar Creek, and West Creek—within 24 km of one another. Trap spacing within each location ranged from 0.3 to 1.1 km. Traps were deployed 7 April in 1997, 18–21 April in 1998, and 27–28 April in 1999 and removed from the field 30 October in 1997, 22 September in 1998, and 1 November in 1999. Traps were serviced about once per week and beetles were collected, brought to the laboratory, and kept frozen until sample processing. Douglas-fir beetle catches were often too numerous and therefore impractical to count, so linear regression models were used to estimate the number of beetles based on dry weight, when needed. For each year, samples comprising from 50 to 2,000 beetles were randomly drawn, counted, oven-dried, and weighed to develop the relationship (n = 19, 15, and 7 for 1997, 1998, and 1999, respectively). Prior to weighing, samples were dried on glass Petri dishes at 35° C for 96 hours and cooled in a desiccator jar. Regression models were estimated for each year as host and environmental factors may affect beetle size and weight in a given year. Regression models were significant for each year. For 1997, F = 1,537, $P < 0.0001$, $r^2 = 0.99$; for 1998, F = 6,512, $P < 0.0001$, $r^2 = 0.99$; and for 1999, F = 228.4, $P < 0.0001$, $r^2 = 0.98$. The 95% confidence interval for intercepts always included 0, indicating that when dry weight = 0, the number of beetles = 0.

Beetles were caught in pheromone traps beginning 23 May at Buffalo Creek and West Creek and 30 May at Sugar Creek in 1997, 20 May at all locations in 1998, and 26 May in Buffalo Creek and 1 June in Sugar Creek and West Creek in 1999. Across all trapping sites beetle catches peaked on June 26, June 25, and June 22 in 1997, 1998, and 1999, respectively (Fig. 1). Every year we observed reduced catches into early September when trapping

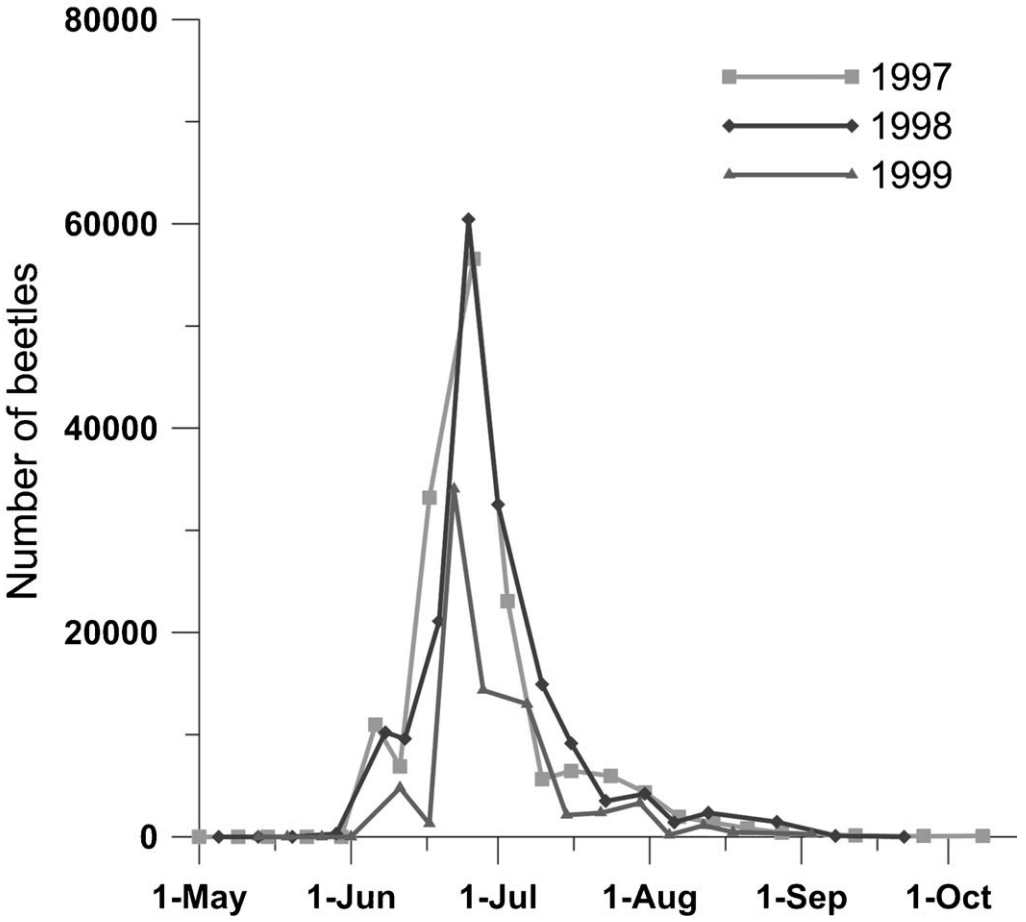

Fig. 1. Number of Douglas-fir beetles in pheromone-baited 12-funnel traps per collection date for 1997, 1998, and 1999, Pike National Forest, Colorado. Actual collection dates varied each year.

was terminated. We did not observe a second peak in trap catch, consistent with the emergence data from Lessard and Schmid (1990). Dates for their emergence peaks closely match our trap catch peaks.

The data presented in this study represent the only flight periodicity data available for Colorado. Douglas-fir beetle seasonal activity in Colorado appears to differ from that reported by Ross and Daterman (1997) from the Northwest. Furniss and Carolin (1977), Schmitz and Gibson (1996), and Wood (1982) provide no locations for their descriptions of seasonal activity. In Colorado, seasonal activity begins with flight in the latter half of May, peaks steeply in mid-June, and attenuates with high catches into early July, subsiding and continuing into September. No second flight peak was observed, implying that no second emergence period took place.

Climate change is already influencing population dynamics and outbreaks of bark beetles and this trend is expected to continue (Bale *et al.* 2002; Bentz *et al.* 2010). Baseline data on insect activity periods will be increasingly important as weather strongly influences insect and host dynamics. It is of relevance to conduct additional seasonal activity studies with Douglas-fir beetle and other bark beetles and to examine processes underpinning differences from one location to another.

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