N O T E

Rain Influences Trap Catch of Adult Parasitoids of the Southern Pine Beetle, *Dendroctonus frontalis* Zimmermann[1]

Sherah L. VanLaerhoven[2] and Fred M. Stephen

Department of Entomology, University of Arkansas, Fayetteville, AR 72701 USA

J. Entomol. Sci. 38(1):143-146 (January 2003)

Key Words Bark beetle parasitoids, biological control, weather, relative humidity, rainfall, trap catch, *Dendroctonus frontalis, Coeloides pissodis, Dinotiscus dendroctoni, Heydenia unica, Roptrocerus xylophagorum, Spathius pallidus, Dendrosoter sulcatus*

There is a rich natural enemy complex of 6 to 9 species of parasitoids associated with the southern pine beetle. *Dendroctonus frontalis* Zimmermann, which can potentially reduce both the size and number of beetle infestations (Berisford, 1980, USDA For. Serv. Sci. Educ. Admin. Tech. Bull. No. 1631; Dahlsten and Whitmore, 1989, Potential for Biological Control of *Dendroctonus* and *Ips* Bark Beetles. Stephen F. Austin State U., Nacogdoches, TX; Stephen et al, 1993, Beetle-pathogen interactions in conifer forests. Academic Press, London, UK; Stephen, 1995, Behavior, population dynamics and control of forest insects. Ohio Agri. Res. Dev. Center, Ohio State U., Wooster, OH; Stephen et al, 1997, Proceedings, Integrating cultural tactics into the management of bark beetle and reforestation Pests: Vallombrosa, Italy, Sept 1-3, 1996. USDA For. Serv. NE For. Exp. Stn. Radnor, PA). Within large *D. frontalis* infestations there is an abundance of bark beetle hosts and parasitoid adults do not need to disperse far to locate hosts. However, the majority of *D. frontalis* infestations consist of fewer than 10 trees and usually decline (Billings, 1980, USDA For. Serv. Sci. Educ. Admin. Tech. Bull. 1631). In these small infestations, beetle hosts may not be available to emerging parasitoids, and the ability of parasitoid adults to disperse and find the patchy host resources of another *D. frontalis* infestation becomes critical for parasitoid survival.

Adult parasitoids in southern forests may be subject to temperature fluctuations of 13°C or more, and fluctuations in relative humidity between 40 and 100% in a single day (Mathews and Stephen, 1999, Environ. Entomol. 28:729-734). While high relative humidity has been associated with increased activity of some adult parasitoids of *D. frontalis,* the activity of other species was not influenced (Dix, 1974, Ph.D. Diss., U. of

[1]Received 10 September 2001; accepted for publication 05 July 2002.

[2]Current address: Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada, PO Box 1000, Agassiz, B. C. Canada V0M 1A0 and to whom offprint requests are to be addressed (email: vanlaerhovens @agr.gc.ca).

Georgia, Athens, GA; Dix and Franklin, 1978, J. Georgia Entomol. Soc. 13:71-80). The relationship between rainfall and activity has not been studied for these parasitoids. The impact of rainfall on activity of these parasitoids may affect area-wide population dynamics of *D. frontalis.*

The study was conducted in July 1998, within two active *D. frontalis* infestations of approximately 50 infested *Pinus taeda* L. within the Oakmulgee Ranger District of the Talladega National Forest in Alabama. In site 1, the study period was 12 to 25 July and in site 2, the study period was 16 to 29 July. From each infestation, nine pines containing *D. frontalis* brood between the third instar and emerging adults were selected to control for the effect of brood stage on parasitoid trapping. Stickem Special® (SeaBright Labs, Emeryville, CA) coated 15 × 20 cm wire mesh (6 mm^2) traps were attached to the trees (4 to 8 traps per tree). The traps were changed on alternate days for 14 d. All adult *D. frontalis* parasitoids on the traps were identified using a binocular microscope and counted. The weather was visually observed and qualitatively recorded daily from within each infestation. Trap counts were analyzed by analysis of variance and Tukey-Kramer HSD mean separations within JMP IN version 3.2.1 (SAS, 1997, JMP IN. SAS Institute Inc, Cary, NC).

The presence of rainfall over a single trapping period significantly increased trap catch of *D. frontalis* parasitoids ($F = 8.4$; df = 3,808; $P < 0.0001$) (Table 1). A total of 4353 parasitoids were trapped from the two sites over 14 d. Six *D. frontalis* parasitoid species were trapped from both sites (Table 2), and rain affected trap catch of each species differently. Between the three *D. frontalis* parasitoid species in the family Braconidae, only the trap catch of *Coeloides pissodis* (Ashmead) was influenced by presence of rain. When it rained both days or was sunny both days of the trapping period, trap catch of *C. pissodis* was lower by half compared to periods with a mix of rain and sun ($F = 13.1$; df = 3,808; $P < 0.0001$). A total of 603 *C. pissodis* were trapped over the entire study.

The trap catch of all three *D. frontalis* parasitoid species in the family Pteromalidae was influenced by rain (Table 2). The trap catch of *Dinotiscus dendroctoni* (Ashmead) was higher when it rained one or both days during the trapping period, compared to sunny trap periods ($F = 7.5$; df = 3,808; $P < 0.0001$). *Heydenia unica* Cook and Davis and *Roptrocerus xylophagorum* Ratzeburg both had highest trap catches with rain on the first trap day and sun the second day of the trapping period, and lowest on sunny days (*H. unica*: $F = 2.6$; df = 3,808; $P = 0.05$; *R. xylophagorum*: $F = 4.3$; df = 3,808; $P = 0.005$). The trap catch of *R. xylophagorum* was twice as high on rainy compared

Table 1. Effect of rain on the overall mean trap catch of adult *D. frontalis* parasitoids

Weather*	Mean (±SE)**	# of traps
Rain	5.7 ± 0.5 **a**	173
Rain-Sun	8.0 ± 0.9 **b**	116
Sun-Rain	6.1 ± 0.6 **ab**	116
Sunny	4.3 ± 0.3 **a**	407
Total parasitoid catch = 4353		

* Rain = rain both trap days, Rain-Sun = rain on first trap day, sun on second, Sun-Rain = sun on first trap day, rain on second, Sun = no rain on either trap day.

** Means followed by the same letter are not significantly different (P > 0.05).

Table 2. Effect of rain on the mean trap catch of individual adult *D. frontalis* parasitoid species

Family & Species	Weather*	Mean (±SE)**		# of traps
Braconidae				
Coeloides pissodis			$F = 13.1$; df = 3,808; $P < 0.0001$	
(Ashmead)	Rain	0.6 ± 0.1	**a**	173
	Rain-Sun	1.1 ± 0.2	**b**	116
	Sun-Rain	1.3 ± 0.2	**b**	116
	Sun	0.6 ± 0.1	**a**	407
Total parasitoid catch = 603				
Dendrosoter sulcatus			$F = 2.1$; df = 3,808, $P = 0.09$	
Muesebeck	Rain	0.2 ± 0.03	**a**	173
	Rain-Sun	0.2 ± 0.04	**a**	116
	Sun-Rain	0.3 ± 0.04	**a**	116
	Sun	0.1 ± 0.03	**a**	407
Total parasitoid catch = 164				
Spathius pallidus Ashmead			$F = 1.6$; df = 3,808; $P = 0.2$	
	Rain	0.2 ± 0.03	**a**	173
	Rain-Sun	0.3 ± 0.1	**a**	116
	Sun-Rain	0.2 ± 0.1	**a**	116
	Sun	0.2 ± 0.03	**a**	407
Total parasitoid catch = 141				
Pteromalidae				
Dinotiscus dendroctoni			$F = 7.5$ df = 3,808; $P < 0.0001$	
(Ashmead)	Rain	0.5 ± 0.1	**b**	173
	Rain-Sun	0.5 ± 0.1	**ab**	116
	Sun-Rain	0.5 ± 0.1	**b**	116
	Sun	0.3 ± 0.03	**a**	407
Total parasitoid catch = 318				
Heydenia unica Cook and			$F = 2.6$; df = 3,808; $P = 0.05$	
Davis	Rain	1.9 ± 0.2	**ab**	173
	Rain-Sun	2.4 ± 0.2	**b**	116
	Sun-Rain	1.9 ± 0.3	**ab**	116
	Sun	1.6 ± 0.1	**a**	407
Total parasitoid catch = 1480				
Roptrocerus xylophagorum			$F = 4.3$; df = 3,808; $P = 0.005$	
Ratzeburg	Rain	2.3 ± 0.4	**ab**	173
	Rain-Sun	3.5 ± 0.7	**b**	116
	Sun-Rain	1.8 ± 0.3	**ab**	116
	Sun	1.6 ± 0.2	**a**	407
Total parasitoid catch = 1647				

* Rain = measurable rain both trap days, Rain-Sun = rain on first trap day, sun on second, Sun-Rain = sun on first trap day, rain on second, Sun = no rain on either trap day.

** Within species means followed by the same letter are not significantly different ($P > 0.05$).

with sunny trap periods. A total of 1647 *R. xylophagorum,* 1480 *H. unica* and 318 *D. dendroctoni* were trapped during the entire study.

Because longevity of *D. frontalis* parasitoids is greater at high relative humidities, as was shown with *C. pissodis* (Mathews and Stephen 1999), activity of these parasitoids should decrease on days when it is sunny as a means of reducing mortality due to dessication. While overall trap catch of *D. frontalis* parasitoids increased in the presence of rainfall, each species responded differently. *Coeloides pissodis* has been shown to be most active on pine boles during periods of high relative humidity (Dix 1974), consistent with our data for *C. pissodis* on days of mixed rain and sun. Although *Dendrosoter sulcatus* Muesebeck and *Spathius pallidus* Ashmead were most active on pine boles during periods of high relative humidity (Dix 1974), this is inconsistent with data presented here, although small trap catches of the species could be insufficient to demonstrate an effect. While *D. dendroctoni* was most active on pine boles during periods of low relative humidity (Dix and Franklin 1978), this is in direct contrast with our results. *Roptrocerus xylophagorum* activity was greatest during periods of rainfall, also not consistent with that of Dix (1974) which demonstrated no effect of humidity on the activity of this parasitoid. Our results for *H. unica* were consistent with Dix (1974).

The potential reasons for increased activity of *D. frontalis* parasitoids associated with rainfall may be due to increased humidity, cloud cover, barometric pressure, backlog of activity during periods of rain followed by high activity immediately after rainfall, or mortality associated with dessication. By being active during periods of rain, it is possible that parasitoid adults avoid dessication that may be associated with high temperature and low relative humidity. High relative humidity has been associated with increased longevity of parasitoids (Kfir, 1981, Ann. Appl. Biol. 99: 225-230; Herard et al, 1988, J. Entomol. Sci. 23: 105-111; Croft and Copland, 1994, Biocontrol Sci. Tech. 4: 347-351; Edwards and Hoy, 1998, Ann. Entomol. Soc. Am. 91: 654-660; Mathews and Stephen 1999). However, not all *D. frontalis* parasitoids were more active when it rained. Perhaps rain causes some parasitoid mortality through physical battery or by an increase in fungal pathogens as has been shown in other host-parasitoid systems (Seamans, 1923, Can. Entomol. 55: 51-53; Sekhar, 1960, Can. J. Zool. 43: 593-603; Fink and Voelkl, 1995, Oecologia 103: 371-378; Weisser et al, 1997, J. Anim. Ecol. 66: 386-400). Further research on the effect of rainfall and relative humidity on the longevity and rates of parasitism of the individual *D. frontalis* parasitoid species may explain the differences in response of the species observed in this study.

We thank T. J. Kring, M. V. Meisch, L. C. Thompson and K. G. Smith for support and guidance, M. P. Lih, G. W. Wallis, N. Wallis, Z. Brown, K. J. Dodds and C. Graber for technical assistance, L. Poirier for her editorial comments, the Talladega National Forest staff for their kind cooperation, the Department of Entomology (University of Arkansas) and the John Heiss family for their generous fellowships. This research was supported in part by the University of Arkansas, Arkansas Agricultural Experiment Station, and the Arkansas Forest Resources Center, Monticello, AR. Published with the approval of the Director, Arkansas Agricultural Experiment Station.