COTTONWOOD FIBER FARM PEST MANAGEMENT: COTTONWOOD LEAF BEETLE

T. Evan Nebeker, Michael D. Warriner, and Elwood R. Hart[1]

Abstract—Defoliation by the cottonwood leaf beetle, CLB, (*Chrysomela scripta* F.) can pose a significant threat to the growth and development of one and two-year old Populus plantings. In the southeastern United States, guidelines for monitoring CLB populations at the landscape level have not been fully developed. Accurate determination of when CLB are present in the field could greatly aid in the efficient management of this pest. To address this situation, we compiled data regarding the developmental rate of the CLB to test predictive models of CLB development. Based upon comparisons with field observations, current temperature-dependent growth models hold promise for predicting the occurrence of first generation adult CLB in the field. Prediction of the appearance of specific CLB life stages, especially in subsequent generations, may be somewhat more difficult and requires more examination.

INTRODUCTION

The cottonwood leaf beetle, CLB, (*Chrysomela scripta* F.) is one of the most important economic pests of *Populus* in the United States (Burkot and Benjamin 1979; Drooz 1985). The CLB is a defoliator, with larval and adult stages feeding on the young leaves and shoots of *Populus* clones (Harrell and others 1982). The defoliation that results from CLB feeding activity poses the most threat to one and two-year old plantings, potentially hampering growth and the accumulation of biomass (Calbeck and others 1987; Fang and Hart 2000; Reichenbacker and others 1996). Accurate determination of when CLB are present in the field could greatly aid in the efficient management of this defoliator.

Cottonwood leaf beetles overwinter as adults in leaf litter and under bark, emerging as temperatures rise in the spring (Head 1972). Shortly after emerging, adults mate and females begin to oviposit on the leaves of *Populus* and other suitable hosts. As for most insects, emergence and development of these offspring from egg to adult is closely tied to temperature. To correctly predict emergence dates or developmental time as a function of temperature, the time scale should be represented as physiological time. This physiological time scale is a combination of calendar time and temperature (Mizell and Nebeker 1978). Theoretically, the rate at which heat is accumulated during the spring will determine when specific life stages are expected to be present. Prediction of when CLB adults are apt to first appear in the field would be of benefit to growers in implementing various management tactics.

Insects are known to require a certain amount of heat to develop from one stage to the next (Gilbert and Raworth 1996). This heat requirement is constant and therefore can be used to predict the occurrence of life stages (larvae, pupae, adults) in the field. Temperature-dependent growth models are predictive tools constructed from developmental studies conducted on specific insect species at a series of constant temperatures. A number of such models have been constructed for a variety of insect pests (Davis and others 1996; Fatzinger and Dixon 1996; Pitcairn and others 1992; Raffa and others 1992).

These predictive models of insect development are based upon estimates of heat required by a particular insect species to develop from one stage of its life cycle to the next. For most insects, development generally only occurs within a species-specific, physiologically set range of temperatures. Temperatures above and below this range represent upper and lower developmental thresholds and constitute temperatures at which development slows or ceases. Between these thresholds, the total amount of heat required by an insect to develop from one stage to the next is expressed in degree-days (DD). Degree-days represent the accumulation of temperature over time and are typically calculated above the lower developmental threshold. With knowledge of how many DD are required for the completion of a particular life stage, predictions can be made as to when that stage would be expected to be present in the field.

At present, there is no generally accepted method of determining when CLB adults will first appear in the field. Nor have models been validated to predict when subsequent life stages and generations will be present in the field. The objectives of this study were 1) to compile existing information regarding estimated developmental thresholds and DD requirements for the CLB and 2) to determine the validity of these estimates in the field as predictors of CLB presence and activity.

[1]Professor and Research Associate II, Department of Entomology and Plant Pathology, Mississippi State University, Mississippi State, MS 39762-9775; Professor, Department of Entomology, Iowa State University, Ames, IA 50011-3222, respectively.

Citation for proceedings: Outcalt, Kenneth W., ed. 2002. Proceedings of the eleventh biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–48. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 622 p.

Table 1— Lower developmental thresholds and degree-day estimates for the cottonwood leaf beetle (*Chrysomela scripta*) compiled from various sources

Source	Lower developmental threshold	Degree-day estimate (egg – adult)
Burkot and Benjamin (1979)- Wisconsin	10.8 °C	257 ± 26.0
Jarrard and others (Unpubl.)- Iowa	8.6 °C	282 ± 16.9
Pope and Nebeker (Unpubl.)- Mississippi	11.8 °C	281 ± 12.2

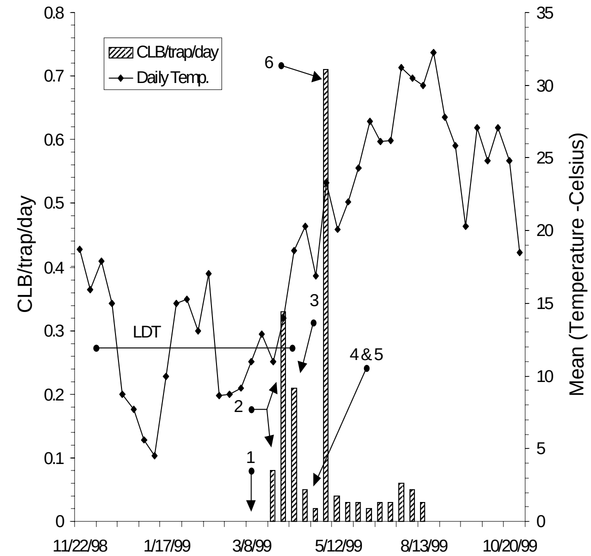

Figure 1—Number of cottonwood leaf beetle adults trapped in relation to average daily temperature: 1) overwintering adults active and present, 2) copulating adults and egg masses present (3/25/99 - 0 DD), 3) CLB larvae present in large numbers, 4) most larvae in pupation at this time, 5) pupal stage continues, and 6) first generation adults eclose in large numbers (4/29/99 - egg to eclosion 280 DD).

METHODS

Information regarding the developmental rate of the CLB was obtained from three independently conducted studies (table 1). All three studies examined the effects of a series of constant temperatures on the developmental rate of laboratory-reared CLB. Each study yielded slightly different lower developmental thresholds (LDT) and DD estimates for total preimaginal development. Two of the studies also determined DD requirements for completion of specific CLB life stages (table 2).

Study Site and Insect Sampling

Evaluation of the validity of these DD estimates in the field was conducted during 1999 at a three-year old cottonwood plantation within the Fitler Managed Forest (Crown Vantage) in west central Mississippi (Issaquena County). Cottonwood leaf beetles were monitored using modified boll weevil traps and visual observations. Basic trap layout consisted of eight trap lines spaced approximately 150 meters apart. Each trap line consisted of five traps along with one control point. Each trap was attached to the top of a 3 meter PVC pole. The control point consisted of a PVC pole without a trap. A control point was added to determine if the presence of a trap resulted in increased CLB damage to surrounding trees. Trap lines were installed 25 meters into the plantation and placed between rows of trees. The traps and control point for each trap line were randomly placed 10 meters apart within a line extending into the plantation. Trap lines at both sites were established on March 5, 1999. Traps were checked for adult CLB and trees along each transect were examined for CLB life stages on a weekly basis. Trap catches at all sites were standardized to number of CLB/trap/day. Monitoring for the CLB ceased by early November 1999.

Table 2— Comparison of degree-day estimates for specific cottonwood leaf beetle (*Chrysomela scripta*) life stages

	Degree-day estimate		
Stage	Fitler, MS	Pope and Nebeker	Jarrard and others
Egg	101	74	62
Larvae	79	127	174
Pupae	100	80	46

Calculation of Degree-days

Accumulation of DD for this CLB population began with first observation of CLB egg masses on the trees (0 degree-days). Daily maximum and minimum temperatures for this site were obtained from the National Climatic Data Center. The closest reporting station to Fitler was in Vicksburg, MS (Warren County) approximately 48 kilometers away. Daily temperatures and DD were calculated in Celsius. We used the LDT of 11.8ºC developed by Pope and Nebeker (unpubl.) to calculate DD for this CLB population. This estimate was appropriate for our validation efforts as Pope and Nebeker (unpubl.) collected CLB from this location to establish their colony at Mississippi State University. The following formula was used to calculate DD:

$$DD = [(m^1 + m^2)/2] - t$$

Where DD represents the degree-days accumulated over a 24 hour period, m^1 the maximum temperature over the 24 hour period, m^2 is the minimum temperature for that 24 hour period above the LDT, and t the LDT for the species in question (Pedigo and Zeiss 1996).

RESULTS AND DISCUSSION

Over the spring and summer of 1999 we observed the emergence of overwintered adults, copulation, oviposition of eggs, larval feeding, pupation, and eclosion of first generation adults. Figure 1 depicts trap catches of CLB adults in relation to average daily temperature. It is evident from this graph that no adult CLB were trapped until average daily temperatures rose above the LDT of 11.8ºC.

Adults emerging from their overwintering sites were first trapped March 18, 1999 after an accumulation of 136 DD with DD accumulation beginning Dec. 1, 1998. Numbers of adult CLB trapped increased a few weeks later (March 25, 1999). This increase roughly coincided with observations of large numbers of copulating pairs and ovipositing females. Numbers of adult CLB trapped and observed on trees declined after that date. As overwintering adults passed away and trap numbers declined, first generation offspring passed through their various life stages. Numbers of adults trapped reached their highest level on April 29, 1999 coinciding with the eclosion of first generation adults.

Twenty-six DD were calculated (figure 1) from a start date of March 25, 1999 as that date marked the first observation of large numbers of CLB egg masses. Accumulation of DD ceased on April 29, 1999 coinciding with eclosion of first generation adults. Based on our observations, this CLB population required approximately 280 DD to complete development (egg – adult). From eggs to larvae 101 DD, from larvae to pupae 79 DD and from pupae to new adults 100 DD (figure 1).

Degree-days required to complete each life stage (egg, larvae, pupae, adult) were also calculated and compared to those of Pope and Nebeker (unpubl.) and Jarrard and others (unpubl.). Whereas total number of estimated DD required for complete development are similar, there is somewhat more variation among the various life stages (table 2).

Our field estimate for complete CLB development corresponds almost perfectly with the predicted estimates of Pope and Nebeker (unpubl.) and Jarrard and others (unpubl.). Both estimates, 281 DD and 282 DD, respectively, occurring just one calendar day past ours. The minimum predicted estimate derived by Burkot and Benjamin (1979) of 257 DD was reached two calendar days prior to our field estimate. The estimate of 280 DD we obtained best coincides with an observed peak in first generation eclosion. Since our observations were only conducted weekly it is very likely that first generation CLB were eclosing prior to 280 DD. Although promising, additional efforts need to be put toward validating these models in the field before reliable predictions can be made.

SUMMARY

Based on this limited data, current temperature-dependent growth models hold promise for predicting the occurrence of first generation adult CLB in the field. However, predicting the appearance of specific life stages may be more difficult as evidenced by the variability in degree-day requirements we observed among our own, and others, estimates.

ACKNOWLEDGMENTS

We appreciate the assistance of Jeff Portwood of Crown Vantage and Billy VanDevener of Van Development Corporation for allowing us access to the plantation and encouraging the work on the cottonwood leaf beetle. We also acknowledge the monetary support and guidance of International Paper and Westvaco through Scott Cameron and Randy Rousseau respectively to the *Populus* Pest Management Research Program at Mississippi State University and Iowa State University. We also acknowledge William Jones for assistance in data collection and analysis.

REFERENCES

Burkot, T.R.; D.M. Benjamin. 1979. The biology and ecology of the cottonwood leaf beetle, *Chrysomela scripta* (Coleoptera: Chrysomelidae), on tissue cultured hybrid *aigeiros* (Populus x Euramericana) subclones in Wisconsin. Canadian Entomology. 111: 551-556.

Caldbeck, E.S.; H.S. McNabb; E.R. Hart. 1987. Poplar clonal preferences of the cottonwood leaf beetle. Journal of Econonomic Entomology. 71: 518-520.

Davis, P.M.; N. Brenes; L.L. Allee. 1996. Temperature dependent models to predict regional differences in corn rootworm (Coleoptera: Chrysomelidae) phenology. Environmental Entomology. 25(4): 767-775.

Drooz, A.T. 1985. Eastern forest insects. USDA Forest Service Miscellaneous Publication 1426. Washington, D.C.

Fang, Y.; E.R. Hart. 2000. Effect of cottonwood leaf beetle (Coleoptera: Chrysomelidae) larval population levels on *Populus* terminal damage. Environmental Entomology. 29(1): 43-48.

Fatzinger, C.W.; W.N. Dixon. 1996. Degree-day models for predicting levels of attack by slash pine flower thrips (Thysanoptera: Phlaeothripidae) and the phenology of female strobilus development on slash pine. Environmental Entomology. 25(4): 727-735.

Gilbert, N.; D.A. Raworth. 1996. Insects and temperature: a general theory. Canadian Entomology. 128(1): 1-14.

Harrell, M.O.; D.M. Benjamin; J.G. Berbee; T.R. Burkot 1982. Consumption and utilization of leaf tissue of tissue cultured *Populus x Euramericana* by the cottonwood leaf beetle, *Chrysomela scripta* (Coleoptera: Chrysomelidae). Canadian Entomology 114(8): 743-749.

Head, R.B. 1972. Studies on the cottonwood leaf beetle, *Chrysomela scripta* (Fab.) with emphasis on reproductive potential, biology, parasites, predators, insecticide resistance, and esterase comparisons. Mississippi State, MS: Mississippi State University. Ph.D Disseratation.

Mizell, R.F.; T.E. Nebeker 1978. Estimating the developmental time of the southern pine beetle, *Dendroctonus frontalis* as a function of field temperature. Environmental Entomology. 7: 592-595.

Pedigo, L.P.; M.R. Zeiss. 1996. Analyses in insect ecology and management. Ames, IW: Iowa State University Press.

Pitcairn, M.J.; F.G. Zalom; R.E. Rice. 1992. Degree-day forecasting of generation time of *Cydia pomonella* (Lepidoptera: Tortricidae) populations in California. 21(3): 441-446.

Raffa, K.F.; D.J. Hall; W. Kearby; S. Katovich. 1992. Seasonal life history of introduced basswood thrips (Thysanoptera: Thripidae) in Wisconsin, with observations on associated thrips species. Environmental Entomology. 21(4): 771-779.

Reichenbacker, R.R.; R.C. Schultz; E.R. Hart. 1996. Impact of artificial defoliation of *Populus* growth, biomass production, and total non-structural carbohydrate concentration. Environmental Entomology. 25: 632-642.