[The Great Lakes Entomologist](https://scholar.valpo.edu/tgle)

Volume 21
Number 1 - Spring 1988 *Number 1 - Spring 1988*

Article 7

April 1988

Movement, Dispersion, and Orientation of a Population of the Colorado Potato Beetle, *Leptinotarsa Decemlineata* (Coleoptera: Chrysomelidae), in Eggplant

Charles E. Williams
Rutgers University

Recommended Citation

Williams, Charles E. 1988. "Movement, Dispersion, and Orientation of a Population of the Colorado Potato Beetle, *Leptinotarsa Decemlineata* (Coleoptera: Chrysomelidae), in Eggplant," *The Great Lakes Entomologist*, vol 21 (1)
DOI: https://doi.org/10.22543/0090-0222.1629
Available at: https://scholar.valpo.edu/tgle/vol21/iss1/7

MOVEMENT, DISPERSION, AND ORIENTATION OF A POPULATION OF THE COLORADO POTATO BEETLE, *LEPTINOTARSA DECEMLINEATA* (COLEOPTERA: CHRYSOMELIDAE), IN EGGPLANT

Charles E. Williams[1]

ABSTRACT

Short-term dispersal, dispersion, and orientation of a population of the Colorado potato beetle, *Leptinotarsa decemlineata*, were examined in a uniformly spaced planting of eggplant using a mark-recapture technique. Recaptures of marked beetles declined throughout the study, the greatest decline occurring 24 h after release. Dispersal of remaining beetles through the field was gradual; beetle numbers declined with distance from the release point during the first 3 days of the study and increased with distance thereafter. Beetles were highly aggregated for 3–4 days after release but were well dispersed for the remainder of the study. Dispersal of aggregated beetles may have been stimulated by host plant defoliation. Orientation of dispersing beetles was significantly nonrandom for the majority of the study. Beetles oriented predominantly east-northeast.

Dispersal is an important process in the dynamics of insect populations. For example, gene flow (Liebherr 1986), population structure (McCaughley et al. 1981, Brown and Brown 1984), and patterns of resource exploitation (Myers 1976, Myers and Campbell 1976) are influenced by the dispersal capabilities of an insect species. Dispersal is also a fundamental consideration for the development of insect pest management programs (Price and Waldbauer 1975). Thus, information on insect dispersal may contribute to an understanding of basic population processes and, in the case of pest species, to the development of potential management schemes.

Insect dispersal has typically been assessed at two, often exclusive (Stinner et al. 1983), scales. The first is large-scale dispersal or migration, involving the movement of insects between habitat patches (Southwood 1962, Johnson 1969, Kennedy 1975). The second is movement within a habitat patch, referred to as "trivial" movement (Southwood 1962, Kennedy 1975) or diffusion (Kareiva 1983). Within patch movements have been examined in predaceous insects and specialized herbivores, particularly in relation to biological control potential (Shepard et al. 1974, Cartwright et al. 1977) and response to variable host plant density, quality, and diversity (Bach 1980, Karieva 1982). Analyses of within patch movements are vital adjuncts to studies of large-scale dispersal; the manner in which an insect disperses through and utilizes a habitat patch also influences migratory tendencies (see Southwood 1977).

In this paper I describe within patch movement of a specialist herbivore, the Colorado potato beetle, *Leptinotarsa decemlineata* (Say) (CPB). The CPB is the major insect pest of solanaceous crops (e.g., potato, tomato, and eggplant) in much of North America.

---

[1]Department of Entomology and Economic Zoology, Rutgers University, New Brunswick, NJ 08903. Present address: Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

Large-scale population dynamics of the CPB have been extensively investigated (Harcourt 1963, 1964, 1971; Latheef and Harcourt 1974; Lashomb and Ng 1984) but little is known about short-term dispersal and dispersion tendencies of this species in host plant patches (Johnson 1969, May and Ahmad 1983). The purpose of this study was to examine movement, dispersion, and orientation of a CPB population released in the center of a uniformly spaced planting of eggplant (*Solanum melongena* L.). I was specifically interested in the rate of movement and directional preference of dispersing beetles in a host plant patch since previous studies have demonstrated that the CPB exhibits high per plant tenure time (Bach 1982) and distinct orientational preferences (Ng and Lashomb 1983). Eggplant was selected as a host because of ongoing investigations of chemical (Silcox et al. 1984) and biological (Williams 1987) controls for the CPB in eggplant crops.

MATERIALS AND METHODS

This study was conducted in South Brunswick, Middlesex County, New Jersey, during July and August 1983. Eggplant seedlings ('Classic' cv.) were planted at 1.8-m intervals in rows 1.8 m apart in a 44 by 44-m plot during early June. Granular fertilizer (Osmocote 20-20-20) was applied in furrow during transplant and plants were irrigated regularly throughout the study. The study plot was manually cultivated to minimize disturbance to beetles. Spacing of study plants was greater than commercial crop spacing (e.g., rows 1.0-1.5 m apart, plants 0.6-1.0 m apart within a row; New Jersey Commercial Vegetables Recommendations [1983]) to allow easy movement among plants when searching for beetles or cultivating the plot. Plant colonization or movement of the CPB among plants does not appear to be affected by host plant density or dispersion (Bach 1982), so a uniform plant spacing was chosen to approximate conditions in a commercial eggplant field and to produce a host plant grid in which each plant had a unique X-Y coordinate location.

The study plot was bounded on the north, south, and west by fallow field (Fig. 1). Greater (*Ambrosia trifida* L.) and lesser ragweeds (*A. artemisiifolia* L.) dominated the fallow field matrix. A woodlot and wooded corridor composed primarily of black cherry (*Prunus serotina* Ehrh.) bordered the eastern edge of the study plot. The study plot and surrounding field had no recent history of solanaceous crop production.

Several thousand newly emerged, summer generation CPB were collected from a commercial potato field on 19 July. Fifteen hundred beetles were selected at random for release into the study plot (estimated sex ratio 1:1, $n=50$). Beetles were marked by a small drop of red nail polish on the right elytron to distinguish released beetles from colonists. Laboratory observations of marked beetles showed negligible mortality or behavioral modification due to marking. Marked beetles were supplied with fresh eggplant foliage and maintained in laboratory cages for 48 h before release.

Fifteen hundred marked CPB were released on the ground in the center of the study plot at 0600 h on 21 July ($\bar{x}$ plant height at release $= 30.21 \pm 1.48$ (S.E.) cm, $n = 24$). Location of beetles was monitored daily for the first 4 days beginning 22 July and twice weekly thereafter. Searches for marked beetles were conducted each sample day on all plants.

Immigration of adult CPB into the study plot was monitored before the release of marked beetles. Both *L. decemlineata* and *L. juncta* Guerin were occasionally removed from the study plot but the influx of beetles from the surrounding matrix was extremely low, attributable to the isolation of the study plot from commercial potato acreages and recent cropping history.

Data were analyzed via the General Linear Models and Univariate procedures of Statistical Analysis Systems (SAS Institute, Inc. 1982). Plant coordinates were converted to compass coordinates and the mean direction of dispersing CPB was determined statistically using Rayleigh's test (Greenwood and Durand 1955, Zar 1984). Movement was considered random when mean angles were not significant ($P > 0.05$). Dispersion of

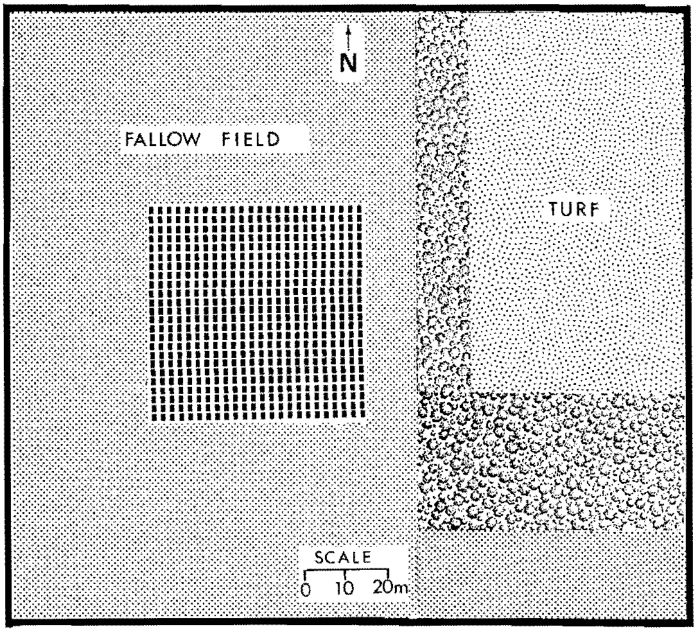


Fig. 1. Field plan for CPB movement study, South Brunswick, Middlesex County, New Jersey.

beetles was described by Green's coefficient of dispersion (G.C.) (Green 1966). G.C. values greater than 0.01 indicate an aggregated population whereas smaller values depict randomness. Green's coefficient was chosen because values are not influenced by population density and provide accurate measures of dispersion (Myers 1978).

RESULTS AND DISCUSSION

Recaptures of marked CPB declined throughout the study (Fig. 2). The greatest decline occurred 24 h post-release when 32% (479) of released beetles were recaptured. Post-release recaptures remained stable from days 1 through 8 after which CPB numbers steadily declined. The reduction in adult density appeared to be primarily due to emigration as few dead or moribund beetles were recovered (but see Young 1984) although some beetles may have entered diapause in the soil and would not have been counted.

Host plant conditioning (i.e., host preference induced by previous feeding experience) or hunger could influence insect dispersal and may have contributed to the large reduction in CPB numbers that occurred 24 h after release, but this seems unlikely. Beetles fed readily upon eggplant foliage prior to release and, although studies have shown that host plant switches may affect fecundity (Hsiao 1978, Brown et al. 1980), conditioning probably does not influence host plant preference in adult CPB (see Hsiao 1978). Moreover, adult CPB frequently colonize eggplant crops after potato crop senescence in New Jersey (May and Ahmad 1983 and pers. obs.), thus shifts between potato and eggplant hosts occur naturally. Initial dispersal may have been in response to handling (agitation dispersal [Aikman and Hewitt 1972]) or to high beetle density at release

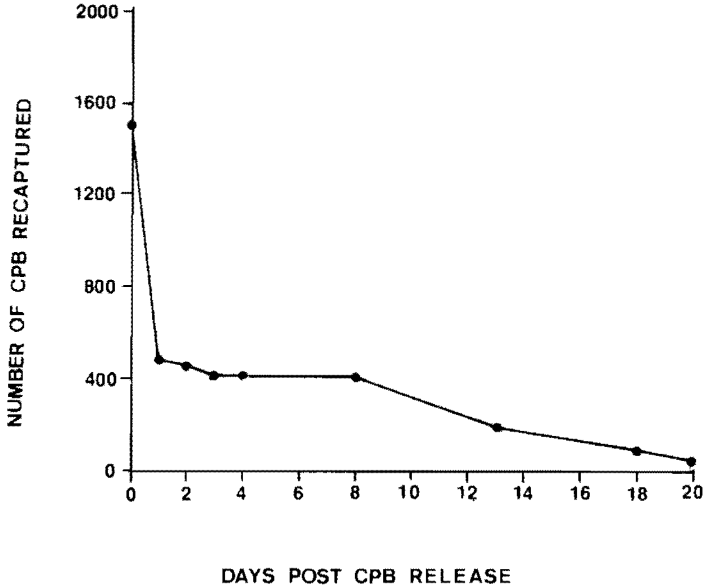
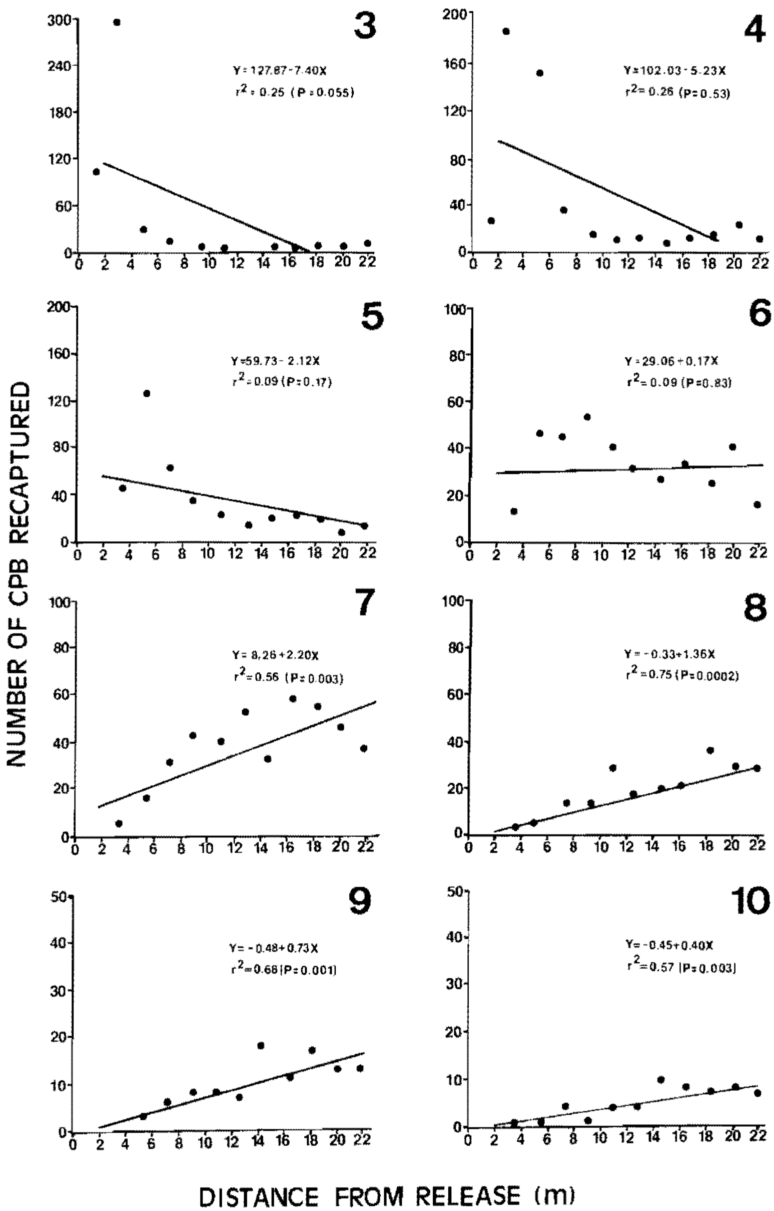


Fig. 2. Numbers of marked CPB recaptured per sampling day during the study.

(over-crowding dispersal [Aikman and Hewitt 1972]). I released beetles under cool ambient temperatures (intense insolation and (or) temperatures above 25°C may stimulate CPB dispersal flights [Johnson 1969]) and minimized handling, but some disturbance to beetles was unavoidable. Beetle density near the release point was high a few hours after release; a cursory examination of plants closest to the release point revealed densities of 50 to over 100 beetles per plant. Numerous CPB dispersal flights were observed from approximately noon to mid-afternoon on the day of release, and these may have been ultimately stimulated by high beetle density. Few dispersal flights were noted during the remainder of the study when beetle populations were lower and nonaggregated (Figs. 2–10, Table 1). Response to high population density may explain in part observations of beetles dispersing from abundant food (e.g., May and Ahmad 1983), particularly since CPB populations in agricultural crops often occur in high density patches (Harcourt 1963, Lashomb and Ng 1984).

Dispersal of remaining CPB through the field was gradual. Beetle numbers declined with distance from the release point during the first three days of the study and increased with distance thereafter (Figs. 3–10). The relationship of beetle numbers to distance from the release point was not significantly linear for the first 4 days after release indicating that movement away from the field center did not occur at a steady rate (quintic polynomial regressions best fit the data for these days but such higher order statistical models are difficult to interpret biologically). Moreover, population distributions were leptokurtic for most of the study, suggesting that vagility varied among beetles in the population (Karieva 1983).

Beetles were highly aggregated for 3–4 days after release but were well dispersed for the remainder of the study (Figs. 3–10; Table 1). Beetle density was particularly high near the release point at 24 and 48 h post-release; 88 and 85% of beetle recaptures occurred within 5.5 m of release on these respective dates. Dispersal of aggregated beetles may have been stimulated by resource depletion; the majority of plants near the release point



Figs. 3–10. Relationship of beetle density to distance from release point: (3) 22 July, (4) 23 July, (5) 24 July, (6) 25 July, (7) 29 July, (8) 3 August, (9) 8 August, (10) 10 August.

Table 1. Dispersion and directional preferences of released CPB during the study. Mean preferred direction was determined by Rayleigh's test. Dispersion was described by Green's coefficient of dispersion (G.C.).

Days post-release	G.C. value	Mean preferred direction[a]
1	0.0958	72.4°[b]
2	0.0387	70.2°[b]
3	0.0131	77.5°[b]
4	0.0058	75.8°[b]
8	0.0018	73.9°[b]
13	0.0017	75.4°
18	0.0014	62.0°[b]
20	0.0014	34.4°[b]

[a]Clockwise from north.
[b]Significantly nonrandom, $P < 0.05$.

were extensively defoliated after 48 h, requiring beetles to move farther into the field to obtain food. Gradual dispersal and high host plant tenure time (Bach 1982) were probably important adaptations for exploiting patchy host plant resources before potato and other solanaceous crops were introduced into the range of the CPB. These two attributes, in addition to host plant adaptability (Jacobson and Hsiao 1983) and a high reproductive capacity, have also made the CPB a major crop pest.

Directional statistics show that population movements were significantly nonrandom for the majority of the study (Table 1). Beetles oriented predominantly east-northeast. The reasons for this directional preference are unknown. A wooded corridor bordered the field in that compass direction (Fig. 1) and may have influenced orientation by providing a visual cue (May and Ahmad 1983) and (or) by altering wind turbulence (Forman and Baudry 1984) which can modify beetle anemotaxis (Visser 1976). Wind direction during the study was variable but strong winds from the northeast were prevalent on the day of release. Plant nutritional quality often varies in an agricultural field and may affect the distribution of insect herbivores (see Mattson 1980), however, variable plant nitrogen does not significantly influence CPB abundance in potato crops (Jansson and Smilowitz 1985). Ng and Lashomb (1983) have demonstrated that the CPB exhibits a fixed northwest orientational tendency in unfamiliar habitats which, they hypothesized, increases the probability that dispersing beetles will encounter suitable new habitat. The results of this study indicate that orientational preferences also occur within host plant patches, although the factors that influence orientation and the significance of orientational preferences in host plant patches are not readily apparent.

ACKNOWLEDGMENTS

Thanks are due to Drs. J. Lashomb and Y-S Ng, Department of Entomology and Economic Zoology, Rutgers University, for suggesting this study. Col. C. P. Brown generously allowed use of land for the study and R. Bullock, New Jersey Department of Agriculture, prepared the study site. K. Williams provided useful comments on the manuscript. The Department of Biology, Virginia Polytechnic Institute and State University, provided computer support.

LITERATURE CITED

Aikman, D., and G. Hewitt. 1972. An experimental investigation of the rate and form of dispersal in grasshoppers. J. Appl. Ecol. 9:807–817.

Bach, C. E. 1980. Effects of plant density and diversity on the population dynamics of a specialist herbivore, the striped cucumber beetle, *Acalymma vittata* (Fab.). Ecology 61:1515–1530.

______. 1982. The influence of plant dispersion on movement patterns of the Colorado potato beetle, *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae). Great Lakes Entomol. 15:247–252.

Brown, J. J., T. Jermy, and B. A. Butt. 1980. The influence of an alternate host plant on the fecundity of the Colorado potato beetle, *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae). Ann. Entomol. Soc. Amer. 73:197–199.

Brown, L., and J. Brown. 1984. Dispersal and dispersion in a population of soldier beetles, *Chauliognathus pennsylvanicus* (Coleoptera: Cantharidae). Environ. Entomol. 13:175–178.

Cartwright, B. O., R. D. Eikenbary, J. W. Johnson, T. N. Farris, and R. D. Morrison. 1977. Field release and dispersal of *Menochilus sexmaculatus*, an imported predator of the greenbug, *Schizaphis graminum*. Environ. Entomol. 6:699–704.

Forman, R. T. T., and J. Baudry. 1984. Hedgerows and hedgerow networks in landscape ecology. Environ. Manage. 8:495–510.

Green, R. H. 1966. Measurement of non-randomness in spatial distributions. Res. Pop. Ecol. 8:1–7.

Greenwood, J. A., and D. Durand. 1955. The distribution of length and components of the sum of n random unit vectors. Ann. Math. Stat. 26:233–246.

Harcourt, D. G. 1963. Population dynamics of *Leptinotarsa decemlineata* (Say) in eastern Ontario. I. Spatial pattern and transformation of counts. Canadian Entomol. 95:813–820.

______. 1964. Population dynamics of *Leptinotarsa decemlineata* (Say) in eastern Ontario. II. Population and mortality estimation during six age intervals. Canadian Entomol. 96:1190–1198.

______. 1971. Population dynamics of *Leptinotarsa decemlineata* (Say) in eastern Ontario. III. Major population processes. Canadian Entomol. 103:1049–1061.

Hsiao, T. H. 1978. Host plant adaptations among geographic populations of the Colorado potato beetle. Entomol. Exp. Appl. 24:237–247.

Jacobson, J. W., and T. H. Hsiao. 1983. Isozyme variation between geographic populations of the Colorado potato beetle, *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae). Ann. Entomol. Soc. Amer. 76:162–166.

Jansson, R. K., and Z. Smilowitz. 1985. Influence of nitrogen on population parameters of potato insects: abundance, development, and damage of the Colorado potato beetle, *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae). Environ. Entomol. 14:500–506.

Johnson, C. G. 1969. Migration and dispersal of insects by flight. Methuen. London.

Kareiva, P. M. 1982. Experimental and mathematical analyses of herbivore movement: quantifying the influence of plant spacing and quality on foraging discrimination. Ecol. Monogr. 52:261–282.

______. 1983. Local movement in herbivorous insects: applying a passive diffusion model to mark-recapture field experiments. Oecologia 57:322–327.

Kennedy, J. S. 1975. Insect dispersal. pp. 103–119 *in* D. Pimentel (ed.) Insects, science and society. Academic Press: New York.

Lashomb, J. H., and Y-S Ng. 1984. Colonization by Colorado potato beetles, *Leptinotarsa decemlineata* (Say) (Coleoptera: Chrysomelidae), in rotated and non-rotated potato fields. Environ. Entomol. 13:1352–1356.

Latheef, M. A., and D. G. Harcourt. 1974. The dynamics of *Leptinotarsa decemlineata* populations in tomato. Entomol. Exp. Appl. 17:67–76.

Liebherr, J. K. 1986. Comparison of genetic variation in two carabid beetles of differing vagility. Ann. Entomol. Soc. Amer. 79:424–433.

Mattson, W. J. 1980. Herbivory in relation to plant nitrogen. Ann. Rev. Ecol. Syst. 11:119–161.

May, M. L., and S. Ahmad. 1983. Host location in the Colorado potato beetle: searching mechanisms in relation to oligophagy. pp. 173–199 *in* S. Ahmad (ed.) Herbivorous insects: host-seeking behavior and mechanisms. Academic Press: New York, NY.

McCaughley, D. E., J. R. Ott, A. Stine, and S. McGrath. 1981. Limited dispersal and its effect on population structure in the milkweed beetle, *Tetraopes tetraophthalmus*. Oecologia 51:145–150.

Myers, J. H. 1976. Distribution and dispersal in populations capable of resource depletion: a simulation model. Oecologia 23:255–269.

______. 1978. Selecting a measure of dispersion. Environ. Entomol. 7:619–621.

Myers, J. H., and B. J. Campbell. 1976. Distribution and dispersal in populations capable of resource depletion: a field study on cinnabar moth. Oecologia 24:7–20.

New Jersey Commercial Vegetable Recommendations. 1983. Rutgers Univ. Coop. Ext. Bull. 406-J.

Ng, Y-S, and J. H. Lashomb. 1983. Orientation by the Colorado potato beetle (*Leptinotarsa decemlineata* Say). Anim. Behav. 31:617–618.

Price, P. W., and G. P. Waldbauer. 1975. Ecological aspects of pest management. pp. 37–74 *in* R. L. Metcalf and W. H. Luckmann (eds.) Introduction to insect pest management. John Wiley and Sons. New York.

SAS Institute, Inc. 1982. SAS user's guide: statistics. Statistical Analysis Systems Institute, Inc. Cary, NC.

Shepard, M., V. Waddill, and S. G. Turnipseed. 1974. Dispersal of *Geocoris* spp. in soybeans. J. Georgia Entomol. Soc. 9:120–126.

Silcox, C. A., J. H. Lashomb, G. M. Ghidiu, and S. R. Race. 1984. Efficacy, persistence, and phytotoxicity of aldicarb applied as a pretransplant treatment to eggplant for Colorado potato beetle (Coleoptera: Chrysomelidae) protection. J. Econ. Entomol. 77:529–533.

Southwood, T. R. E. 1962. Migration of terrestrial arthropods in relation to habitat. Biol. Rev. 37:171–214.

______. 1977. Habitat, the templet for ecological strategies. J. Anim. Ecol. 46:337–365.

Stinner, R. E., C. S. Barfield, J. L. Stimac, and L. Dohse. 1983. Dispersal and movement of insect pests. Ann. Rev. Entomol. 28:319–335.

Visser, J. H. 1976. The design of a low-speed wind tunnel as an instrument for the study of olfactory orientation in the Colorado beetle *(Leptinotarsa decemlineata)*. Entomol. Exp. Appl. 20:275–288.

Williams, C. E. 1987. Exploitation of eggs of the Colorado potato beetle, *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae), by the exotic egg parasitoid *Edovum puttleri* (Hymenoptera: Eulophidae) in eggplant. Great Lakes Entomol. 20:181–186.

Young, O. P. 1984. Utilization of dead insects on the soil surface in row crop situations. Environ. Entomol. 13:1346–1351.

Zar, J. H. 1984. Biostatistical analysis. Prentice-Hall, Inc. Englewood Cliffs, NJ.