The Great Lakes Entomologist

Volume 22
Number 1 - Spring 1989 *Number 1 - Spring 1989*

Article 2

April 1989

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Recommended Citation

Drummond, Francis A.; Groden, Eleanor; Haynes, D. L.; and Edens, Thomas C. 1989. "Some Aspects of the Biology of a Predaceous Anthomyiid Fly, *Coenosia Tigrina*," *The Great Lakes Entomologist*, vol 22 (1)
Available at: https://scholar.valpo.edu/tgle/vol22/iss1/2

SOME ASPECTS OF THE BIOLOGY OF A PREDACEOUS ANTHOMYIID FLY, *COENOSIA TIGRINA*[1]

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ABSTRACT

The results of a two-year study in Michigan on the incidence of *Coenosia tigrina* adults under different onion production practices is presented. In Michigan, *C. tigrina* has three generations and is more abundant in organic agroecosystems than chemically-intensive onion production systems.

Adults of the tiger fly, *Coenosia tigrina* (F.), are primarily predators of Diptera. The species is common to both Europe and North America. Hobby (1931, 1934) published lists of prey species reported for *C. tigrina* in Europe, mostly represented by muscid and anthomyiid flies. Studies designed to quantify predation by *C. tigrina* are lacking. Thomas (1967) suggests that the tiger fly is a key predator of the face fly, *Musca autumnalis* DeGeer, in the United States, although this hypothesis is solely based upon the abundance of *C. tigrina*. It is very abundant in apple orchards in the northeastern United States where it preys upon adults of the apple maggot fly, *Rhagoletis pomonella* Walsh (Drummond, unpubl. obs.). Yellow panel and red sphere traps caught *C. tigrina* there from the beginning of July into October (Drummond et al. 1982). *C. tigrina* has also been referred to as an important predator of the seedcorn maggot fly, *Delia platura* (Meigen), in England (Miles 1948), and Canada (Miller and McClanahan 1960).

In Michigan (USA), *C. tigrina* is a very common predator associated with the onion agroecosystem where it preys upon the seedcorn maggot adult, *Delia platura*, and the onion maggot adult, *Delia antiqua* (Meigen) (Groden 1982, Carruthers et al. 1985). This is also the case in the onion growing regions of eastern Canada (Perron and LaFrance 1952, Perron and LaFrance 1956, LeRoux and Perron 1960, Tomlin et al. 1985). In fact, what little is known about the biology of *C. tigrina* has been obtained in association with *D. antiqua*.

All life stages of *C. tigrina* have been found in onion fields (LeRoux and Perron 1960). Detailed descriptions of the stage are presented by LeRoux and Perron (1960) and Perron and LaFrance (1956). The life cycle is as follows. In the spring (late April–early May) adult females lay eggs, singly, on or just beneath the soil surface (LeRoux and Perron 1960). Only one larval instar occurs from egg hatch to pupation (LeRoux and Perron 1960). Perron and LaFrance (1956) failed to rear the larvae to maturity on a variety of vegetable and animal diets, but believed the larvae fed upon organic matter in the soil. Yahnke and George (1972) discovered larvae of *C. tigrina* preying on the earthworm, *Eisenia rosea* (Savigny), in the field. Repeated sampling confirmed the hypothesis that the larvae are predaceous on earthworms (Yahnke and George 1972). These researchers found that survival in the laboratory of *C. tigrina* larvae reared on *E. rosea* was significantly greater on dissected prey than on live intact earthworms. They also found

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that earthworms parasitized by the cluster fly, *Pollenia rudis* (F.), increased the survival of *C. tigrina* larvae compared to unparasitized earthworms. *C. tigrina* is multivoltine, having 3–4 generations in onion fields between May and October. This period of activity coincides with that of *D. antiqua* in eastern Canada (Perron and LaFrance 1961, Perron 1972) and Michigan (Whitfield et al. 1985). The tiger fly overwinters as mature larvae which pupate in the early spring (LeRoux and Perron 1960).

Additional information on some aspects of tiger fly biology in the Michigan organic soil onion agroecosystem was obtained during studies we conducted between 1979 and 1982. The objective of the studies was to compare the invertebrate fauna found in onion farms without pesticide inputs to the fauna found in chemically-intensive farms.

MATERIALS AND METHODS

Study sites in 1979 were located in Laingsburg (Clinton Co.), Grant (Newaygo Co.), and Eaton Rapids (Eaton Co.), Michigan. In two of the three muck soil onion agroecosystems, a field representative of a chemically-intensive onion production system and one representative of an unsprayed organic onion production system, were chosen for investigation. In Grant, three fields were selected, an unsprayed onion field and two sprayed fields. Earthworm populations were sampled from these fields and compared.

In 1979 the earthworm survey was conducted 11 July and 18 July, and after harvest 20 October and 4 November. The sampling procedure utilized in July consisted of taking ten randomly selected sample units 1647 cm^3 in soil volume (Par-Aide® turf cutter) between onion rows. Earthworms were hand-picked from each soil sample. After harvest, the sampling method was changed to 15 quadrat samples (9.26 m^2 to a depth of 15 cm) per field, stratified such that one-third of the randomly-selected samples were from areas of low cull density (1-40 culls/9.26 m^2), one-third were from areas of medium cull density (41–80 culls/9.26 m^2), and one-third were from areas of high cull density (81–120 culls/9.26 m^2) relative to the specific field level density of culls. During both survey periods each field within a region was sampled on the same day so as to minimize the effect of day-to-day fluctuations in weather conditions on earthworm vertical distribution. Friedman's Two-way Analysis of Ranks was used in interpreting the data (SAS 1985). This nonparametric test was used due to the high frequency of zero counts in the data.

During 1981 and 1982 adult tiger fly populations were monitored using yellow water traps in both unsprayed and pesticide treated fields. Four farms were chosen for this study. They had similar soil types, different levels of pesticide input, and different cultural practices. The **Control** plot was in a commercially cultivated field that received no pesticide applications, but prior to our study received high levels of synthetic fertilizers and pesticides. The **Organic** site received no pesticides or synthetic fertilizers, was lightly disked, and intercropped. This field had been in organic production for ca. 15 years. Both **High Input** (referred to as A and B) sites were treated with high levels of pesticides and chemical fertilizers, were disked heavily, and were not intercropped. The Control and High Input A sites were on the same commercial farm in Grant Township, MI. The farm was 33.3 hectares in size and bordered by a paved road, a 5 m wide ditch, a two-lane dirt road, and a single row willow tree wind break. A strip of oats and rye was planted in the middle of the field. The High Input B site also was on a commercial farm in Grant Township, MI. This farm had 50 hectares of alternating onion and carrot crops, 8 to 13 hectares each. Two sides were bordered by paved roads and a third side by forest. The fourth margin abutted 12 hectares of carrots. The organic site studied had 1.3 hectares of onions, bounded by weeds on two opposite sides, trees and weeds on another, and a polyculture of radishes, spinach, potatoes, carrots, and oats on the fourth.

Twenty water traps were randomly placed in four rows of each site every Thursday throughout the growing season of 1981 and 1982. Traps were collected from the fields every Monday. Because the traps were checked and reset every four days, the confounding effects of rainfall and soil deposition on trap efficiency were minimized. The traps were 10 × 10 × 10 cm and contained a 1–2.5 cm depth of 50% aqueous antifreeze.

Table 1. Results of 1979 Earthworm Survey.

Region	Mean Earthworm Density (SE)[a]				Significance[d]
	Field[b]	October	November	X^2	
Eaton Rapids				2.10	.10
	K	4.00 (0.96)	2.67 (0.68)		
	R	0.07	0.00		
Grant				2.40	.16
	GR	0.20 (0.23)	—[c]		
	G1	0.00	—		
	G3	0.00	—		
Laingsburg				2.10	.10
	R	0.80 (0.37)	0.40 (0.18)		
	P	0.00	0.00		

[a] Standard error.
[b] Fields without pesticide treatment = K (Eaton Rapids), GR (Grant), R (Laingsburg); others received pesticides typical of conventional onion farms during the growing season.
[c] Not sampled.
[d] Based on Friedman's two-way analysis.

Each sample was rinsed with water through a sieve, put into 95% alcohol, and thoroughly gleaned of all invertebrates and small vertebrates.

RESULTS AND DISCUSSION

The earthworm species sampled in this study were all of the family Lumbricidae as determined from Edwards and Lofty (1972). Earthworms were not identified to the species level, although subsamples identified to the generic level suggested that more than 80% of the individuals were of the genus *Eisenia* (taxonomic keys were from Edwards and Lofty 1972). A classification of the Michigan earthworm fauna by Murchie (1956) suggests that the predominant species in Michigan organic soil agroecosystems is *Eisenia rosea* (Savigny).

An inspection of the data collected during the July sampling period suggests that a trend might exist in which fields without a pesticide history have higher earthworm densities than fields that had pesticides applied throughout the season; however, upon analysis of the data no supportive evidence of this hypothesis exists (Laingsburg region, $X^2 = 1.00$, $P = 0.317$; Grant region $X^2 = 3.804$, $P = 0.703$; and the Eaton Rapids region, $X^2 = 1.00$, $P = 0.317$ [based on Friedman's two-way analysis of ranks]). Low population levels characterized all fields.

Researchers in Europe have shown that high soil temperatures (>20°C) along with low soil moisture levels (<25%) are responsible for vertical migrations of earthworms (Edwards and Lofty 1972). Murchie (1958) found that *E. rosea* in southern Michigan were at low densities near the soil surface during late July and August compared with densities in the spring and fall. Similar results were found by Drummond (1982) in Michigan onion fields.

The fall earthworm survey was initiated in a response to the high surface densities (relative to the July survey) of earthworms found in onion fields toward the end of October, 1979. The results of the survey (Table 1) in which fields that had not received pesticides during the growing season and those that had (within each of three regions) were compared, suggest that in two of the three regions (Eaton Rapids and Laingsburg)

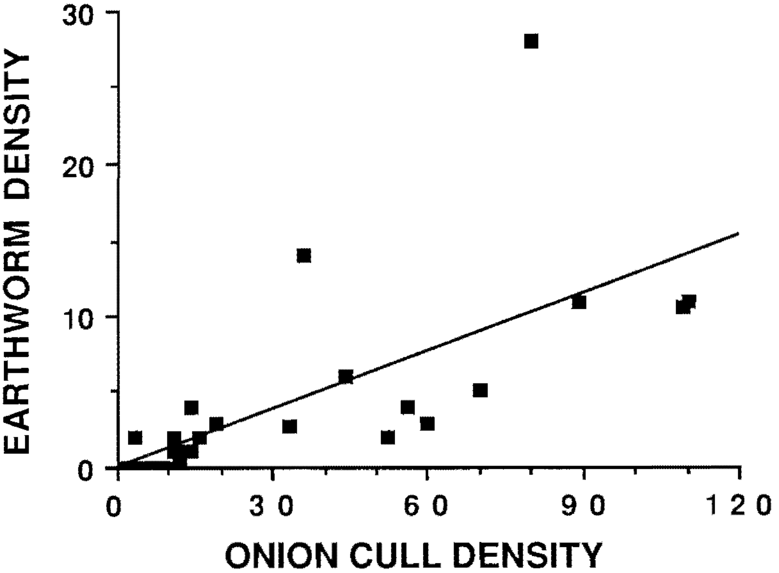

Figure 1. Correlation between onion cull density and earthworm density. Fitted line is used only to help depict relationship.

earthworm densities were higher in fields that did not receive pesticides than fields that did.

Pesticides have been shown to cause mortality to earthworms. There has not been sufficient evidence from research findings to suggest that herbicides directly affect earthworm populations in this manner (except for the triazine compounds). However, herbicides may still play a major role in reducing population densities by killing the vegetation that serves as the earthworms' food source (Edwards and Lofty 1972). Fungicides, in general, have not been considered deleterious to earthworm populations although copper fungicides have proven to be extremely toxic to earthworms (Edwards and Lofty 1972, Stringer and Lyons 1974). There have been many studies on the effects of insecticides on earthworms, many of which are reviewed by Edwards and Lofty (1972). Some insecticides such as aldrin, dieldrin, and BHC (all chlorinated hydrocarbons) have little effect on earthworms as far as direct mortality is concerned, whereas chlordane is extremely toxic to earthworms. The effect of organophosphate insecticides, the basis for onion maggot control in Michigan, is also dependent upon the particular chemical in question. Azinphosmethyl and carbofuran have not been shown to effect earthworms whereas Diazinon®, Dyfonate®, and Dursban® (all common soil insecticides used for the control of onion maggot) have deleterious effects on earthworm populations (Edwards and Lofty 1972). Parathion and malathion (two commonly used foliar insecticides used to control adults of the onion maggot) have been reported as being toxic to earthworms (Hopkins and Kirk 1957).

The relationship between cull density and earthworm dentisy in the organic field in Eaton Rapids for both the October and November sampling dates is shown in Figure 1. Correlation analysis for both dates respectively yielded correlation coefficients of +0.77 (n = 15) and +0.55 (n = 15). Since the sampling variation in "r" is quite large for small sample sizes, homogeneity of the correlation coefficients was tested through the use of the inverse tangent transformation (Steel and Torrie 1980). The correlation coefficients

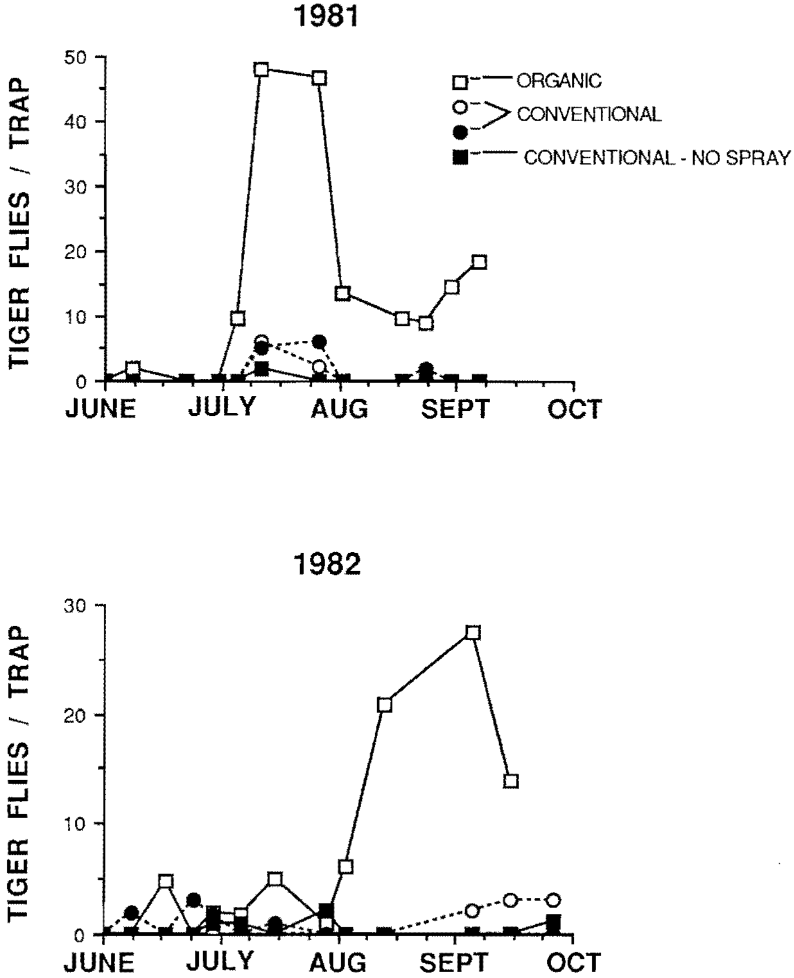

Figure 2. Relative abundance of *Coenosia tigrina* adults during 1981 and 1982.

were not found to be significantly different ($z = .98$, n.s., $\alpha = .05$, df $= 30$). A pooled estimate of the association ($r = +.72 \pm .12$, $p = .001$) indicated that there is sufficient evidence to suspect a positive correlation between onion cull density and earthworm density. Therefore, growers' harvest practices may greatly influence the population dynamics of the tiger fly. Depending on the affinity the earthworms have for onions and the maximum distance of horizontal migration, it may be possible to manipulate the density of culls in such a manner that predation and survival of the tiger fly is increased.

In both 1981 and 1982, tiger fly trap catches suggest three distinct generations from the beginning of June until September (Fig. 2). The first generation peaked on approximately 10 June in 1981 and in 1982. The second generation peaked on ca. 13 July in 1981 and 12 July in 1982. Not enough of the incidence curve could be constructed to determine the date or peak third generation occurrence in 1981, but in 1982 it appears peak abundance

Table 2. Adult Tigerfly Abundance[b] in 1981 and 1982.

Year	Treatment			
	Control	High Input A	High Input B	Organic
1981	0.92 ± 2.06***[b]	0.62 ± 1.45***	0.08 ± 0.28***	16.60 ± 20.00
1982	1.08 ± 1.24***	0.33 ± 0.65***	0.08 ± 0.28***	7.33 ± 9.54

Analysis of Variance

Source	DF	SS	MS	F	Sig. Level
Total	63	226.43			
Treatment	3	189.84	63.28	109.46	0.001
Years	1	0.47	0.47	0.82	0.37
Treatment X Years	3	3.74	1.25	2.15	0.11
Error	56	32.37	0.58		

[d] Mean number of adult *C. tigrina* per trap per collection date.

[b] ***Significantly different between years at p = 0.001.

of adults occurred between 6 and 20 September. Since it is known that the tiger fly overwinters as a larva, a generation of adults probably occurs in April and May.

Tiger fly populations in both years are much higher in the organic field than either the control or high input fields (Table 2). The low tiger fly trap catches in the control field in 1981 and 1982 suggest that it may take more than two years for a population to recover after the cessation of chemical input. Also, the control site had little "structure" relative to the organic site which was intercropped and had field borders supporting diverse biotic systems (Motyka and Edens 1984). Tomlin et al. (1985) conducted a study in Ontario, Canada, where they caught tiger fly adults only from onion fields which did not receive pesticides over the two years of the study period.

Management practices in commercial onion fields in Michigan may have both detrimental and beneficial effects on the tiger fly. Direct pesticide-induced mortality of *C. tigrina* adults was investigated by Carruthers et al. (1985). They found that three commonly used herbicides (Chloro-IPC, nitrofen, and CDAA) and two fungicides (maneb and chlorothalanil) had no effect on mortality at recommended field application rates. The LC_{50} of Malathion for the tiger fly was ca. one and a half times higher on a numerical basis than that of the seed corn maggot fly and almost six times higher than that of the onion maggot fly. However, there appears to be little residual activity of malthion. Residue five hours after application resulted in only ten percent mortality. Mortality was less than one percent ten hours after application. However, some Michigan onion growers apply insecticide as frequently as every three days during portions of the season (Whitfield et al. 1985) and *C. tigrina* is certainly detrimentally affected by insecticide applications relative to onion maggot flies.

In conclusion, we have provided a preliminary data set which supports previously published laboratory studies showing the deleterious effects of pesticides upon the tiger fly. We are aware that the proper design for a study aimed at quantifying the impact of onion production practices upon tiger fly populations needs to be replicated across regions. In the study, however, limited resources and a lack of organic onion farms prevented us from carrying this out. Admittedly, this does not allow us to draw strong conclusions about differences in abundance between fields. Future studies aimed at elucidating this relationship between the tiger fly and its prey, earthworm populations, and cropping practices may make it possible for less damaging management practices to be implemented in commercial onion production.

ACKNOWLEDGMENTS

We would like to thank Mr. Fred Warner and Mr. William Taft for assisting in the collection of pitfall trap data and Mr. Neal Newman for assisting in the collection of the earthworm data. We also thank Ms. Becky Mather for typing the manuscript.

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