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PHENOLOGY AND HOST ASSOCIATIONS OF EASTERN CHIPMUNK (*TAMIAS STRIATUS*) EPIFAUNA IN CENTRAL TENNESSEE

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ABSTRACT

The epifauna of eastern chipmunks was monitored from 1977-1979 in a 5 ha suburban deciduous forest plot in central Tennessee. The louse, *Hoplopleura erratica*, was the only epizoite occurring on chipmunks throughout the year, showing slight summer abundance peaks and winter scarcity. The infestation rate for this species on male chipmunks was significantly greater than on females and infested juveniles supported significantly more lice than adults. The flea, *Ctenophthalmus pseudagyrtes*, was encountered in distinct spring and autumn infestation periods. The fly, *Pegomya finitima*, whose exact relationship with chipmunks remains undetermined, was taken mainly during summer. The mite, *Androlaelaps casalis*, was unexpectedly abundant being encountered from May through November. *Haemogamasus* spp. mites were taken in late summer/autumn and the mite, *Eulaelaps stabularis*, was recorded from October through May. The chigger, *Eutrombicula alfreddugesi*, was a summer parasite being especially common in 1978 when a significantly greater proportion of female than male chipmunks supported this species. Other arthropods, encountered in very low numbers, include the bot, *Cuterebra emasculator*, the beetle, *Lathridius liratus*, cheyletid mites, *Balaustium* sp. mites, the hypopial mites, *Dermacarus hylandi* and *Aplodontopus sciuricola*, and various incidental epizoites considered to represent accidental infestations.

INTRODUCTION

Few studies on eastern chipmunk, *Tamias striatus* (L.), epifauna have been undertaken. This is surprising since it is one of the most abundant and familiar mammals over much of the eastern third of North America. Noteworthy accounts have however appeared by Amin (1973, 1975, 1976a, b), Jackson (1974), Whitaker, Pascal and Mumford (1979) and Wilson (1961). Apart from the papers by Amin (1975, 1976a), which deal with seasonal occurrence and host relationships (for fleas), previous work has largely been concerned with species listings and infestation rates and means. Since Amin's studies in Wisconsin involve flea species that contrast with those that apparently infest *T. striatus* in central Tennessee, the present work should prove useful. This paper represents a synopsis of part of the Ph.D. research undertaken by the author while registered as an external student of the University of London, U.K. (Durden 1981).

METHODS

The study area was a 5 ha tract of suburban deciduous woodland about 11 km southwest of Nashville, Davidson County, Tennessee. Chipmunks were captured using specially constructed Longworth design live-traps (Chitty and Kempson 1949) baited with sunflower seeds and set close to chipmunk burrow entrances or at randomly selected sites within the experimental plot. Set traps were checked at two-hour intervals and captives were processed immediately to reduce specimen losses. If more than one chipmunk was taken in a checking round those individuals not examined first were retained in separate, clean, white, chambers until they could be processed. In this way, epifauna falling from host pelage could be retrieved later. Chipmunks were immobilized by anesthetization with ether and then scanned for epizoites by systematically pushing fur aside with probes and microforceps. Viewing the pelage with a low power binocular microscope aided this effort. Epifauna was identified, recorded and when possible replaced onto the original host (to avoid inoculation to resistant chipmunks and to conserve individuals of small populations) when both had recovered from the ether. Chipmunks were then dye-marked for future identification and released at their site of capture. Recaptures were common but records from any given individual were not taken more than once per month to assure unbiased data.

Results and Discussion

Characteristic epifauna encountered together with monthly infestation rates, means and ranges is listed in table 1. Each species listed, together with the more infrequent arthropod associates, is discussed below with respect to its phenology and host associations.

TABLE 1. *Monthly infestation parameters for eastern chipmunk epifauna in central Tennessee for 1977-1979.*

Species	1977		1978										1979									
	Oct.	Nov.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
Hoplopleura erratica	48.0*	100	16.7	14.3	18.8	20.0	17.9	23.5	14.8	23.1	21.4	12.5	25.0	10.0		20.0	17.6	50.0	66.7	25.0	36.4	46.7
	35.9*	40.0	0.5	0.3	0.6	1.0	7.9	1.9	1.5	5.6	4.4	0.3	0.6	0.3		0.8	1.2	1.8	9.0	5.8	2.6	4.3
	1-643*	18-62	-3-	1-3	1-7	1-15	13-79	1-44	1-21	1-69	8-41	-2-	2-3	-3-		3-6	6-9	1-12	1-39	13-39	1-26	1-32
Ctenophthalmus pseudagyrtes	32.0			35.7	22.7			2.9	18.5	3.8	7.1	11.1				20.0	33.3	12.5		11.1	18.2	20.0
	0.40			0.36	0.23			0.03	0.19	0.04	0.07	0.14				0.20	0.50	0.13		0.11	0.18	0.20
	1-3			-1-	-1-			-1-	-1-	-1-	-1-	-2-				-1-	1-2	-1-		-1-	-1-	-1-
Pagomya finitima				7.1	4.5		10.3	21.1	7.4		7.1						18.2	15.8	23.1	23.8	15.8	
				0.07	0.05		0.10	0.26	0.07		0.07						0.18	0.16	0.23	0.24	0.16	
				-1-	-1-		-1-	1-2	-1-		-1-						-1-	-1-	-1-	-1-	-1-	
Androlaelaps casalis	4.0				9.1	16.0	33.3	35.3	33.3	34.6	78.6					28.6	36.4	22.2	7.7	16.7	12.5	31.6
	0.04				0.2	0.8	0.6	1.4	0.6	7.1	2.4					1.4	1.6	0.8	0.1	0.2	0.3	1.9
	-1-				1-3	1-9	1-5	1-10	1-2	1-170	1-8					1-9	2-7	1-9	-1-	-1-	2-3	1-27
Haemogamasus sp. A	12.0						2.6	8.8	11.1	7.7										5.0		
	0.16						0.03	0.09	0.59	0.08										0.05		
	1-2						-1-	-1-	3-8	-1-										-1-		
Eulaelaps stabularis		50.0									7.1	50.0	25.0	42.9	33.3	16.7					10.0	11.1
		0.50									0.07	2.25	0.50	0.70	0.67	0.17					0.4	0.11
		-1-									-1-	2-8	1-3	1-3	-2-	-1-					-4-	-1-
Eutrombicula alfreddugesi						24.0	30.8	26.5	11.1	7.7								16.7	7.7			
						9.6	26.3	2.7	0.4	2.4								1.4	0.2			
						1-166	1-389	1-53	-4-	1-61								5-12	-2-			
N** (chipmunks)	25	2	6	14	22	25	39	34***	27	26	14											

*Reading down, figures refer to infestation rate (%), mean per host and range, respectively.

**In 1979, monthly chipmunk totals examined for each arthropod species were different because of some related experiments undertaken at this time (numbers examined ranged from 3 to 22).

***For *P. finitima*, 38 chipmunks were processed.

Hoplopleura erratica (Osborn) (Anoplura, Hoplopleuridae)

This sucking louse, a specific parasite of *T. striatus,* was the only epizoite present on chipmunks throughout the year. This was probably due to all life stages being adapted to existence in host pelage unlike the remaining epifauna which during some or all stages occupied alternative habitats (notably, host burrow systems and nests). Except for louse scarcity during winter (December-March) the phenology of *H. erratica* abundance is difficult to analyse although infestation means peaked in July (1978) and August (1979). Low louse numbers during winter were anticipated because of host hibernation—N.B. hibernation in *T. striatus* is unusual for although there is a real drop in basal metabolic rate and body temperature, arousal to vigorous activity may occur every one to six days (Panuska 1959; Wang and Hudson 1971). Observations on two captive chipmunks were of little help in elucidating the mode of winter survival for *H. erratica* since louse populations on both became extinct by early January and accumulated ova glued to host pelage failed to hatch the following spring. Possibly, lice that survive on some chipmunks serve to re-infest other individuals in spring. The summer peaks in infestation means occurred during or immediately after the host summer mating period (July) suggesting some positive effect on louse numbers at this time.

Total data revealed 27.0% of 381 chipmunks examined to be infested by *H. erratica* (mean/host =5.4). This compares favorably with the 17.4% (N=23) and 2.8/host reported by Wilson (1961) and 32.1% (N=81) and 3.9/host obtained by Whitaker, Pascal and Mumford (1979), both on Indiana *T. striatus* samples. Overall, significantly more male than female chipmunks supported *H. erratica* (34.6% versus 20.1%; K=3.19, *P*=0.0014); no corresponding difference was detected between juveniles and adults (29.9% versus 25.8%; K=0.83. *P*=0.4065) using Treloar's (1951) difference between two proportions test. The more frequent infestation of male chipmunks could be related to their larger home ranges (Durden 1981) providing for more host contact and louse transfer. Laboratory tests did however reveal losses of lice from parent female chipmunks to their litters; this could also have caused or contributed to observed differences. Infested male and female hosts showed no significant difference in mean infestation size (13.2 versus 15.2; t=1.14, *P*>0.1) although infested juveniles supported significantly more lice than adult counterparts (21.9 versus 9.7; t=3.28, *P*=0.001 - 0.01) (N.B. for these data, the single heavy infestation of 643 lice on a juvenile female chipmunk has been disregarded). Juveniles were probably less adept at grooming or else had a poorly developed immune response against *H. erratica.*

The 2070 lice taken during this survey consisted of 58.6% nymphs, 17.8% adult males and 23.6% adult females. Static life table data for summer, 1979 revealed 57.8% ova, 9.1% first instar nymphs, 8.0% second instar nymphs, 4.8% third instar nymphs, 9.0% adult males and 11.3% adult females. This is indicative of a type III survivorship curve when differences between stadia durations are considered.

Host site analysis showed most *H. erratica* ova to accumulate on anterior lateral and anterior dorsal body regions just behind the head. However, in large infestations (>about 80 ova) additional sites were used, presumably because an optimal density on preferred locations had been reached. Since survival and embryonic development of some lice ova are highly sensitive to temperature and to a lesser extent relative humidity and CO_2 concentration (Askew 1973; Rust 1974), desired properties of sites used by *H. erratica* are probably related to these requirements. Adult lice were most frequent on the head and dorsal body and nymphs on the hind limbs and dorsal body. Chipmunk grooming behavior appears to influence these distribution patterns since the larger adult lice should be most difficult to remove from the head and dorsal body by host biting activities; scratching seems to eliminate few, if any, lice (Murray 1965; Rust 1974). Intraspecific antagonism or competition may displace weaker nymphs to suboptimal sites but first and second instars occur mainly at hair shaft bases and are probably too small to be easily removed by biting.

Ctenophthalmus pseudagyrtes Baker (Siphonaptera, Hystrichopsyllidae).

C. pseudagyrtes and a single specimen of *Epitedia wenmanni* (Rothschild) were the only fleas taken from *T. striatus* during this survey. *C. pseudagyrtes* was present on chipmunks in two yearly broods, these being in spring (April/May, 1978 and May-July, 1979) and autumn (August-December, 1978 and September-November, 1979). Their initiation coincided with young chipmunk (resulting from the February/March and July mating periods, respectively) presence in burrow systems. Whether or not juvenile chipmunk presence influences flea eclosion must remain speculation. However, Rothschild and Ford (1973) located a kairomone in nestling rabbit urine affecting reproductive status in the flea, *Spilopsyllus cuniculi*. Similar phenology for *C. pseudagyrtes* has not previously been reported. Jameson (1950) found *C. pseudagyrtes* about equally abundant in all months on short-tailed shrews in Ontario and New York; Wilson (1961) took this flea from Indiana small mammals in all months (except September) with greater numbers occurring during spring and summer, a finding similar to that expressed by Verts (1961) for Illinois. Although Holland and Benton (1968) also took *C. pseudagyrtes* in all months from Pennsylvania small mammals, a sharp abundance peak in early spring was noted. Amin (1976a) took *C. pseudagyrtes* from *T. striatus* from June through September in Wisconsin.

Only 40 *C. pseudagyrtes* were taken during this survey, these comprising 21 females and 19 males. During those months in which fleas were taken, 16.4% of the 220 chipmunks examined were infested (mean/host=0.18). There was no significant difference between the percentages of male versus female (18.3% versus 14.4%; K=0.78, P=0.4354) or juvenile versus adult (18.3% versus 15.6%; K=0.59, P=0.5552) chipmunks infested. Means for host sub-groups were not compared because on only three occasions was more than one flea taken from a chipmunk during a single examination.

It is interesting to note that neither of the fleas normally associated with *T. striatus* was taken in central Tennessee. *Megabothris acerbus* (Jordan) (Ceratophyllidae) is normally the dominant flea on *T. striatus* in the northern part of this mammal's range (Amin 1976a; Holland and Benton 1968). *Tamiophila grandis* (Rothschild) (Hystrichopsyllidae) is mainly nidicolous (Amin 1976a; Holland and Benton 1968) and also fails to extend much further southward than *M. acerbus* in its range. *M. acerbus* appears to parasitize *T. striatus* to the north of a line passing through central Pennsylvania and central Wisconsin and *T. grandis* to the north of a line extending across central Indiana. Sanford and Hays (1974) similarly took only *C. pseudagyrtes* from *T. striatus* in Alabama.

Pegomya finitima Stein (Diptera, Anthomyiidae).

The association of this fly with *T. striatus* has been discussed elsewhere (Durden 1982) and will not be detailed here. *P. finitima* was an occasional (36 specimens collected) epizoite on chipmunk pelage although the exact nature of the association has not been resolved. Anthomyiid larvae extracted from chipmunk burrows could not be reared to adults for identification so it is uncertain whether *P. finitima* larvae feed in this habitat. Hendricks (1967) has taken *P. finitima* from 13-lined ground squirrel pelage in Indiana in a similar manner.

Androlaelaps casalis (Berlese) (Acarina, Laelapidae).

This mite has not previously been collected in large numbers from *T. striatus* although Whitaker, Pascal and Mumford (1979) reported one specimen from this host in Indiana. Squirrels of the genus *Sciurus* appear to be normal hosts for *A. casalis* (Morlan 1952; Parker 1968; Parker and Holliman 1972; Whitaker, Spicka and Schmeltz 1976). *Androlaelaps fahrenholzi* (Berlese) seems to be a more normal associate of this genus on eastern chipmunks so it is surprising that this species was not represented in the present survey. *A. casalis* was taken from May through November in both 1978 and 1979 although contrasting seasonal abundance patterns were evident for these two years. During 1978, infestation rates increased from a low in May to a peak in November, whereas in 1979, May and November rates were similar with a late summer drop in between.

For those months in which *A. casalis* was taken 28.3% of 314 chipmunks examined supported this mite (mean/host=1.3); this represents a total of 418 mites. There was no significant difference between proportions of male versus female (28.5% versus 28.2%; K=0.06, P=0.9522) or juvenile versus adult (28.7% versus 28.1%; K=0.11, P=0.9124) chipmunks infested by this mite. Similarly, means for infested males and females (3.5 versus 2.5; t=1.27, P>0.1) and juveniles and adults (4.0 versus 2.4; t=1.61, P>0.1) showed no significant differences (N.B. for these data the single heavy infestation of 170 *A. casalis* on an adult female chipmunk has been disregarded).

A. casalis occurred most commonly on the tail, rump and outer hind limbs of chipmunks.

Haemogamasus sp. A (Acarina, Laelapidae).

This mite and the scarcer *Haemogamasus pontiger* (Berlese) were both collected from *T. striatus* during this survey. According to many sources (e.g. Jameson 1950; Jameson and Brennan 1957), host infestation by congeneric epizoites in the same geographical area is unusual unless avoidance patterns are followed to reduce usage of very similar microhabitats. Both *Haemogamasus* species in this survey were at such low densities however that this was probably not the case; densities appeared to be low enough for stable coexistence without interspecific competition. Both species were taken in late summer/autumn and were never taken from the same host in the same examination.

A total of 27 *Haemogamasus* sp. A and six *H. pontiger* was collected. For those months in which *Haemogamasus* sp. A was taken, 7.6% of 171 chipmunks sampled were infested (mean/host=0.16); corresponding figures for *H. pontiger* were 7.7% of 65 chipmunks and 0.09. There was no significant difference between percentages of males and females (10.7% versus 5.2%; K=1.35, P=0.1770) or juveniles and adults (4.8% versus 9.3%; K=1.07, P=0.2846) infested by *Haemogamasus* sp. A. Data were too sparse for further statistical analysis for either species. Both species were present on the host tail, rump and hind limbs.

Eulaelaps stabularis (Koch) (Acarina, Laelapidae).

This mite was taken mainly during the winter months with peaks in the infestation rate and mean per host occurring in December, 1978. *E. stabularis* therefore occurs on *T. striatus* in central Tennessee when other epizoites are least common. This phenology may result in a feeding problem for this mite if it is an obligate hematophage because of concomitant chipmunk hibernation involving restricted peripheral blood flow. Frequent periods of host activity may restore normal systemic circulation for adequate time to nullify this apparent problem however. Allred and Beck (1966) took *E. stabularis* from Utah mammals in the months of February, May, June and August.

For those months in which *E. stabularis* was taken, 20.9% of 67 chipmunks sampled were infested by a total of 37 mites (mean/host=0.6). There was no significant difference between percentages of male and female (22.9% versus 18.8%; K=0.41, P=0.6818) or juvenile and adult (20.0% versus 21.2%; K=0.10, P=0.9203) chipmunks infested. Data were too sparse for futher analysis.

Eutrombicula alfreddugesi (Oudemans) (Acarina, Trombiculidae).

Larvae of this chigger are ectoparasitic on many vertebrates in the western hemisphere; nymphs and adults are not parasitic but prey on soil/humus arthropods (Krantz 1978). *E. alfreddugesi* larvae were especially common in the summer of 1978 (1433 specimens taken) being recorded from June through October; this is similar to phenology noted for this species in North Carolina by Wharton and Fuller (1952). This summer prevalence was anticipated since *E. alfreddugesi* larvae cease activity when the ambient temperature falls below 10 C and do not resume movement until it reaches 16 C (Farrell 1956). In 1979, chiggers were scarce (27 specimens taken) and were collected only in the months of July and August. This difference from 1978 could have arisen as a consequence of possible mite destruction caused by flash floods which covered the experimental site for short periods in the spring of 1979 or from a natural crash in the population.

For June through October, 1978, 21.2% of 151 chipmunks examined supported chiggers (mean/host=9.5); comparable figures for July/August, 1979 were 12.9% of 31 chipmunks and 0.9. For those months in 1978 in which chiggers were collected, the percentages of neither male versus female (16.7% versus 25.3%; K=1.29, P=0.1971) nor juvenile versus adult (25.8% versus 17.6%; K=1.22, P= 0.2225) chipmunks infested showed any significant difference. Chigger means were however significantly larger on infested female chipmunks than on males (66.4 versus 8.8; t=2.75, P=0.01) a finding that did not hold for juvenile versus adult infestations (55.5 versus 32.7; t=0.86, P>0.1). Also, during June, July and October only female chipmunks carried chiggers, wheras in August and September, only males did so (in 1979, only males had chiggers). Data for 1979 were too sparse for statistical testing.

Chiggers were most common on the rump and inner limb surfaces of hosts.

In addition to the epifauna already mentioned, some other arthropods were taken from chipmunks during this survey. Some of these are considered to represent accidental occurrences and most were scarce or infested few chipmunks.

One adult thysanopteran (*Malacothrips* sp.) with erythrocytes in its gut was removed from a chipmunk in April, 1978. Although Thysanoptera are not normally hematophagous, their mouthparts are pre-adapted for such a feeding mode and indeed hematophagy has been recorded previously for this group (Lewis 1973).

Four third instar *Cuterebra emasculator* Fitch (Diptera, Cuterebridae) bots were taken from three male (July, 1978) and one female (September, 1979) chipmunks. These larvae are specific parasites of *T. striatus* with third instars normally migrating to dermal tissues of inguinal regions. These form externally visible respiratory pores through which fully fed larvae subsequently squeeze on their way to pupation in soil. *C. emasculator* was scarce in central Tennessee when compared to infestation figures for other surveys in more northerly legions (e.g. Bennet 1955, 1972; Dorney 1965).

One adult *Lathridius liratus* LeConte beetle (Lathridiidae) was taken from chipmunk pelage in November, 1978. This species is normally nidicolous in mammal burrows (Dillon and Dillon 1972).

Three cheyletid mites were collected from one chipmunk in July, 1978 and seven *Balaustium* sp. mites (Erythraeidae) were taken from chipmunks in June/July, 1979. These probably represent normal nest/burrow fauna. Two species of phoretic, hypopial mites were secured during this survey. These were *Dermacarus hylandi* Fain (Glycyphagidae) and *Aplodontopus sciuricola* Hyland and Fain (Chortoglyphidae). Two chipmunks were infested by *D. hylandi* (one supporting 89 mites and the other about 3,000); all specimens were recorded from hair shafts on the rump of hosts. *A. sciuricola* was located only in endofollicular recesses of tail hairs. These were processed only in October, 1979 (by squeezing the bases of 25 hairs chosen as randomly as possible on each chipmunk sampled) when 33.3% (N=12) of chipmunks examined supported this species.

The following apparently accidental infestations were recorded during this survey: one adult entomobryid collembolan; one first instar coleophorid moth larva; one adult phalacrid beetle; one lampyrid beetle larva; one third instar sphaerocerid fly larva; one undetermined cyclorrhaphan fly larva; and one lithobiid centipede.

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