A STUDY OF THE PARASITES OF THE FLORIDA MOUSE, *PEROMYSCUS FLORIDANUS*, IN RELATION TO HOST AND ENVIRONMENTAL FACTORS[1]

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I. Introduction

The kinds and abundance of parasites associated with a particular mammalian host depend upon a complex interaction of many factors. Knowledge of these factors and their relative importance is essential to a full understanding of the significance of parasitism in terms of the biology of the host. In the present study an attempt has been made to obtain as complete a representation as possible of the parasitic fauna of the Florida mouse, *Peromyscus floridanus* (Chapman), and to examine the relationships between the occurrence and prevalence of particular parasite species or larger groups and such factors as age, sex, and density of host, habitat, and season.

Peromyscus floridanus occurs only in Florida, where it is further restricted in its distribution to a narrow range of habitats in certain parts of the state. It is taxonomically distinct from other species of the abundant and widespread genus *Peromyscus* and is referred to the monotypic subgenus *Podomys*. The Florida mouse apparently has affinities with western species. Its presently restricted range probably represents the survival in a Floridian refuge of a formerly more widespread population eliminated in other parts of its range by environmental changes during the Pleistocene. Information on the parasites of this rodent is therefore of interest both from the standpoint of its contribution to a knowledge of the population dynamics and environmental relationships of the species in its present range and habitats as well as perhaps providing some indication of the ecological factors that might have played a role in its evolutionary and distributional history.

II. Materials and Methods

The data on parasites included in this paper were obtained from over 800 mice collected between February, 1957, and October, 1960. Collections were made at 35 localities. Thirty-three of these were in six counties (Alachua, Clay, Gilchrist, Levy, Putnam, and St. Johns) in the northern half of peninsular Florida and two were in Highlands County in the southern part of the State (Fig. 1). All of the known habitats of *P. floridanus* were sampled, in approximate proportion to their importance, and an attempt was made to procure adequate seasonal representation from each habitat type. However, low population levels in some habitats prevented obtaining sufficient numbers of mice in all seasons.

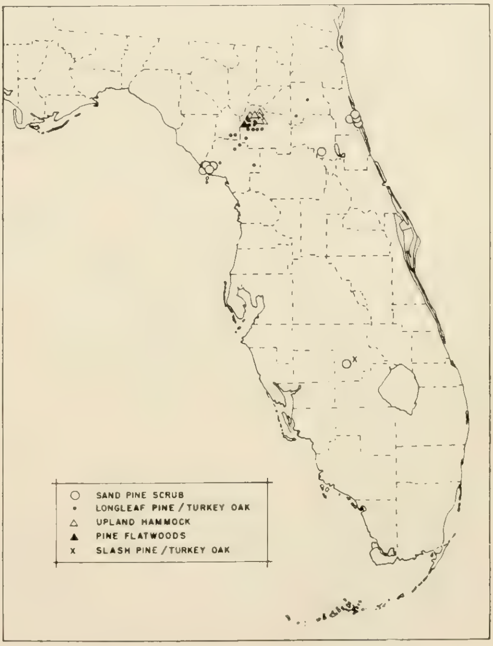

Figure 1. Map of peninsular Florida showing location of habitat types sampled.

Mice were collected with small (2 x 2½ x 6½ in.) Sherman live traps baited with rolled oats. The majority of specimens examined for parasites were trapped specifically for laboratory data. A smaller number of animals from which parasite data were

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obtained consisted of specimens that had died in traps during mark-and-release studies.

Traplines of varying numbers of stations spaced at approximately 50-ft. intervals were used in general collecting. Two traps were set at each station. Traplines ordinarily were run for periods of one to three days, and the number of mice taken per 100 trapnights was used as a general index of population density. Traps on mark-and-release study plots were set in a grid pattern of 50- or 100-ft. intervals.

Samples of from 542 to 610 mice were examined for different types of ectoparasites. Most of the specimens were brought alive to the laboratory in traps. Each mouse was then transferred directly to a waxed sandwich bag containing a pledget of ether-soaked cotton. After the mouse had died, the bag was torn open along the sides and the specimen, cotton, and bag carefully searched for parasites. After the ectoparasites that had dropped off the specimen into the bag or become entangled in the cotton were collected, the mouse was carefully combed and examined, usually with the aid of a dissecting microscope, to recover those still attached or lodged in the pelage. In some cases, specimens were quick frozen in the waxed bags after death and examined at a later time. Mice found dead in traps on mark-and-release study areas usually were kept in plastic bags until examined.

The majority of the mice obtained in the course of general collecting or from live-trapping study plots were routinely surveyed for the more conspicuous types of endoparasites at the time of necropsy. The liver, stomach, and intestines of most of the mice were preserved in 10% formalin. The livers of 698 specimens were subjected to a formalin-ether concentration technic (Ritchie, 1948) for examination for certain helminth eggs, and the alimentary tracts of 186 specimens from different habitats were intensively searched for parasites. In addition, a detailed survey for endoparasites was made in a series of 38 freshly-killed mice. Urine and kidney tissue of four mice from a single locality were cultured and examined for leptospires, and blood samples from the same individuals were tested for leptospire antibodies. Blood smears from a number of specimens taken during the course of the study were checked for parasites after staining with Wright's.

Fleas, lice, ticks, and botfly larvae occurring on individual hosts were counted. The presence of mites was recorded. Although actual counts of individuals on infested hosts were not made, relative abundance was noted. Because of limitations of time, not every ectoparasite collected was identified. The percentages of infested hosts from which parasites in a particular group were identified are as follows: trombiculid mites, 5%; non-trombiculid mites, 85%; ticks, 70%; lice, 100% (only 1 collected); fleas, 88%; and cuterebrids, 100%. All endoparasites collected were identified to the lowest taxonomic level possible, and numbers and sites of occurrence in the host were recorded for helminths and pentastomids. The abundance of intestinal protozoans was estimated from microslide preparations of fecal smears stained with hematoxylin.

For the purposes of this study, two age classes of mice were recognized: young and adult. The former category included mice in juvenal pelage or undergoing the postjuvenal molt, and the latter, specimens in which the postjuvenal molt was complete. These age classes correspond to chronological ages of approximately 4 to 16 weeks and 17 weeks or older, respectively.

III. Description of Habitats

Mice were collected from several major habitat types that are essentially equivalent to ones recognized by Rogers (1933), Carr (1940), and Laessle (1942, 1958). These habitats, together with the number of stations of each type sampled, include: sand pine scrub—10, longleaf pine/turkey oak—16, slash pine/turkey oak—1, upland hammock—6, and pine flatwoods—2. The upland hammock category employed here corresponds to that termed "ecotonal" in an earlier paper (Layne and Griffo, 1961).

The Florida mouse typically is associated with sand pine scrub and longleaf pine/turkey oak habitats. Sand pine scrub is found on fine, white, and excessively well-drained sandy soils. Sand pine (*Pinus clausa*) and three species of oaks of shrubby habit (*Quercus myrtifolia, Q. virginiana,* and *Q. chapmanni*) are diagnostic woody plants of this association. In most of the scrubs sampled in this study, the sand pines were widely spaced, and the oaks formed dense, low clumps with extensive patches of bare sand between them. Forbs were sparse, and the litter layer was largely restricted to the area beneath clumps of shrubs. Two of the stations included in the scrub category were somewhat atypical in that slash pine (*Pinus elliottii*) replaced sand pine. In all other respects, however, these areas were similar to true scrub.

The longleaf pine/turkey oak association also occurs on well-drained sandy soils, usually on low ridges or hills. Longleaf pine (*Pinus australis*) and turkey oak (*Q. laevis*) are ordinarily the only common tree species present. The pine is often sparse and in some instances may be absent. At some of the stations studied the oaks were so closely spaced as to produce nearly a closed canopy, but in most cases the stand was more open. The shrub and sapling understory varied from dense and brushy to nearly absent. Forbs were generally more abundant than in sand pine scrub habitats, and the ground cover was ordinarily better developed. Wire grass (*Aristida stricta*) is a characteristic component of the ground vegetation in longleaf pine/turkey oak habitats and may be present as scattered clumps or form a nearly continuous cover. The former condition, in which open patches of ground are frequent, is preferred by the Florida mouse. As the turkey oak is deciduous, the seasonal change in the aspect of the vegetation is more pronounced in the longleaf pine/turkey oak habitats than in the others studied.

The slash pine/turkey oak association has a limited distribution in the southern part of the state. It is intermediate between scrub and typical longleaf pine/turkey oak in species composition and general aspect.

Upland hammocks are open woodlands with sandy soils that contain more organic matter than those of the foregoing habitats and which, though still quite dry and well drained, tend toward a moister state than either scrub or pine/oak associations. Southern red oak (*Q. falcata*) is a characteristic tree in upland hammocks and a number of other species, including persimmon. (*Diospyros virginiana*), mockernut hickory (*Carya tomentosa*), loblolly pine (*Pinus taeda*), and laurel oak (*Q. laurifolia*) may also occur. The understory and ground cover ranged from heavy to sparse in the examples included in this study. Those stations that produced the best catches of mice usually had numerous stumps, logs, and bare patches of exposed soil. Also included in the upland hammock category are several stations representing ecotones between longleaf pine/turkey oak and mesic hammocks (broad-leaved woodlands containing such evergreen species as American holly and magnolia) and live oak hammocks. Both of these types environmentally were similar to typical upland hammocks. The ecotone sites had essentially the same species composition and aspect, differing chiefly in being more limited in extent and thus possibly more influenced by contiguous habitats. Live oak hammocks differed from typical upland hammocks in having the live oak as the dominant tree and a lesser variety of other woody plants. The understory was usually more open than in most of the upland hammocks with red oak as the principal tree as the result of closer spacing of the live oaks.

Pine flatwoods occupy level, poorly drained soils that are relatively rich in organic matter. Pines are the dominant trees, with the particular species present depending largely upon the edaphic conditions of the site. The understory may be variously developed and may include young pines and a variety of hardwood species. The lower strata are typically dense and may range from mostly shrubs or palmetto, or an intermixture of both, to principally grasses and forbs. As is also true of the other habitats mentioned, fire is an important factor in determining the particular vegetative characteristics of flatwoods stands. *Peromyscus floridanus* apparently only rarely inhabits pine flatwoods, and then only the better drained types during dry seasons or years. In the present study, mice were collected in only two flatwoods sites, both with longleaf pine and grassy ground cover.

Sand pine scrub and longleaf pine/turkey oak are relatively xeric environments. Studies by Rogers (1933) of evaporation rates in six woodland habitats in northern Florida showed scrub and turkey oak to have the highest overall evaporation rates, with the former having the greatest increment due to insolation (Fig. 2). Cooper *et al.* (1959) recorded temperatures in the litter layer of a scrub stand in central Florida. Monthly maximum temperatures were over 100° F every month of the year and above 125° in 8 months. The highest values occurred from

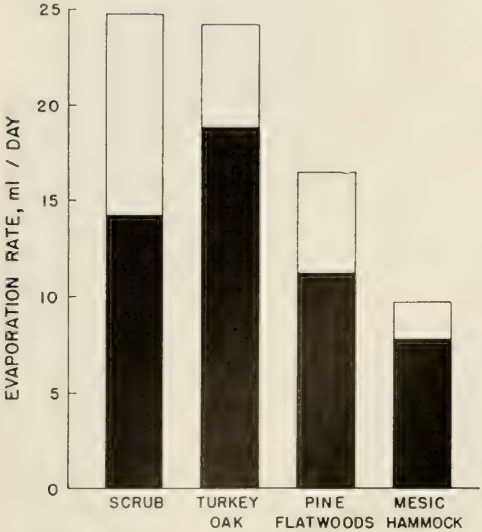

Figure 2. Average evaporation rates in four habitats in northern Florida. Based on weekly measurements given by Rogers (1933) for the period from 26 February through 23 July. White and black bulb atmometer readings are shown by solid and open portions of bars, respectively. The latter represent the increment due to insolation.

May through August, exceeding 160° in June.

Slash pine/turkey oak habitats on the basis of general observations appear to agree closely with scrub and typical turkey oak in their environmental conditions.

Upland hammocks, though still comparatively dry, are less so than the preceding habitats. They occupy an intermediate position on the moisture scale between sand pine scrub and mesophytic hammocks, which are considered to represent the climax community in northern Florida (Laessle, 1942).

The environment of pine flatwoods is subject to rather drastic fluctuations; therefore this habitat type does not fit as neatly into a sequence based on a moisture gradient as do the preceding. During droughty periods, flatwoods may be exceedingly dry, only to become quickly flooded after a brief period of rain. Under normal weather conditions, however, flatwoods are probably appreciably more mesic than either scrub or turkey oak, and possibly upland hammocks as well.

IV. Results

A. *Mites*

1. *Species records and relationships to host.*—Seven species of mites in four families were recorded. These include *Euschongastia peromysci* (Ewing), *Gahrlepia* (*Walchia*) *americana* Ewing, and *Trombicula crossleyi* Loomis of the family Trombiculidae; *Eulaelaps stabularis* (C. L. Koch) and *Haemogamasus liponyssoides* Ewing of the family Haemogamasidae; *Ornithonyssus bacoti* (Hirst) of the family Dermanyssidae; and *Haemolaelaps glasgowi* (Ewing) of the family Laelaptidae.

Trombiculid mites were collected from within the external auditory meatus, on the margin of the pinnae, and from the underside of the tail base, edge of the anus, and external genitalia. The ear canal was the most frequent site of attachment of chiggers, and ear-infesting chiggers were the most frequent ectoparasites recorded. The prevalence of chiggers in the ears of 610 specimens examined was 69.3%, as compared to 4.3% for infestations on other parts of the body. Trombiculids occurred in the ears of 70.5% of 519 adults and in 62.6% of 91 young, whereas infestations on other parts of the body were observed in 3.8% of the adults and 6.6% of the young. In neither case were the age differences significant when tested by chi-square ($P > .05$).

Samples of trombiculids for identification were collected from 22 mice selected at random from different habitats. In this series, *T. crossleyi* occurred on 10 hosts, *E. peromysci* on 7, *Trombicula* sp. on 6, and *G. americana* on 4. *T. crossleyi* was found in the ear canal of all specimens except 1, which had a single mite of this species beneath the base of the tail. Clusters of numerous individuals ordinarily occurred in the ear canal. *Trombicula* sp. was taken once on the margin of the pinna and 5 times on the underside of the tail base or on the perineal areas. *E. peromysci* was recorded only from the ear canal, and *G. americana* only from the ventral tail base and perineum. These limited data suggest species differences in the selection of attachment sites.

Trombicula sp. and *G. americana* occurred together on 2 of the 22 hosts from which chiggers were identified, *Trombicula* sp. and *T. crossleyi* on 1, and *T. crossleyi* and *E. peromysci* on 2. In view of the similarity of attachment site and the high frequency of single infestations of the last two species, the seemingly low number of joint occurrences may indicate competition as the result of similar niche requirements, as was suggested for other trombiculid species by Jameson and Brennan (1957).

Five-hundred and ninety mice were surveyed for mites other than trombiculids, and 25.9% of this sample was infested. The incidence of non-trombiculid mites on 497 adults was 28.0%, as compared to 15.0% on 93 young. The difference is highly significant on the basis of the chi-square test ($P<.01$).

Samples of body mites from 130 mice were identified. *H. glasgowi* was the commonest species, occurring on 118 (90.8%) of the specimens. *E. stabularis* was recorded from 10 (7.7%) of the mice, *H. liponyssoides* from 6 (4.6%), and *O. bacoti* from 2 (1.5%). The number of individuals of each species in the total sample indicates the same order of abundance as does prevalence. Of the total of 389 randomly collected mites identified, 89.2% (299 adults, 148 nymphs) were *H. glasgowi;* 6.2% (24 adults), *E. stabularis;* 3.9% (3 adults, 12 nymphs), *H. liponyssoides;* and 1.0% (4 nymphs), *O. bacoti.* Mixed species infestations occurred in only 8 of the 130 samples. *E. stabularis, H. glasgowi,* and *H. liponyssoides* occurred together in 1 sample; *E. stabularis* and *H. glasgowi* in 3; and *H. glasgowi* and *H. liponyssoides* in 4.

The adult sex ratio in *H. glasgowi,* the only species represented by a sufficient number of specimens to warrant this calculation, was markedly unequal. Only 15 (5.2%) of 286 sexed specimens were males, as compared to 271 (94.8%) females.

2. *Effect of host density on prevalence.*— To analyze the effect of host density on the incidence of various groups of ectoparasites, three population levels were recognized. Catches of less than 5, 6-10, and 11 or more mice per 100 trapnights were designated as "low," "moderate," and "high" populations, respectively. The prevalence of parasitism at each density level was calculated by habitat and season, then comparisons of levels of prevalence in pairs of populations representing different density levels, *e.g.,* low-moderate, moderate-high, and low-high, were made. In those instances where a change of prevalence occurred with increase in population density, the average change in prevalence as well as the direction was determined. Because of seasonal effects on prevalence in a number of ectoparasites, actual comparisons of pairs of values were made within the same season. With the sizes of the samples involved, no difference could be seen in the direction or magnitudes of change associated with low-moderate, moderate-high, and low-high pairs, thus the data for these separate comparisons were combined into two density categories, "lower" and "higher."

The relationships between host density and prevalence of mites are shown in Tables 1 and 2. In the case of trombiculids, the differences in frequencies of the three possible categories of response of prevalence to higher host density fall far short of statistical significance when tested by chi-square ($.80>P>.70$). The differences between observed and expected frequencies in the three categories approach more closely to significance ($.10>P>.05$) in the case of non-trombiculid mites. Considering only the cases of increase or decrease of prevalence corresponding to higher population density, ear-infesting trombiculids exhibit nearly twice as many increases than decreases, with a correspondingly greater change in preva-

TABLE 1.
Influence of increased host density on the prevalence of trombiculid mites attached within the ear canal

Habitat	Number of Comparisons	No Change	Decrease		Increase	
		N	N	$\bar{x}$ change in prevalence	N	$\bar{x}$ change in prevalence
Sand pine scrub	4	1	1	64.1	2	62.5
Longleaf pine/turkey oak	5	0	4	14.4	1	6.1
Upland hammock	7	4	0	–	3	46.4
Pine flatwoods	1	–	–	–	1	52.6
Combined Habitats	17	5	5	24.3	7	46.1

TABLE 2.
Influence of increased host density on the prevalence of non-trombiculid mites

Habitat	Number of Comparisons	No Change	Decrease		Increase	
		N	N	x̄ change in prevalence	N	x̄ change in prevalence
Sand pine scrub	4	1	0	–	3	16.0
Longleaf pine/turkey oak	5	0	2	20.1	3	23.7
Upland hammock	5	0	3	29.4	2	37.6
Pine flatwoods	1	0	1	25.8	0	–
Combined Habitats	15	1	6	25.7	8	24.3

lence in the increase than in the decrease category. A similar but less pronounced trend is suggested by the data for non-trombiculid mites. In neither group of parasites, however, is the evidence for a correlation between host and parasite abundance particularly convincing.

3. *Effect of habitat on prevalence.*—None of the trombiculid mite species was recorded from all of the habitats studied. *T. crossleyi* occurred in sand pine scrub, longleaf pine/turkey oak, and upland hammock; *Trombicula* sp. in longleaf pine/turkey oak and upland hammock; *G. americana* in scrub and longleaf pine/turkey oak; and *E. peromysci* in scrub, upland hammock, and flatwoods. Since the sample of identified trombiculids was small, there is some question as to how accurately the above data reflect the actual habitat tolerances of the several species represented. Most likely further sampling would have increased the known habitat distribution of at least some of the forms.

Table 3 gives the seasonal and overall prevalence of trombiculid mites in the four major habitat types studied. The incidence of trombiculids in the ear canal, presumably mostly or entirely *T. crossleyi* and *E. peromysci,* varies markedly with habitat. The prevalence ranges from a low of 41.4% in scrub to a high of 83.0% in upland hammock, with intermediate values for turkey oak (70.6%) and flatwoods (65.5%). When an R x C test for independence (Snedecor, 1946) is applied to these data, with the calculation of expected values for individual habitats being based on the incidence in all habitats combined, the observed differences are highly significant ($P<.01$). The incidence of trombiculids occurring on other parts of the body is low in all habitats, and the differences between habitats are not significant ($.20>P>.10$).

The trend in prevalence of ear-infesting trombiculids in relation to habitat probably is primarily a reflection of the environmental requirements of the free-living nymphal and adult stages. An influence of habitat on the prevalence of chiggers has been noted by a number of workers (*e.g.* Ewing, 1944; Jameson and Brennan, 1957; Michener, 1946; Mohr, 1947; Pearse, 1929; Worth, 1950), and in many instances abundance of chiggers has been correlated with habitats having a well-developed litter layer or heavy ground vegetation and relatively moist conditions. Jenkins (1947) found that *Eutrombicula batatas* laboratory colonies were most successful when maintained on a nearly saturated medium at temperatures ranging from 25 to 35° C. At relative humidities above 85%, optimum egg-laying took place between 27 and 34°, a decline occurring when temperature exceeded 35°. Apparently, therefore, temperature, humidity, and the development of litter or ground cover are among the critical factors determining the suitability of a given habitat for chiggers, a combination of relatively moist conditions, limited temperature fluctuation, and abundance of litter or ground cover tending to favor high populations.

Upland hammocks and pine flatwoods approach these conditions more closely than the other habitats represented in this study. Sand pine scrub apparently provides the poorest habitat for trombiculids, while typical longleaf pine/turkey oak woodlands rank only slightly better. The lower prevalence of ear trombiculids in these habitats as compared to upland hammock bears out these assumptions. On the basis of general environmental conditions, flatwoods would

TABLE 3.
Habitat and seasonal prevalence of trombiculid mites within the ear canal and on other parts of the body

Period	Sand pine scrub			Longleaf pine/turkey oak			Upland hammock			Pine flatwoods		
	No. exam.	Percent infested		No. exam.	Percent infested		No. exam.	Percent infested		No. exam.	Percent infested	
		Ear canal	Other		Ear canal	Other		Ear canal	Other		Ear canal	Other
Jan.-Mar.	–	–	–	52	25.0	0.0	40	72.5	2.5	27	37.0	0.0
Apr.-June	82	20.7	4.9	12	41.7	0.0	54	46.3	1.8	31	90.3	9.7
July-Sept.	33	90.9	6.1	77	97.4	14.3	76	100.0	3.9	–	–	–
Oct.-Dec.	1	100.0	0.0	60	81.4	0.0	65	100.0	1.5	–	–	–
Total	116	41.4	5.2	201	70.6	5.5	235	83.0	2.6	58	65.5	5.2

TABLE 4.
Habitat and seasonal prevalence of non-trombiculid mites

Period	Sand pine scrub		Longleaf pine/ turkey oak		Upland hammock		Pine flatwoods	
	No. exam.	Percent infested	No. exam.	Percent infested	No. exam.	Percent infested	No. exam.	Percent infested
Jan.-Mar.	–	–	61	26.2	40	57.5	28	32.1
Apr.-June	81	19.8	20	40.0	54	44.4	31	25.8
July-Sept.	29	13.8	61	14.8	72	16.7	–	–
Oct.-Dec.	1	0.0	50	24.0	62	19.4	–	–
Total	111	18.0	192	23.4	228	31.1	59	28.8

be expected to have a relatively higher prevalence than that observed. The apparently low value for this habitat may be explainable, at least in part, on the basis of a sample bias. Data for other habitats indicate a strong interaction between habitat and season, with a marked increase in the abundance of chiggers in the period from July through December. This interval is not represented in the sample from flatwoods. Thus, if the same seasonal trend in chigger prevalence occurs in this habitat as in others, the overall prevalence should equal or even exceed that for upland hammock. The alternation between wet and dry conditions may also influence trombiculid populations in flatwoods.

Infestation rates of non-trombiculid mites are slightly higher in the moister habitats (Table 4). However, the observed frequencies in different habitats do not differ significantly from expected values based on the overall prevalence ($.02>P>.05$). The occurrence and relative abundance of the individual non-trombiculid species identified from 130 mice taken in different habitats (Table 5) indicate that *H. glasgowi* is the most common species on *P. floridanus* in every habitat. It does not exhibit any pronounced habitat specificity, although Worth (1950) reported this species to be more prevalent in moist habitats in south Florida. *H. liponyssoides* is the only other species occurring in all habitat types, appearing to be most abundant in flatwoods. *E. stabularis* seems to be more abundant in the moister of the two environments, longleaf pine/turkey oak and upland hammock, from which it was recorded.

The apparent low degree of correlation between habitat type and prevalence of non-trombiculid mites as compared to chiggers may be a reflection of the greater influence of physical environmental factors on the latter as a result of their free-living nymphal and adult stages. Since non-trombiculid species are parasitic in both nymphal and adult stages and require the host's nest for their life cycle, they may be more independent of the direct effects of environment than chiggers. Thus, over the environmental range encountered in this study, their populations may depend to a greater extent on the kinds and abundance of mammalian hosts in a given habitat.

4. *Effect of season on prevalence.*—When the data on prevalence of trombiculid mites in all habitats are combined into 3-month periods (January-March, April-June, July-September, October-December), pronounced seasonal trends in abundance are indicated. The prevalence of trombiculids in ears is low during the first six months of the year (43.7% for the January-March period and 41.9% for the April-June interval) and high in the last half of the year (97.3% in the July-September period and 90.4% in the October-December quarter). The differences

TABLE 5.
Percentages of mice carrying different non-trombiculid mites in four habitats

Species of Mite	Sand pine scrub	Longleaf pine/ turkey oak	Upland hammock	Pine flatwoods
Eulaelaps stabularis	–	5.6	11.3	–
Haemogamasus liponyssoides	5.6	2.8	3.2	21.4
Ornithonyssus bacoti	–	5.6	–	–
Haemolaelaps glasgowi	94.6	86.1	90.3	100.0

in prevalence in the quarterly periods are highly significant (P<.01) when tested for independence against expected values based on the overall incidence. Monthly infestation rates for all habitats give a more precise indication of seasonal trends in abundance of ear chiggers. The prevalence exceeded 90% from June through November, declined in December (79.6%) and January (82.1%), reached its lowest levels in February (4.5%), March (18.2%) and April (4.6%), then increased again in May (37.5%). These data indicate a yearly cycle in prevalence, with peak abundance occurring during the summer and fall months.

In the case of individual habitats, complete seasonal data on prevalence is available for longleaf pine/turkey oak and upland hammock, and in both habitats the seasonal trends are similar to those of the combined data. Although certain periods are not represented in the data for sand pine scrub and flatwoods, the trends suggested by the partial information also indicate agreement with the overall pattern. However, while the four habitats appear to exhibit the same seasonal patterns in prevalence, infestation rates in individual habitats during comparable seasons show considerable variation. Thus, upland hammock exhibits a higher incidence in the January-March period than either turkey oak or flatwoods (data not available from scrub for this interval), while flatwoods has a much higher prevalence in the April-June period than any of the other habitats. These differences probably represent the interaction between habitat and seasonal factors. For example, the generally higher prevalence in upland hammock and flatwoods during the early part of the year as compared to scrub and turkey oak may indicate a higher survival of trombiculids in these habitats during the winter as a result of more favorable cover, moisture, and temperature conditions.

Although the differences are less pronounced than those of ear-infesting trombiculids, the prevalence of chiggers on other parts of the body exhibits seasonal variation. The differences are highly significant (P<.01). The prevalence in the January-March and October-December periods was 0.8%, as compared to 4.5% in the April-June interval and 8.6% in the July-September quarter. The general trend is similar to that of ear trombiculids except that the peak in abundance may occur somewhat earlier.

The seasonal changes in abundance of chiggers probably reflect a response to climatic conditions, particularly temperature and humidity. The period of greatest abundance occurs when temperatures are high and rainfall is abundant. Strong seasonal trends in abundance of various species of trombiculids on mammalian hosts have been reported by other workers (e.g., Elton *et al.*, 1931; Jameson and Brennan, 1957; Michener, 1946; Worth, 1950), with peak abundance often coinciding with increased moistness of the habitat.

Seasonal differences in the prevalence of non-trombiculid mites are also pronounced. The departure of the observed frequencies for quarterly periods from expected values calculated from overall incidence is highly significant (P<.01). In contrast to chiggers, however, the increased prevalence of other mites occurred during the January-June period. The months of greatest abundance, 53.3% and 58.9%, respectively, were March and April. Insofar as data are available, these trends for individual habitats agree generally with that for all habitats combined. As in the case of trombiculids, differences in prevalence between habitats in comparable seasons probably reflect the interaction between habitat and season.

The observed trends in seasonal abundance of non-trombiculid mites are chiefly due to *Haemolaelaps glasgowi,* which is the most abundant species in the sample. The increased prevalence of this species during late winter and early spring agrees generally with the findings of Morlan (1952) and Smith and Love (1958). The latter also found *H. glasgowi* to be more abundant in wet years.

The increased occurrence of non-trombiculid mites on hosts in the cooler months may reflect a peak in an annual population cycle. This trend may also be the result, at least in part, of a greater tendency of mites to remain on the host rather than in the nest in cool weather. Paralleling the situation in the case of habitat, the seasonal changes in apparent abundance of non-trombiculids are of lesser magnitude than those of chigger mites. Again, this may indicate that the former, being more closely associated with the nest, are less subject to outside environmental conditions. A similar relationship

TABLE 6.
Influence of increased host density on tick prevalence

Habitat	Number of Comparisons	No Change	Decrease		Increase	
		N	N	x̄ change in prevalence	N	x̄ change in prevalence
Sand pine scrub	4	0	3	10.6	1	5.3
Longleaf pine/turkey oak	5	2	0	–	3	8.1
Upland hammock	9	1	5	10.9	3	10.8
Pine flatwoods	1	0	1	11.1	0	–
Combined Habitats	19	3	9	10.8	7	8.9

in the seasonal prevalence of trombiculids and other mites on small mammals in California was observed by Jameson and Brennan (1957).

B. *Ticks*

1. *Species records and relationships to host.*—Four species of ticks collected on *P. floridanus* included *Dermacentor variabilis* (Say), *Amblyomma maculatum* Koch; *Amblyomma americanum* (Linn.), and *Ixodes minor* Neumann (=*I. bishoppi* Smith and Gouck).* The prevalence of ticks on a total of 600 mice examined for these parasites was 7.8%. The prevalence on adults (7.2%) was not significantly different (.50>P>.30) from that on young (11.2%). *D. variabilis,* the only tick commonly represented, occurred on 29 of 33 hosts from which ticks were identified. All were nymphs or larvae. *A. americanum* (2 larvae) was collected on only two mice, and *A. maculatum* (1 nymph) and *I. minor* (1 adult), were each taken on a single host. The average number of ticks on infested hosts was 1.3. The number of *D. variabilis* larvae or nymphs on mice ranged from 1 to 8, with a mean of 1.6.

*Smith and Gouck (1947) described *Ixodes bishoppi* from Georgia. However, according to G. M. Kohls (personal communication) *I. bishoppi* is probably a synonym of *I. minor* earlier described from Guatemala, and on this basis the latter name is employed in this paper.

In a series of 39 infested mice, ticks were attached to the pinna of 31 (79.5%), to the shoulder of 6 (15.4%), and within the ear canal of 3 (7.7%). The one specimen of *I. minor* was attached to the shoulder.

2. *Effect of host density on prevalence.*—The frequencies of no change, decrease in prevalence, or increase in prevalence of ticks in comparisons between lower and higher host population levels (Table 6) do not differ significantly from those expected on a random basis (.20>P>.10). In contrast to mites there is slight indication of a negative correlation between tick prevalence and host density.

3. *Effect of habitat on prevalence.*—*D. variabilis* was recorded in each of the major habitats studied, whereas the other species were each taken in one habitat type: *I. minor* in scrub, *A. maculatum* in upland hammock; and *A. americanum* in longleaf pine/turkey oak. Because of the few records involved, the extent to which the data reflect actual habitat specificity of these ticks is questionable.

Table 7 presents the habitat and seasonal distribution of 47 tick infestations on 600 mice. The differences between observed and expected habitat-specific frequencies is highly significant (P.<.01), with the greatest number of infestations occurring in upland hammock. The increased prevalence of ticks in upland hammock habitats probably is due

TABLE 7.
Habitat and seasonal prevalence of ticks

Period	Sand pine scrub		Longleaf pine/ turkey oak		Upland hammock		Pine flatwoods	
	No. exam.	Percent infested	No. exam.	Percent infested	No. exam.	Percent infested	No. exam.	Percent infested
Jan.-Mar.	–	–	58	6.9	40	15.0	28	3.6
Apr.-June	81	2.5	16	0.0	54	16.7	31	0.0
July-Sept.	30	10.0	68	1.5	76	6.6	–	–
Oct.-Dec.	1	100.0	52	5.8	65	16.9	–	–
Total	112	5.4	194	4.1	235	13.6	59	1.7

mainly to the existence of favorable environmental conditions. The relatively high humidity of this habitat type, absence of extremely high temperatures, and abundance of brush, debris, and litter probably offer more suitable conditions for tick survival and reproduction than the other vegetative associations represented. Since the adult stages of the ticks recorded, except possibly *I. minor,* are found typically on larger mammals, the population levels of raccoons, opossums, bobcats, and foxes presumably would interact with habitat factors in influencing tick abundance. Evidence indicates that larger mammals were not abundant in the flatwoods habitats represented in the present study, and this might be at least partly responsible for the lower prevalence of ticks in this environment than would be predicted on the basis of vegetative characteristics alone.

4. *Effect of season on prevalence.*—The prevalence of ticks in 3-month intervals through the year was as follows: January-March, 8.7%; April-June, 6.4%; July-September, 5.2%; and October-December, 12.7%. Although the observed seasonal frequencies do not differ significantly ($.10 > P > .05$) from expected values, the limited data suggest, however, that tick abundance may be highest in the fall and early winter months.

C. *Lice*

One specimen of *Hoplopleura hirsuta* Ferris was collected in a sample of 574 mice examined, a prevalence of 0.2%. The louse was taken on a Florida mouse collected in pine flatwoods in March. The cotton rat, *Sigmodon hispidus,* was abundant at this locality, and in all probability the louse was a straggler from this host.

D. *Fleas*

1. *Species records and relationships to host.*—Four species of fleas recorded included *Polygenis floridanus* Johnson and Layne, *Polygenis gwyni* (Fox), *Ctenophthalmus pseudagyrtes* Baker, and *Hoplopsyllus affinis* (Baker).

One hundred and eighty (33.2%) of the 542 mice examined carried fleas. The prevalence of fleas on adults was 33.6% as compared to 30.8% on young, the difference not being statistically significant ($.90 > P > .80$). The numbers of adult males and females infested were practically equal (males, 33.3%; females, 34.0%), but a greater number of young males (36.8%) carried fleas than females (25.0%). The number of fleas on infested mice ranged from 1 to 16, averaging 2.3. The mean was somewhat lower in adults (2.2) than in young (3.0), but in neither age class did the flea index of the sexes differ appreciably (adult males, 2.3; adult females, 2.1; young males, 3.0; young females, 2.9).

Three hundred and sixty-five fleas were identified, this number representing all of the fleas carried by 158 of the 180 animals infested. *Polygenis floridanus* occurred on 94.9% (150) of the mice and comprised 92.3% (337) of the total identified sample. It was the only common flea on *Peromyscus floridanus,* being known thus far only from this host (Johnson and Layne, 1961). *Polygenis gwyni,* perhaps the most abundant flea on other small terrestrial rodents in Florida, occurred on only 10.1% (16) of the mice and constituted only 5.2% (19) of the sample. *C. pseudagyrtes* was taken on 5.1% (8) of the specimens and represented only 2.2% of the fleas determined. One *H. affinis* was collected. Since the typical hosts of this flea are hares and rabbits (Kohls, 1940), its presence on the Florida mouse is considered accidental.

The majority (89.8%) of infestations were of single species, and in no instance was more than two species of fleas found on the same host. *Polygenis floridanus* was the only flea recorded in 85.4% of the infestations, *P. gwyni* in 3.8%, and *C. pseudagyrtes* in 0.6%. *P. floridanus* and *gwyni* occurred together on 5.7% of the hosts, *P. floridanus* and *C. pseudagyrtes* on 3.8%, and *P. gwyni* and *C. pseudagyrtes* on 0.6%. The mean numbers of specimens per infested host of each species were: *P. floridanus,* 2.2; *P. gwyni,* 1.2; and *C. pseudagyrtes,* 1.0.

2. *Effect of host density on prevalence.*—The prevalence of fleas apparently is more closely related to host numbers than in the case of acarine parasites (Table 9); the effect of change in host density on the flea index is more pronounced than would be expected on the basis of chance ($P < .01$). In 22 pairs of values compared, an increase was recorded in 15 (68.2%) and a decrease in 6 (27.3%). The mean percentage change in prevalence in going from a lower to higher population was approximately equal

TABLE 8.
Influence of increased host density on flea prevalence

Habitat	Number of Comparisons	No Change	Decrease		Increase	
		N	N	$\bar{x}$ change in prevalence	N	$\bar{x}$ change in prevalence
Sand pine scrub	4	0	0	–	4	38.8
Longleaf pine/turkey oak	5	0	3	20.7	2	31.9
Upland hammock	12	1	2	51.5	9	26.1
Pine flatwoods	1	0	1	1.2	0	–
Combined Habitats	22	1	6	27.6	15	30.3

for both increases and decreases (Table 8) in infestation rates.

3. *Effect of habitat on prevalence.*—The differences in prevalence in different habitats are highly significant ($P<.01$). Infestations were more frequent than expected in sand pine scrub and longleaf pine/turkey oak and less so in upland hammock and pine flatwoods habitats (Table 9).

C. pseudagyrtes was collected in upland hammock and flatwoods only, its prevalence being 3.1 and 1.7%, respectively in the two habitats. *H. affinis* occurred in slash pine turkey oak, from which numerous *Polygenis floridanus* were also obtained. *P. floridanus* and *gwyni* were each taken in the four major habitats studied, but the relative abundance of these species varied from one habitat to another. *P. gwyni* occurred most frequently in sand pine scrub (7.4%) and flatwoods (10.3%) and had a low prevalence in longleaf pine/turkey oak (1.3%) and upland hammock (0.9%). *P. floridanus,* on the other hand, was most abundant in sand pine scrub (34.6%) and longleaf pine-turkey oak (35.5%), and least so in upland hammock (23.8%) and flatwoods (27.6%).

A relationship between the host's environment and the occurrence and abundance of particular flea species has been shown by a number of workers, including Gabbutt (1961), Jameson (1947), Jameson and Brennan (1957), Pearse (1929), and Worth (1950). The habitat distribution of two of the flea species associated with the Florida mouse may be related mainly to the ecological distribution of their typical small mammal hosts, while that of the third may be due in greater measure to the direct effect of environmental factors. *C. pseudagyrtes* commonly occurs on moles and shrews, and the greater abundance of these mammals in upland hammocks and flatwoods than in either scrub or turkey oak probably accounts for the appearance of this flea on the Florida mouse only when it occurs in the first two habitats. *Polygenis gwyni* is a characteristic flea of the cotton rat. In this study cotton rats occurred commonly only in flatwoods and in certain scrub habitats, and it is in these vegetation types that *P. gwyni* is encountered most frequently on the Florida mouse. Within scrub habitats, the prevalence of *Polygenis gwyni* on the Florida mouse showed a close positive correlation with the size of the cotton rat population.

The greater abundance of *Polygenis floridanus* in scrub and turkey oak habitats than in upland hammock and flatwoods may be indicative of preference for more xeric conditions, since host predilection can be ruled out. The environmental distribution of flea and host show a close correspondence. Present data indicate that sand pine scrub and

TABLE 9.
Habitat and seasonal prevalence of fleas

Period	Sand pine scrub		Longleaf pine/ turkey oak		Upland hammock		Pine flatwoods	
	No. exam.	Percent infested	No. exam.	Percent infested	No. exam.	Percent infested	No. exam.	Percent infested
Jan.-Mar.	–	–	50	52.0	39	28.2	28	21.4
Apr.-June	50	40.0	14	92.8	68	30.9	31	41.9
July-Sept.	32	43.8	61	21.3	56	12.5	–	–
Oct.-Dec.	1	0.0	52	38.5	60	26.7	–	–
Total	83	41.0	177	40.7	223	24.7	59	32.2

longleaf pine/turkey oak are the primary habitat types of the Florida mouse. Upland hammock is less important, and the species occurs only sporadically in flatwoods, and then only under particular conditions. The low prevalence of *Polygenis floridanus* in flatwoods might be the result of general environmental conditions or specific microclimates of the nests of the host in this habitat. Also, possibly the initial flea population on mice dispersing from more favorable habitats may have been low.

4. *Effect of season on prevalence.*—Fleas were most abundant (41.0%) in the period from April to June, while the prevalence dropped to 22.8% in the July-September interval. In the following 3-month period infestations increased to 31.8% and rose still higher (36.8%) in the January-March interval. These values depart significantly ($P<.01$) from the assumption of equal prevalence in all seasons. Trends of seasonal abundance in upland hammock and longleaf pine/turkey oak agree with that of the combined data. Although data are available from only the January-June period in flatwoods, the trend in prevalence of fleas during this interval follows the general pattern also. In sand pine scrub, however, a higher prevalence is indicated for the July-September period relative to the April-June interval than in other habitats.

The one *H. affinis* was collected in April. *C. pseudagyrtes* was obtained in upland hammock habitats in March, April, and June; and in flatwoods in May. *P. gwyni* occurred on mice only during the first six months of the year. Its prevalence in the January-March interval was 3.1% and in the April-June period, 7.9%. The data for this species suggest, therefore, an increased abundance on hosts during the late winter and spring. Similar findings were reported for this species on cotton rats in Georgia by Morlan (1952) and Smith and Love (1958).

The overall seasonal trend in flea abundance can be attributed largely to *P. floridanus*. The prevalence of this species in the January-March period was 31.6%, in the April-June interval, 34.8%, in the July-September period, 22.0%, and in the October-December period, 28.4%. The mean number of fleas per infested host exhibited a similar trend, being 2.9, 2.5, 1.5, and 2.4 for the four periods. Copulating pairs of fleas were observed on hosts during live-trapping operations in March. Where comparable periods are represented, the data for individual habitats show about the same seasonal patterns. Sand pine scrub, however, appears to have peak flea abundance at a somewhat later time of the year than other habitats. The data indicate that the abundance of fleas on hosts is highest during the cooler months of the year, reaching a peak in the spring. The extent to which the trend involves actual changes in flea populations or seasonal differences in the activity or behavior of the fleas or hosts is unknown.

Total and seasonal sex ratios were calculated for *Polygenis floridanus*. In a sample of 378 specimens collected in all months of the year 48.9% were males, 51.1% females. The highest proportion of males (57.3%) occurred in the January-March sample, followed by the April-June period (48.6%). Males constituted 47.8% of the fleas collected in the July-September interval and only 42.1% of those from the October to December period. Although the sex ratios calculated for 3-month periods do not differ significantly ($.3>P>.2$) from equality, a trend toward a higher number of females in late fall and early winter is suggested. This may indicate a sex difference in temperature response similar to that shown for *Xenopsylla cheopis* by Cole (1945). The correlation of high flea prevalence and increased proportion of males in the spring with observed copulation suggests the possibility that changes in sex ratio or overall abundance of fleas on hosts also may be associated with reproductive activity.

E. *Botflies*

1. *Species record and relationships to host.*—The species of botfly, *Cuterebra*, infesting the Florida mouse is questionable. An unsuccessful attempt was made to rear specimens obtained from this host. However, adult flies were reared from larvae taken from cotton mice (*Peromyscus gossypinus*) trapped in the same habitats as *Peromyscus floridanus*. According to Dr. C. W. Sabrosky these forms, presumably the same parasitizing the Florida mouse, closely resemble *C. angustifrons* Dalmat, although differing slightly from the latter in some particulars.

The overall prevalence of *Cuterebra* larvae in 630 mice was 3.6% (23 specimens infected). The difference in infection between adults (3.5%) and young (4.4%) was not significant (.98>P>.95). The location of the bots was recorded for 20 mice. The larvae were located in the inguinal region of 18 specimens, in the lumbar region of 1, and in the sacral region of 1. Ten of 15 mice carrying living larvae had a single bot. Two larvae were present in each of 3 mice, and 2 animals each contained 3 larvae.

2. *Effect of host density on prevalence.*— Because of the low prevalence rate in other habitats, host abundance and prevalence of cuterebrids can be considered for upland hammock habitats only. In three pairs of values, the prevalence was decreased in two and increased in one case with higher population density. The small sample of course precludes drawing any definite conclusions about the relationship between prevalence of cuterebrids and host density, although, as suggested by the data for ticks, an increase of hosts might be associated under some circumstances with a reduction in the frequency of botfly infections. Wilson (1945) observed an increase in the occurrence of cuterebrids correlated with a low population of *Peromyscus leucopus,* and a similar trend is indicated by the data of Scott and Snead (1942) and Wecker (1962).

3. *Effect of habitat on prevalence.*—Habitat differences in the prevalence of botfly infections (Table 10) were highly significant in terms of expected values based on prevalence in all habitats combined (P<.01). Upland hammock was the only habitat type in which botfly infection reached significant proportions. The prevalence of infections in longleaf pine/turkey oak and pine flatwoods was low, and no mice with cuterebrid larvae were recorded from sand pine scrub. The apparently strong restriction of infections to upland hammock associations becomes even further pronounced when the data for longleaf pine/turkey oak areas are examined more closely. All of the records of botfly larvae in mice in this habitat type came from a single station in which a long term live trapping study is in progress. The study area consists of about 26 acres of longleaf pine/turkey oak habitat surrounded on two sides by mesophytic hammock, with a narrow ecotone between the two habitat types. The Florida mice in this area are confined largely to the turkey oak association, although some are trapped in the ecotone. None has ever been taken in the hammock. An examination of the trapping records of the infected individuals from this area showed that, although their home ranges lay largely in the turkey oak zone, occasionally they did range into the moister ecotone areas. No animals known to live entirely within the turkey oak were recorded with botfly infections.

The restricted ecological distribution of cuterebrid infections probably can be attributed to the effect of physical environmental factors on the adult or larval stages of the parasite. The adult flies may prefer moist, shady situations and may occur less frequently in more open, drier environments. Evidence on the life cycle of the forms infesting *Peromyscus* suggests that the flies lay their eggs around the homesites or in local areas frequented by the mice and that the eggs hatch into larval stages which are attracted by the proximity of the host (Dalmat, 1943; Penner and Pocius, 1956). A poorer survival of larval stages might also be a factor contributing to the low level of infections in the drier habitats.

4. *Effect of season on prevalence.*—Living bots or fresh exit sites were recorded

TABLE 10.
Habitat and seasonal prevalence of cuterebrid larvae

Period	Sand pine scrub		Longleaf pine/ turkey oak		Upland hammock		Pine flatwoods	
	No. exam.	Percent infected	No. exam.	Percent infected	No. exam.	Percent infected	No. exam.	Percent infected
Jan.-Mar.	–	–	58	0.0	40	4.5[a]	28	0.0
Apr.-June	72	0.0	23	0.0	56	5.4[b]	31	3.2
July-Sept.	46	0.0	70	0.0	77	2.6	–	–
Oct.-Dec.	1	0.0	63	6.3	65	16.9[c]	–	–
Total	119	0.0	214	1.9	238	7.6	59	1.7

[a] one old scar, 1 dead.
[b] one with old scar.
[c] two with old scars.

in June (1); July (3), October (4), and November (7). The differences in prevalence in 3-monthly periods are significant ($P<.01$) when tested for independence. The seasonal distribution of infections thus indicate an increased prevalence in the fall months. Similar seasonal trends in prevalence of cuterebrid larvae in *Peromyscus* have been reported for more northerly regions (Burt, 1940; Test and Test, 1943; Dalmat, 1943; Sealander, 1961; Wecker, 1962). The infection rate in Florida mouse populations is lower generally than those reported for *Peromyscus leucopus* by several authors (Test and Test, 1943; Dalmat, 1943; Scott and Snead, 1942; Hirth, 1959; Sealander, 1961, Abbott and Parsons, 1961; Wecker, 1962), a possible reason being that *P. leucopus* occurs more regularly in habitats favorable to *Cuterebra* than does P. *floridanus.*

F. *Leptospires*

No evidence of leptospire infections was obtained from four mice collected at one sand pine scrub station. This sample is far too small to give any indication of the true status of leptospires in this host.

G. *Protozoa*

Blood smears of 10 mice and fecal samples of 38 specimens were examined for parasites. All blood smears were negative. *Endamoeba ? muris* (Grassi), *Trichomonas ? muris* (Grassi), and *Giardia ? muris* (Grassi) were recorded in fecal preparations. *Endamoeba* occurred in 2 (7.1%) of 28 mice from which smears were made, *Trichomonas* in 17 (60.7%), and *Giardia* in 12 (42.8%). One young mouse had relatively large numbers of *Trichomonas* and *Giardia*, and the former was abundant in one adult female. According to Dr. Elliott Lesser, who made the examinations and determinations, the remainder of the mice had relatively light infections of these protozoans, with the incidence of *Endamoeba* being particularly low.

Preserved feces from 8 of 10 mice from scrub habitats contained parasitic protozoans. Two specimens had only *Trichomonas,* 4 only *Eimeria* sp. (oocysts), and 2 both.

H. *Helminths*

1. *Trematodes.*—The ova of an unidentified, apparently dicrocoeliid, fluke were recovered from livers subjected to the formalin-ether concentration technic. Although careful dissections of numbers of both fresh and preserved livers were made, no adult flukes were observed, or were recognizable fragments of adults found in the egg-containing sediments from treated livers.

The prevalence of this parasite, as indicated by the occurrence of ova in livers, was 7.0% in a sample of 723 mice from all habitats combined. Considering only populations from which infected specimens were recorded, the prevalence of infection was 15.0%. In these populations, 15.9% (50) of 315 adults were infected, as compared to 3.8% (1) of 26 young. Although suggestive of the existence of an age difference in infection rare, the difference is not statistically significant ($.10>P>.05$).

The correlation between habitat type and infection rate is high ($P<.01$). Forty-five (88.2%) of 51 infected mice were from upland hammock or pine flatwoods habitats (Table 11). The evidence for the restriction of infections to the moister of the habitat types utilized by Florida mice is strengthened by the fact that the one infected mouse recorded from sand pine scrub was collected in close proximity to a mesic hammock and that each of five infected animals from longleaf pine/turkey oak were from a live-trapping study area and had capture records showing that they ranged into the moister ecotone area between the turkey oak and an adjoining mesic hammock. The close correlation between the occurrence of the parasite and the moistness of the habitat is probably related to the ecological distribution of an intermediate molluscan host.

Infections were recorded in all months with the exception of May, August, and September. In those populations in which in-

TABLE 11.
Prevalence of unidentified trematode in different habitats based on presence of eggs in liver

Habitat	Number Examined	Percent Infected
Sand pine scrub	120	0.8[a]
Slash pine/ turkey oak	45	0.0
Longleaf pine/ turkey oak	246	2.0
Upland hammock	256	15.6
Pine flatwoods	56	8.9
Total	723	7.0

[a] captured near mesophytic hammock

fections were present, the mean prevalence was 15.9% for the January-March period, 30.9% for April-June, 18.0% for July-September, and 6.7 for October-December. The data are, therefore, suggestive of a tendency toward a higher frequency of infections in the warmer months of the year.

2. *Cestodes.*—Larval cestodes were rare, only 3 cases being recorded in over 700 specimens examined from all habitats. One mouse from longleaf pine/turkey oak had cysticerci of either *Cladotaenia* or *Paruterina* in the liver. The former is a parasite of hawks in the adult stage and the latter, a parasite of owls. One mouse from slash pine/turkey oak and another from sand pine scrub habitat about ½ mile away had *Taenia lyncis* Skinker cysticerci in the liver. Only one specimen was present in each case.

The only adult cestode recorded was *Hymenolepis ? nana* (Siebold). It occurred in 4.8% (9) of 186 mice examined from all habitats combined. Although the prevalence of infections was higher in adults (5.1%) than young (3.6%), the difference is not significant. The mean number of worms per infected host was 3.0, with a range of from 1 to 11. *Hymenolepis* was recorded in mice from all habitats, with the highest number of infections being encountered in sand pine scrub and upland hammock environments (Table 12). A seasonal trend in infections is suggested by the data. The highest prevalence during the year (12.0%) occurred during the January-March period. From April to June, 3.6% of the mice were infected. No infections were recorded in the July-September interval, and the prevalence in the October-December period was only 2.0%.

3. *Nematodes.*—Five species of nematodes were recorded. These included *Capillaria hepatica* (Bancroft), *Rictularia ?coloradensis* (Hall), *Aspiculuris americana* Erickson, *Syphacia peromysci* Harkema, and *Trichostrongylus ransomi* Dikmans.

The prevalence of *C. hepatica* infection in the livers of 723 mice from all habitats was 2.9% (Layne and Griffo, 1961). Considering only those populations in which infections were recorded, the prevalence was 12.7%. *Aspiculuris* occurred in 32.2% (60) of 186 mice examined from the four major habitats. The mean number of worms in infected hosts was 4.2 with a range of from 1 to 31. *Rictularia* occurred in 9.1% of the mice. The average number of worms in infected mice was 5.7, with extremes of 2 and 14. Harkema (1936) observed a higher prevalence rate for this parasite in *Peromyscus leucopus* in North Carolina, but usually found only single worms, rarely two, in infected hosts. *Syphacia* was present in 2.2% of the animals, averaging 2.2 worms per host. Only one mouse had more than one worm (6). One infection of *Trichostrongylus* was recorded, a prevalence of 0.5%, and only one individual was collected.

Seven of 84 mice infected with either *Hymenolepis, Rictularia, Aspiculuris, Syphacia,* or *Trichostrongylus* possessed more than one form. Three had both *Hymenolepis* and *Aspiculuris,* while single cases each were recorded for the following combinations: *Rictularia/Aspiculuris, Syphacia/Trichostrongylus,* and *Aspiculuris/Syphacia.*

A general trend of higher infection rates in adults as compared to young was noted in all nematodes for which adequate samples were available. *C. hepatica* occurred in 15.5% of the adults in infected populations and in only 2.8% of the young (Layne and Griffo, 1961). The prevalence of *Rictularia* in adults was 10.1% as compared to 3.6% in young. Corresponding values for *Aspiculuris* were 34.2 and 21.4%. These differences are statistically significant ($P < .05$) only in the case of *C. hepatica.*

TABLE 12.
Prevalence of five helminths in different habitat types

Habitat	Total No. Examined	Percent Infected	Hymenolepis	Rictularia	Aspiculuris	Syphacia	Trichostrongylus
			Percent infected	Percent infected	Percent infected	Percent infected	Percent infected
Sand pine scrub	45	48.9	8.9	35.6	11.1	0.0	0.0
Longleaf pine/ turkey oak	59	42.4	1.7	1.7	40.7	0.0	0.0
Upland hammock	52	48.1	5.7	0.0	44.2	0.0	0.0
Pine flatwoods	31	38.7	3.2	0.0	25.8	12.9	3.2

C. hepatica exhibited a marked habitat restriction, occurring only in mice from sand pine scrub and slash pine/turkey oak habitats (Layne and Griffo, 1961). The combined prevalence of five helminths of the alimentary tract was highest in sand pine scrub and upland hammock, lowest in pine flatwoods, and intermediate in longleaf pine/turkey oak (Table 12). When tested for independence, however, these differences are not statistically significant ($.80 > P > .70$). Of the other four nematode species, *Aspiculuris* had the greatest habitat range, showing greater abundance in mice from longleaf pine/turkey oak and upland hammock and less in sand pine scrub and pine flatwoods. *Rictularia* was the most prevalent nematode in sand pine scrub, occurring outside of this habitat only in longleaf pine/turkey oak, where it was infrequent. *Syphacia* and *Trichostrongylus* were recorded only in pine flatwoods.

Some suggestion of seasonal trends in prevalence is evident in the data for three of the nematodes. The prevalence of *C. hepatica* reached its highest level (9.8%) in the April-June period, declining to 3.0 and 2.4%, respectively, in the July-September and October-December samples. No infections were recorded in the January-March interval. In contrast, *Rictularia* and *Aspiculuris* were most prevalent in the January-March period. The former declined from 14.0% to 10.9% in the April-June interval. The lowest infection rate occurred in the July-September sample (3.2%), that for the October-December period being somewhat higher (6.0%). *Aspiculuris* infections dropped from 42.0% in the January-March sample to 30.9% in the April-June period. The prevalence of this parasite was 38.7% in the July-September interval and 20.0% in the October-December period.

I. *Pentastomids*

Nymphal stages of the pentastomid *Porocephalus crotali* (Humboldt) were found in 7 (0.8%) of 840 Florida mice examined. Apparently the occurrence of *P. crotali* nymphs in the Florida mouse constitutes the third record of this parasite in North American mammals. Penn (1942) reported its presence in the muskrat (*Ondatra zibethicus*) in Louisiana, and Self and McMurry (1948) recorded it from *Peromyscus leucopus* in Oklahoma.

All infections were in adult mice. In two specimens the parasites were partially embedded in the liver. One female had a nymph in the mesovarium and one in the bladder. A male had nymphs in the mesenteries of the epididymides, and a female had them in the mesenteries of the abdominal viscera and attached to the lung and liver. In the above instances the number of nymphs present was small, ranging from one to five in the cases where counts were made. Two mice were heavily infected. A female had numerous nymphs located on the liver, intestine, lungs, body wall, kidney, and bladder and in the mesenteries of the abdominal organs. A male had the nymphs beneath the tunica albuginea of the testes, around the cauda epididymis, in the trunk mesenteries, on the surface of the liver, and in the mesentery near the lung. None of the mice infected with *Porocephalus* exhibited any evidence of weakness or debilitation when alive nor any gross effects of the parasites when necropsied. Esslinger (1962) found that the tissue responses of the liver of the rat to immature stages of *Porocephalus* resembled those produced by other agents of visceral larva migrans and metazoan parasites generally.

Of the 840 mice examined for *Porocephalus,* 202 were from sand pine scrub habitats, 49 from slash pine/turkey oak, 300 from longleaf pine/turkey oak, 230 from upland hammock, and 60 from pine flatwoods. Infections occurred only at a single scrub station. Here, 103 adults and 11 young mice were collected, giving a prevalence of *Porocephalus* in this population of 6.1% for both age groups combined or 6.8% for adults. The difference in infection rate of adult males and females was not significant on the basis of the small sample involved.

The scrub station from which pentastomids were recorded was a slight ridge surrounded by low pine flatwoods, marshes, and cypress swamps. There was evidence of a high snake population at this locality, and such semi-aquatic forms as the cottonmouth (*Agkistrodon piscivorus*) and water snake (*Natrix fasciata*) were recorded. Possibly, therefore, the occurrence of *Porocephalus* at this station was in part due to an abundance of snakes. However, additional factors probably were involved, since certain other scrub stations as well as those in other habitat types appeared to support high snake populations while *Porocephalus* was apparently absent.

Twelve mice collected in February were free of infections. Three of 59 specimens taken in April (11), and May (48) were infected, as were 3 of 30 specimens from July (5) and August (25). Of 11 specimens examined in October (6) and November (5), 1 had a *Porocephalus* infection. Thus, although the data are not conclusive, a slight trend toward a higher frequency of infections in late summer and fall is indicated. Whether this trend is related to the life cycle of the parasite or to seasonal differences in the movements or behavior patterns of mice or snakes is uncertain.

V. Discussion

Thirty-two parasites, including 18 ectoparasites and 14 endoparasites, were recorded from the Florida mouse. Although further collecting may yield additional forms, particularly microorganisms and helminths, the present list probably is a relatively complete representation of the parasitic fauna of this rodent. Comparative data for other small mammals are few. However, Elton *et al.* (1931) found 41 species of parasites associated with the wood mouse (*Apodemus sylvaticus*) in England.

Based on combined data for all localities, habitats, and seasons, the overall level of parasitism on the Florida mouse is low. The prevalence of ectoparasites as a group considerably exceeds that of endoparasites. The difference is especially pronounced if Protozoa are excluded from consideration. A number of the parasites recorded were rare in all habitats or occurred with any frequency only in particular habitat types. Of the seven categories of ectoparasites recognized for the purpose of analysis, only non-infesting trombiculids, non-trombiculid mites, ticks, and fleas occurred on more than 5% of the mice in the total sample. In each of these groups, only one or two species dominated in the identified samples. These included the mites *Trombicula crossleyi, Euschongastia peromysci,* and *Haemolaelaps glasgowi,* the tick *Dermacentor variabilis,* and the flea *Polygenis floridanus.* Two of the ectoparasitic species collected, *Hoplopleura hirsuta* and *Hoplopsyllus affinis,* were clearly accidental. In the case of endoparasites, *Endamoeba, Giardia, Trichomonas, Eimeria,* an unidentified trematode, *Hymenolepis ?nana,* and *Aspiculuris americana* approached or exceeded the 5% prevalence level. Thus, even with the rather liberal criterion of commonness accepted here, only 12 of the 32 parasites of the Florida mouse would be considered as generally common. Roughly the same proportion, 13 out of 41 species, of the parasites of the wood mouse was considered to be of possible importance in the study by Elton *et al.* (1931).

Parasitism apparently plays a relatively minor role in the population dynamics of the Florida mouse. There is no evidence to indicate that parasites constitute an important source of direct mortality. In addition to the generally low prevalence rates, the numbers of ecto- or endoparasites carried by individual hosts were seldom high for the particular parasite involved. Nor was any animal encountered during the course of the study in a sick or weakened state that could be attributed to its parasite load, although the possibility that sick or weak mice may be less responsive to traps must be considered. However, in some cases even relatively low parasite burdens probably may produce effects on the host's physiology or behavior that render the animal more susceptible to predation or various environmental stresses. At the general levels of abundance of parasites found in this study, endoparasites would probably be more important in this regard than ectoparasites. Certain ectoparasites without an obvious direct effect on the host also may be involved in inter- and intra-specific transmission of bacterial or viral diseases that may produce debilitation or death, although no evidence for this is as yet available for *Peromyscus floridanus.*

Although the overall parasite level of the Florida mouse is low, the actual combinations of parasitic species and prevalence rates in different host populations are far from uniform. Differences in patterns of parasitism may be related to such factors as age of host, host density, habitat, and season and are of interest from the standpoint of their causation as well as their significance in terms of the biology of the host. Adult mice appear to carry more parasites than young. However, a marked difference in the effect of host age on prevalence exists between ecto- and endoparasites. The average prevalence of ectoparasites was 24.4%

on adult mice and 21.8% on young. For those endoparasites (unidentified trematode, *Hymenolepis, Capillaria, Rictularia, Aspiculuris,* and *Porocephalus*) for which adequate data for a comparison of age-specific infection rates were available, mean prevalence was 14.6% in adult and 5.9% in young mice.

Several factors might contribute to the greater difference in age-specific prevalence of endoparasites compared to ectoparasites. One of these is the relative mobility of the infective stages of the two kinds of parasites. Most of the ectoparasites have a relatively mobile, free-living infective stage, in contrast to that of endoparasites which is typically an ovum, cyst, or essentially sedentary larval stage. A young mouse outside its burrow thus would have a higher probability of encountering an ectoparasitic organism than an endoparasitic one, consequently acquiring a population of the former more rapidly than the latter.

The extent to which parasites are acquired in the nest might also have a bearing on the problem of the different age relationships in prevalence of ecto- and endoparasites. Infestation in the natal nest might be expected to contribute significantly to a faster build up on the young mouse of those ectoparasites (non-trombiculid mites and fleas) which require the host's nest for at least part of the life cycle. The present data, however, do not indicate any trend toward higher prevalence of these forms than of those ectoparasites in which infestations are probably ordinarily acquired outside the nest. This may be due to the fact that most of the young in the samples were of post-weaning age and might, therefore, have already moved from the natal burrow and established their own nests, in which mite and flea populations had not yet had sufficient time to build up. Drummond (1957) showed that the nesting activity of white-footed mice (*Peromyscus leucopus*) was a particularly important influence on the fluctuations in numbers of species and individuals of mites in nests.

Circumstantial evidence suggests that nests may not be an important source of endoparasitic infections in the Florida mouse. The low prevalence of endoparasites in young might in itself be cited in support of this. Some endoparasites also exhibit distinct trends in prevalence associated with habitat type, which suggests that physical environmental factors outside the nest may be influencing the distribution of the parasites in question. Furthermore, if fecal contamination is assumed to be a principal route of nest infections, then the fact that the Florida mouse appears to practice good nest sanitation would perhaps also serve to limit the incidence of nest-acquired infections. No accumulations of feces were found in two nests excavated, and captive mice generally defecated in parts of the cages removed from the nest. Another factor that might contribute to a lower rate of endoparasitic infections in young mice in the natal nest is the existence of some degree of immunity.

A final possibility is that the difference in age-specific prevalence rates of the two major groups of parasites is actually partly or entirely due to the age classification used. In ectoparasites, excepting botflies, an infestation presumably is recognizable as soon as it occurs, whereas there may be a variable period between the acquisition of the infective stage of an endoparasite and the time at which the infection would be apparent at necropsy. Since the average interval a mouse spends in the young age class is considerably shorter than that spent in the adult category, it follows that a significant proportion of infections acquired by young mice may not reach a stage at which they would be detected at routine autopsy until the animals have passed over into the adult age group. Therefore, the actual numbers of endoparasites carried by young mice may have been appreciably greater than observed. Unfortunately, the present data do not permit any conclusions as to the relative importance of the above-mentioned factors, either singly or in combination, in explaining the differences noted. Whatever the cause, the lighter parasite load, particularly of endoparasites, of young mice is of significance from the standpoint of population dynamics in that it can be assumed to contribute to better survival of this age class.

Comparisons of prevalence rates of five groups of ectoparasites at different host population levels showed no overall effect of population density on the proportion of mice infested. In going from a lower to a high population level, decreases in prevalence averaged 42.2% and increases, 46.6%. The number of instances in which no change occurred averaged 10.4%. The mean decrease in prevalence was 22.1% and the average increase, 27.4%. Because of the small number of comparisons available, trends in individual habitats cannot be considered conclusive. However, sand pine scrub differed from other habitat types in showing a stronger correlation between ectoparasite prevalence and host abundance.

The relationship between host population level and parasite prevalence varies between different types of ectoparasites. The data for fleas and mites indicate a positive correlation between host abundance and parasite levels, while an inverse relationship is suggested in the case of ticks and botflies. The prevalence of fleas shows the strongest association with host numbers of any group of ectoparasites. This trend is largely due to the species *Polygenis floridanus,* which thus far is known only from the Florida mouse. The ultimate factor responsible for this narrow host restriction may be microclimate of the nest of *Peromyscus floridanus,* although several proximate factors also may operate to prevent host transfer (Johnson and Layne, 1961).

In view of this host specificity, the numbers of *Polygenis floridanus* would be expected to conform more closely to the population level of the Florida mouse than those of other ectoparasites which have a broader host range. The relationship between prevalence of mites and host population level was considerably less pronounced than in the case of Siphonaptera. The prevalence of non-trombiculid mites on a particular small mammal species appears to depend at least in part on the abundance of other possible hosts in the same habitat. The Florida mouse was the principal small mammal species at many of the stations sampled during this study, which might explain the apparent correlation between mouse and mite population trends. As chiggers are parasitic only in the larval stage and do not require the nest environment to complete their life cycle, the correlation, though slight, between their prevalence and mouse density may be due to a certain degree of host specificity in the commoner species such as *Trombicula crossleyi.* The particular habits or relative abundance of the Florida mouse in the habitats studied may also be factors influencing the host density correlated abundance of chiggers.

Botflies and ticks have a low infestation rate on the Florida mouse, usually occurring as one or only a few individuals. They do not require the nest for their life cycle, although ticks may seek refuge in the nest (Drummond, 1957). The inverse relationship between the prevalence of these parasites and mouse abundance suggested by the data might be taken to indicate an effect of the parasite on host population. An alternative explanation which assumes a limited number of parasites so that an increase in host density results in reduced frequency of infestations seems more likely. Two factors might operate to prevent an increase of parasites, after an appropriate lag, with an expanding mouse population: (1) a limitation on the numbers of parasites in certain habitats by environmental factors (physical or biotic) independent of the number of mice present; (2) the existence of marked, short-term fluctuations in host populations that even in an environment with an otherwise high carrying capacity for the particular parasites would inhibit a build-up of parasite numbers. Elton *et al.* (1931) advanced a similar explanation for the inverse relationship between wood mouse population density and certain endoparasites.

Of the factors considered in this study, habitat is probably the most important in determining the patterns of parasitism in particular host populations. The average prevalence of ectoparasites was lowest in sand pine scrub (22.2%), slightly higher in flatwoods (22.5%) and longleaf pine/turkey oak (24.4%), and highest in upland hammock (27.1%). The data on prevalence of ectoparasites in flatwoods are probably biased by the fact that samples were available for this habitat type only in the early part of the year, while all seasons are represented in the remaining habitats. Since there is evidence that in such groups as trombiculid mites, ticks, and botflies greatest prevalence occurs in late summer, fall, and early winter, it is possible that the overall ectoparasite prevalence in flatwoods is actually higher than indicated by the available data. On the other hand, the marked fluctuations of soil moisture in this habitat may be detrimental to some types of parasites.

The abundance of ectoparasites as a group apparently is correlated with the moistness of the habitat and development of ground cover and litter. This trend is particularly clear for ear-infesting chiggers and non-trombiculid mites and present, though less obvious, in ticks and botflies. Fleas are the only group of ectoparasites exhibiting a reverse trend, being more abundant in sand pine scrub and longleaf pine/turkey oak habitats. This habitat distribution pattern primarily reflects that of *Polygenis floridanus.*

No obvious correlation exists between the prevalence of endoparasites as a group and common environmental factors such as moisture or ground cover. Sand pine scrub had the highest average infection rate (9.7%), longleaf pine/turkey oak the lowest (5.8%), and upland hammock and flatwoods occupied intermediate positions with rates of 8.2 and 6.8%, respectively. Individual parasite species, however, did show distinct trends in abundance correlated with habitat type. This suggests that the various kinds of endoparasites are more variable in their environmental requirements than the ectoparasitic forms and may thus exhibit greater habitat restriction. Other evidence points to the existence of narrower habitat specificity of endoparasites as compared to ectoparasites. Only 4 (24%) of 17 species of ectoparasites were collected from a single habitat, whereas 6 (60%) of 10 macro-endoparasites are in this category. If the similarities (presence or absence of species) in total parasite faunas are analyzed, sand pine scrub agrees with other habitat types in an average of 54% of the parasites. Longleaf pine/turkey oak exhibits a 58% agreement, upland hammock 66%, and flatwoods, 57%. The differences, though slight, suggest that variation in species composition as well as in prevalence of large groups is associated with habitat differences. When the habitat similarities are determined separately for ecto- and endoparasites, a difference in habitat tolerance is indicated for the two groups. The average similarity in species composition of ectoparasites between different habitat types is slightly higher (61%) and the range of values for individual habitats less variable (57-65%) than for endoparasites, for which corresponding figures are 57% and 47-67%, respectively. On the basis of its endoparasitic fauna, scrub is again more distinctive than other habitats. Sand pine scrub is also the only habitat type in which the prevalence of parasites with an egg as the infective stage greatly exceeds those with free-living larvae. This suggests that high soil temperatures and dry conditions may limit the success of parasites with free-living larval stages in the scrub habitat.

The extent to which new species of ecto- and endoparasites are added as the habitat range is increased is shown in Figure 3. The data for this graph were obtained by systematically varying the sequence of the four principal habitats involved in the study and determining the mean percentage of the total species of parasites added with the addition of each habitat. The results seem to indicate that for any single habitat a higher proportion of the ectoparasite fauna is represented than of endoparasites and as a consequence the rate at which new species are added per habitat is higher in the latter. This again supports the supposition that the ectoparasites of the Florida mouse tend to show less habitat restriction than endoparasites.

The above data demonstrate clearly that populations of the Florida mouse living in different habitats are subjected to different regimens of parasite pressure, and that certain parasites of negligible significance over

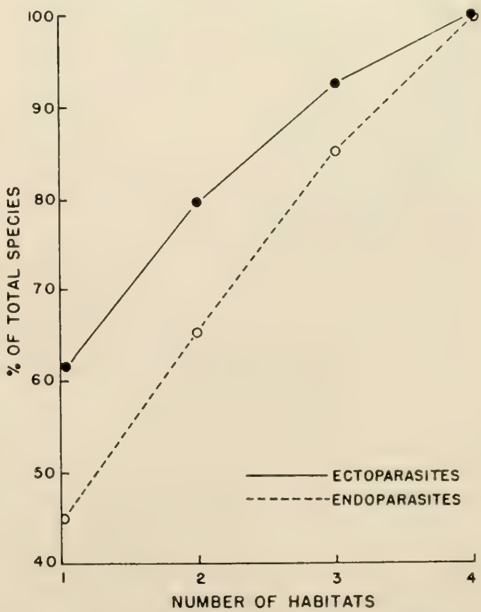

Figure 3. A comparison of the increase of ecto- and endoparasite species on the Florida mouse with increase in habitat types.

the entire geographic and ecologic range of the species as a whole may be of some local importance. This provides an example of the variation in selective forces that may operate on populations of a species in different habitats and influence its ability to invade new environments.

Both the overall prevalence and abundance of particular groups of ecto- and endoparasites are influenced by season. The highest prevalence of ectoparasites as a group occurs in the late fall and early winter (27.8%) and declines to the lowest level in the April-June interval (20.9%). Individual groups show varying degrees of departure from this general pattern. The peak prevalence of endoparasite infections falls in the January-March interval (14.0%) and exhibits a general decline through the year, reaching the lowest point in the October-December period (7.7%). The causes of these trends may be different in the two groups of parasites. The general pattern in ectoparasites is probably attributable mainly to the direct effects of weather on the life cycles of the parasites, particularly in the case of chiggers, ticks, and botflies. In other groups, such as non-trombiculid mites and fleas, seasonal trends may be influenced by variation in the nesting habits or activity of the hosts. Two factors may be important in explaining the seasonal patterns of general endoparasite abundance. The peak levels occur in that part of the year when the food supply of the mice appears to be most limited. The mice may forage more intensively and do more digging for food at this time and as a consequence have a higher probability of acquiring an infection than at other seasons. The other factor concerns a change in the age composition of populations during the year. Much of the breeding of the Florida mouse is concentrated in the late fall and early winter. Thus when reproduction has been successful, young age groups predominate in the population. The observed differential in adult and young infections noted earlier could therefore account for at least a part of the fall and winter decline in infection rate. Elton *et al.* (1931) attributed seasonal changes in the frequency of the nematode *Nematospiroideas dubius* in the wood mouse to changes in host age composition. Additional factors may be involved in the trends shown by particular parasites, for example, the unidentified trematode and *Porocephalus,* in which seasonal changes in the habits or activity of intermediate or definitive hosts might in turn influence the prevalence of infections in mice.

The influence of seasonal changes in parasite prevalence on the host probably is greater in the case of endoparasites than ectoparasites. As noted previously, at the general levels of abundance shown by the two groups, endoparasites probably would be expected to have more effect on the health of the host than ectoparasites, assuming that none of the ectoparasites recorded transmits some as yet unknown viral or bacterial disease that causes significant mortality. In addition, the annual peak in endoparasite burden coincides with the time of year in which populations appear to be under greatest stress from other environmental factors, particularly low temperatures and food shortage.

VI. Summary

Data on the parasites of the Florida mouse, *Peromyscus floridanus,* were obtained from 35 localities during the period February, 1957, to October, 1960. Samples of from 542 to 610 mice were surveyed for different kinds of ectoparasites, while the numbers of specimens examined for various groups of endoparasites ranged from 4 to 840. Where adequate data were available, analyses were made to determine the influence of sex, age, and density of host, habitat, and season on parasite composition and prevalence.

Thirty-two species of parasites were recorded, only 12 of which were of relatively common occurrence from the standpoint of the species as a whole. Ectoparasites as a group were more abundant than endoparasites. Overall infestation rates for the former ranged from 69.3% for trombiculid mites in the ear canal to 0.2% for lice. Protozoans were the most frequent endoparasites (42.0%), larval cestodes the rarest (>.4%). In addition to generally low prevalence rates for various kinds of ecto- and endoparasites, the numbers of parasites carried by individual hosts were seldom high for the particular parasite involved. No evidence of mortality or weakening of mice attributable to parasites was obtained, and it is concluded that parasites probably play a relatively minor role in the ecology of the Florida mouse, although in some populations para-

sitism may be of more significance than in others.

The mean prevalence of six groups of ectoparasites on adult mice was 24.4% as compared to 21.8% on young. Age differences in prevalence were more pronounced in the case of endoparasites. Six species had a mean prevalence of 14.6% in adults and 5.9% in young. The lighter parasite load, particularly of endoparasites, of young mice probably favors a higher survival rate in this age class and is therefore of significance from the standpoint of the population dynamics of the host.

No general correlation between overall ectoparasite abundance and host numbers was demonstrated, certain groups appearing to exhibit a tendency to increase in prevalence with increase in host density and others showing a reverse trend. The most marked positive correlation between prevalence of a parasite and host numbers was shown by fleas. This relationship is presumed to reflect the intimate association between the Florida mouse and the flea *Polygenis floridanus,* which appears to be restricted to this host. The prevalence of ticks and botflies may vary inversely with host abundance. If actual, this trend might indicate that in the habitats studied these parasites are held at relatively low levels of abundance by factors not directly related to the Florida mouse or that short-term fluctuations in the small mammal populations in these habitats prevent an increase in their numbers.

Of the host and environmental factors considered in this study, habitat exerted the strongest effect on parasite composition and abundance. Among ectoparasites, mites, ticks, and botflies tended toward greater abundance in moister woodlands with greater development of ground cover and litter layer, while fleas were the only group showing greatest prevalence in drier habitat types. No overall correlation between endoparasites as a group and habitat type was apparent, although individual species exhibited strong variation in habitat-specific prevalence.

Prevalence of ectoparasites as a group was highest in late fall and early winter. Individual kinds departed from this overall trend to varying degrees. Endoparasites as a group were most abundant from January through March. The trends in ectoparasite abundance are probably mainly correlated with seasonal changes in physical environmental factors. The peak in endoparasite abundance may be related to greater foraging activity of mice during a time of food scarcity or to variation in age composition of populations. The influence of seasonal changes in parasite pressure on the host is probably greater in the case of endoparasites than ectoparasites, since the heaviest endoparasite burden corresponds with the period of the year in which mouse populations may be under greatest stress.

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VIII. References Cited

Abbott, H. G. and M. A. Parsons 1961 *Cuterebra* infestation in *Peromyscus.* J Mammal. 42: 383-385.

Burt, William H. 1940 Territorial behavior and populations of some small mammals in southern Michigan. *Misc. Publ. Mus. Zool. Univ. Mich. No. 45,* 58 pp.

Carr, Archie Fairly, Jr. 1940 A contribution to the herpetology of Florida.

Univ. Fla. Publ. Biol. Sci. Ser. 3: 1-118.

COLE, L. C. 1945 The effect of temperature on the sex ratio of *Xenopsylla cheopis* removed from live rats. *Public Health Reports* (*U.S.*) 60: 1337-1342.

COOPER, ROBERT W., CLIFFORD S. SCHOPMEYER, and WILLIAM H. DAVIS MCGREGOR 1959 Sand pine regeneration on the Ocala National Forest. *Production Res. Rep. No. 30, U. S. Dept. Agr. For. Serv.*, 37 pp.

DALMAT, HERBERT T. 1943 A contribution to the knowledge of the rodent warble flies (Cuterebridae). *J. Parasitol.* 29: 311-318.

DRUMMOND, ROGER O. 1957 Observations on fluctuations of acarine populations from nests of *Peromyscus leucopus*. Ecol. *Monogr.* 27: 137-152.

ELTON, C., E. B. FORD, J. R. BAKER, and A. D. GARDENER 1931 The health and parasites of a wild mouse population. *Proc. Zool. Soc. Lond.* 1931 (3): 657-721.

ESSLINGER, J. H. 1962 Hepatic lesions in rats experimentally infected with *Porocephalus crotali* (Pentastomida). *J. Parasitol.* 48: 631-638.

EWING, H. E. 1944 The trombiculid mites (chigger mites) and their relation to disease. *J. Parasitol.* 30: 339-365.

GABBUTT, PETER D. 1961 The distribution of some small mammals and their associated fleas from central Laborador. *Ecology*, 42: 518-525.

HARKEMA, REINARD 1936 The parasites of some North Carolina rodents. *Ecol. Monogr.* 6: 153-232.

HIRTH, H. F. 1959 Small mammals in old field succession. *Ecology*, 40: 417-425.

JAMESON, E. W., JR. 1947 Natural history of the prairie vole (mammalian genus *Microtus*). *Univ. Kans. Publ. Mus. Nat. Hist.* 1: 125-151.

————, JAMES M. BRENNAN 1957 An environmental analysis of some ectoparasites of small forest mammals in the Sierra Nevada, California. *Ecol. Monogr.* 27: 45-54.

JENKINS, D. W. 1947 A laboratory method of rearing chiggers affecting man (Acarina: Trombiculidae). *Ann. Entomol. Soc. Am.* 40: 56-68.

JOHNSON, PHYLLIS T., and JAMES N. LAYNE 1961 A new species of *Polygenis* Jordan from Florida, with remarks on its host relationships and zoogeographic significance. *Proc. Entomol. Soc. Wash.* 63: 115-123.

KOHLS, GLEN M. 1940 Siphonaptera. A study of the species infesting wild hares and rabbits of North America north of Mexico. *Nat. Inst. Health Bull.* No. 175. 27 pp.

LAESSLE, ALBERT M. 1942 The plant communities of the Welaka area. *Univ. Fla. Publ., Biol. Sci. Ser.* 4: 1-143.

———— 1958 The origin and successional relationships of sandhill vegetation and sand-pine scrub. *Ecol. Monogr.* 28: 361-387.

LAYNE, JAMES N., and JAMES V. GRIFFO, JR. 1961 Incidence of *Capillaria hepatica* in populations of the Florida deer mouse, *Peromyscus floridanus*. *J. Parasitol.* 47: 31-37.

MICHENER, C. D. 1946 Observations on the habits and life history of a chigger mite, *Eutrombicula batatas*. *Ann. Entomol. Soc. Am.* 39: 101-118.

MOHR, CARL 1947 Notes on chiggers, rats, and habitats on New Guinea and Luzon. *Ecology* 28: 194-199.

MORLAN, HARVEY B. 1952 Host relationships and seasonal abundance of some southwest Georgia ectoparasites. *Am. Midl. Nat.* 48: 74-93.

PEARSE, A. S. 1929 Ecology of the ectoparasites of Nigerian rodents and insectivores. *J. Mammal.* 10: 229-239.

PENN, GEORGE H., JR. 1942 The life history of *Porocephalus crotali*, a parasite of the Louisiana muskrat. *J. Parasitol.* 28: 277-283.

PENNER, L. R., and F. P. POCIUS 1956 Nostril entry as the mode of infection in the first stage larvae of a rodent *Cuterebra*. *J. Parasitol.* 42 (4, Sect. 2—suppl.): 42.

RITCHIE, L. S. 1948 An ether sedimentation technic for routine stool examinations. *Bull. U. S. Army Med. Dept.* 8: 326.

ROGERS, J. S. 1933 The ecological distribution of the craneflies of northern Florida. *Ecol. Monogr.* 3: 1-74.

SCOTT, T. G. and E. SNEAD 1942 Warbles in *Peromyscus leucopus noveboracensis*. *J. Mammal.* 23: 94-95.

SEALANDER, J. A. 1961 Hematological values in deer mice in relation to botfly infection. *J. Mammal.* 42: 57-60.

SELF, J. TEAGUE and FRANK M. MCMURRY 1948 *Porocephalus crotali* Humbolt (Pentastomida) in Oklahoma. *J. Parasitol.* 34: 21-23.

SMITH, C. N., and H. K. GOUCK 1947 *Ixodes bishoppi*, a new species from Georgia (Acarina: Ixodidae). *Ann. Entomol. Soc. Am.* 40: 75-81.

SMITH, W. W., and G. J. LOVE 1958 Ectoparasite populations and prevalence of murine typhus antibodies in cotton rats of southwest Georgia during wet and dry periods. *Trans. Am. Microscop. Soc.* 77: 48-56.

SNEDECOR, GEORGE W. 1946 Statistical methods. Iowa State Coll. Press, Ames. 485 pp.

TEST, FREDERICK H., and AVERY R. TEST 1943 Incidence of dipteran parasitosis in populations of small mammals. *J. Mammal.* 24: 506-508.

WECKER, STANLEY C. 1962 The effects of

botfly parasitism on a local population of the white-footed mouse. *Ecology* 43: 561-565.

WILSON, L. WAYNE 1945 Parasites collected from wood mouse in West Virignia. *J. Mammal.* 26: 200.

WORTH, C. B. 1950 Observations on ectoparasites of small mammals in Everglades National Park and Hillsborough County, Florida. *J. Parasitol.* 36: 326-335.

ABSTRACT

Thirty-two species of parasites, including 18 ectoparasites and 14 endoparasites, were recorded from the Florida mouse, *Peromyscus floridanus*. Only 12 species had a prevalence equalling or exceeding 5% in the total samples of mice examined. The present data include that, for the species as a whole, parasitism is not a major factor in the ecology of the Florida mouse and probably has little direct role in the regulation of population size. Although the overall level of parasitism is relatively low, conspicuous differences in the kinds and abundance of parasites may occur between populations. Age composition and density of the host populations, habitat, and season are shown to be among the factors influencing patterns of parasite distribution and abundance on *P. floridanus*.