Seasonal changes in louse populations on white-tailed deer (*Odocoileus virginianus*)

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The hides of 47 white-tailed deer (*Odocoileus virginianus*) shot at Long Point, Ontario, between September 1972 and August 1973 were examined for lice. Adult *Tricholipeurus lipeuroides* were most abundant from January to April and *T. parallelus* from May to August. The distributions of biting lice changed over the study period, possibly influenced by environmental factors such as solar radiation, temperature, rainfall, and changes in pelage. *Solenopotes ferrisi* was found throughout the study period. There was no significant change in abundance of the various louse stages throughout the study, although all stages were slightly more numerous during winter. Adults primarily infested the head and neck, while immature stages infested upper body regions. Changes in distribution of lice may be the result of environmental and host pelage changes.

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On a cherché des poux dans les peaux de 47 cerfs à queue blanche (*Odocoileus virginianus*) abattus à Long Point, Ontario, entre septembre 1972 et août 1973. Les adultes de *Tricholipeurus lipeuroides* prédominent de janvier à avril et ceux de *T. parallelus* de mai à août. La répartition des mallophages s'est modifiée au cours de la recherche, influencée sans doute par les facteurs du milieu tels que les radiations solaires, la température, les précipitations et par les changements de pelage. *Solenopotes ferrisi* parasite les cerfs tout au long de l'année. On n'a pas constaté de changement important de l'abondance des divers stades, bien que tous les stades soient présents en nombres légèrement plus grands pendant l'hiver. Les adultes parasitent surtout les régions de la tête et du cou, alors que les staues immatures infestent surtout les régions supérieures du tronc. Les changements de répartition des poux sont probablement dûs à des modifications du milieu et aux changements de pelage. [Traduit par le journal]

Introduction

Numerous ectoparasites have been reported from white-tailed deer (*Odocoileus virginianus* (Zimmermann)) of North America. However, only a few species have been reported from deer of Ontario and northern United States in close proximity to Ontario (Kellogg and Ferris 1915; Cooley and Kohls 1944, 1945; Bequaert 1945; Gregson 1956; Ignoffo 1959; Scanlon 1960; Anderson 1962; Emerson 1962; Scholten 1962; Scholten *et al.* 1962; Webster and Stewart 1964; Stojanovich and Pratt 1965; Samuel 1969; Walker and Becklund 1970; Kellogg *et al.* 1971).

Few attempts have been made to study the biology and population dynamics of lice on deer, although Samuel and Trainer (1971) studied the seasonal fluctuations of *Tricholipeurus parallelus* on white-tailed deer from southern Texas.

The present study is based on a detailed examination for lice on deer collected from Long Point, Ontario, during 1972 and 1973. Deer were collected as part of a herd improvement program carried out by the Ontario Ministry of Natural Resources. The herd has been relatively isolated from other deer populations and has no contact with livestock.

Materials and Methods

White-tailed deer (*Odocoileus virginianus*) were collected from Long Point, Ontario, on Lake Erie (for description of study area see Baker and Anderson 1975). Deer were aged by the cementum annuli method (Gilbert 1966). Mainly old and young deer were taken, as the program was intended to improve the quality of the herd. Generally, deer were killed near yarding areas during winter months and in more accessible areas at other times of the year. The approximate ages (years) and sex of the deer collected each month were as follows.

Oct. 1972—4+ (M), 1+ (F), <1 (F), <1 (F), 10+ (F), 1+ (M).
Nov. 1972—9+ (F), 9+ (F), 1+ (M), 3+ (M), <1 (M).
Dec. 1972—<1 (F), 1+ (M), 8+ (F), 4+ (M).
Feb. 1973—6+ (F), 2+ (F), <1 (F), 1+ (F), 5+ (F), <1 (F).
Mar. 1973—2+ (M), 1+ (M), 7+ (M), 5+ (F), 1+ (F).
Apr. 1973—1+ (M), 5+ (M), 6+ (F).
May 1973—7+ (F), 4+ (M), 3+ (F), ? (M), 4+ (F).

Jun. 1973—4+ (M), 3+ (M), 3+ (M), 6+ (M).
Jul. 1973—6+ (F), <1 (F fawn), ? (F).
Aug. 1973—1+ (M), 1+ (M), <1 (F fawn), <1 (F fawn), 1+ (M), <1 (F fawn).

Fawns taken during July and August were not included in the overall analysis but, because they were new recruits to the population, they were used to indicate initial infestation of fawns of the year.

Most deer were skinned within 1 h of death. The hide was cut along the backbone and the midventral line from the tail to the base of the head. Longitudinal incisions were made along the midline of each side. Each side was then cut at right angles to the initial incisions in four locations, i.e. anterior to the flank and groin, posterior to the shoulder and brisket, around the base of the neck, and around the base of the head (Fig. 1). Thus, each side of the body was divided into seven regions, each of which was placed in a separate labelled bag as it was removed from the carcass (Cook 1954). Samples were kept cool in the field and taken back to the laboratory and frozen as soon as possible. The head, cut from the body at the atlas, was placed in a plastic bag. Deer heads were kept as cool as possible until they could be skinned.

Samples of hide were thawed, measured, and digested in warm 4.5% KOH. Digestion continued until no hair remained on the skin. The digest was passed through an 80-mesh Endecott sieve and the material remaining on the sieve was collected and preserved in a solution of 10% glycerine in 70% ethyl alcohol.

Since heads were required by the Ministry of Natural Resources for another research project, the KOH digest technique could not be used on the skin of the head. Following Henry and McKeever (1971) and Lipovsky (1951), skins from heads were washed in a detergent–water solution. The wash was passed through an 80-mesh sieve. The sieved material was transferred to warm 4.5% KOH to digest hair removed during washing. Head skins were combed thoroughly with a nit-comb and finally the remaining parasites were removed by hand. Material retrieved by these methods was also added to the digest. The digest was passed through a sieve and the residue preserved.

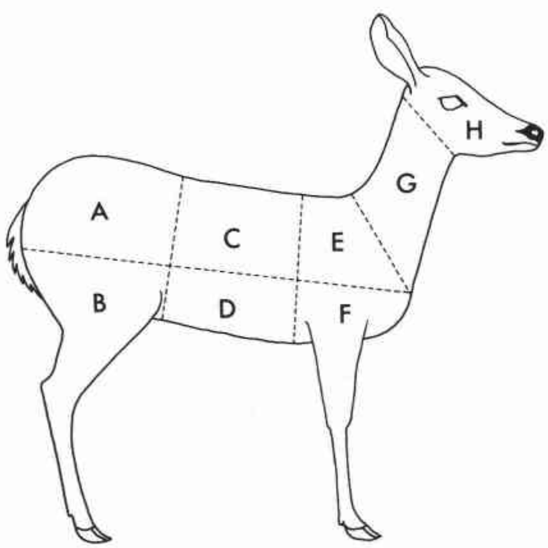

FIG. 1. Approximate partitioning of the hide of white-tailed deer (*Odocoileus virginianus*) collected from Long Point, Ontario, from September 1972 to August 1973.

Areas of head skin were estimated using 13 deer from the Parry Sound District, Ontario. Heads were skinned and the skins laid flat on a piece of cardboard. Each was outlined and a planimeter was used to estimate the areas. Volumes of the skinned heads were estimated by using an overflow technique. A linear regression was conducted on the area of the skin versus the volume of the head. The area of the skin could then be determined from the following equation: area = $-4408.72 + (1796 \times \log \text{volume})$, $r = 0.8833$. The areas of skin of the heads of deer from Long Point were determined from this formula.

Lice collected were counted and classified according to sex and age (adult or immature). The densities of lice (i.e. lice/cm^2) on the body were determined. Data were grouped into 2-month periods for analysis, since few deer were collected during certain months of the year. For statistical analyses, the transformation $X^{0.1}$ was applied to the density data to normalize the distribution as much as possible. Statistical tests carried out included an analysis of variance called profile analysis and Scheffe's multiple comparison tests (Morrison 1967) conducted at the 0.05 level. Finally the percentage of the total density of lice was determined for each region of the body in any collecting period (e.g. all deer collected during November and December). Percentage of total density was derived from the density of lice species on each designated region (Fig. 1) on individual deer. Deer were grouped in 2-month periods and a mean density of lice on each region was calculated. This mean density was expressed as a percentage of the sum of the mean densities on all regions on deer in a 2-month period. Regions with the highest percentage of the total louse density in any period are referred to as *preferred sites*.

Detailed collection data have been placed in the Depository of Unpublished Data.[1]

Results

Between October 1972 and August 1973, 47 deer were collected and examined for ectoparasites. Adult *Tricholipeurus lipeuroides* were found on 74% of the deer. Eighty-six percent of the deer were infested with *T. parallelus*, and 74% with *Solenopotes ferrisi* (Table 1).

The four fawns collected in July–August[2] were infested with adult *T. parallelus*. Only three fawns were infested with adult *S. ferrisi* and adults of *T. lipeuroides* were not found. All four fawns were infested with immature *Tricholipeurus* spp.

[1]Detailed collection data is available, at a nominal charge, from the Depository of Unpublished Data, CISTI, National Research Council of Canada, Ottawa, Canada K1A 0S2.

[2]The dash between months will indicate grouped collection periods of 2 months (see Table 1).

TABLE 1

Adult lice collected from white-tailed deer from Long Point, Ontario, September 1972 to August 1973

Months	Deer examined	*Tricholipeurus lipeuroides*	*T. parallelus*	*Solenopotes ferrisi*
Oct.	6	5 (83)*	6 (100)	4 (67)
Nov.–Dec.	9	9 (100)	8 (89)	4 (67)
Feb.	6	6 (100)	2 (33)	5 (83)
Mar.–Apr.	8	8 (100)	7 (87)	7 (87)
May–Jun.	9	4 (44)	9 (100)	7 (78)
Jul.–Aug.	5 (adult)	0 (0)	5 (100)	3 (60)
Jul.–Aug.	4 (fawns)	0 (0)	4 (100)	3 (75)
Jul.–Aug.	9 (total)	0 (0)	9 (100)	6 (67)

*Number of deer infested (% infested in parentheses).

Tricholipeurus lipeuroides (Mégnin) (Mallophaga: Trichodectidae)

Adults of this louse were most prevalent from November 1972 to April 1973, when all deer collected were infested (Table 1). Adults were not found on deer collected during July–August.

Densities of male and female lice fluctuated similarly throughout the study period (Figs. 2, 3). Highest densities were found on deer collected from February to April and the lowest densities from May to August. During the period of maximum abundance (Figs. 2, 3) the preferred sites on the body appeared to be the belly (D) (Table 2), although relatively high numbers occurred also on the back (C) in February and the neck (G) and rump (A) during February, March, and April. Lice were scarce in May–June and not found in July–August (Figs. 2, 3). During this period of low abundance the preferred sites for the lice appeared to be the belly (D), forelegs and brisket (F), and the rump (A) (Table 2). The head (H) was never a preferred site and the forelegs and brisket (F) was a relatively preferred site only during the spring months (Table 2).

Tricholipeurus parallelus (Osborn) (Mallophaga: Trichodectidae)

Adults were most prevalent on deer from May to October, when all deer collected were infested (Table 1). Adults were found throughout the year.

Densities of adult male and female lice fluctuated similarly throughout the study period (Figs. 2, 3). Adults were most numerous from March to August and relatively scarce during the winter months from October to February. During the periods of maximum abundance

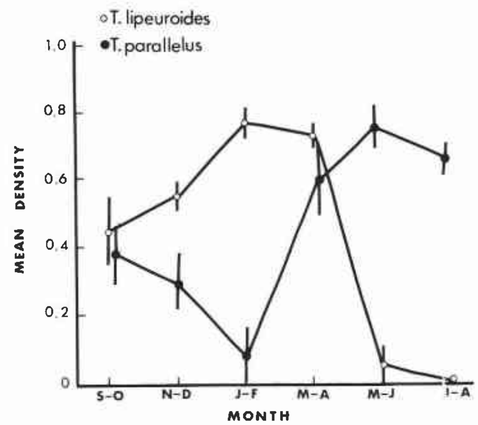

FIG. 2. Mean density (lice/cm²) of males of *Tricholipeurus lipeuroides* and *T. parallelus* collected from white-tailed deer (*Odocoileus virginianus*) from Long Point, Ontario, September 1972 to August 1973. The vertical bars represent the mean ± one standard error.

(March to August), preferred sites of infestation appeared to be the rump (A) and the hindlegs and groin (B) (Table 2). During winter, when infestations were relatively light (Figs. 2, 3), preferred sites of infestation appeared to be the belly (D), neck (G), rump (A), and shoulder (E). The head (H) was not heavily infested at any time of the year. The forelegs and brisket (F) seemed to increase in importance as a preferred site during the spring and summer months.

Immature Tricholipeurus spp.

Immature *T. lipeuroides* and *T. parallelus* were not differentiated in the collections. Densities of immature biting lice were highest from February to April (Fig. 3). During the period when density of immature lice was highest, preferred sites appeared to be the back (C), neck

TABLE 2

The distribution of lice on white-tailed deer from Long Point, Ontario 1972–1973*

Oct.	Nov.–Dec.	Feb.	Mar.–Apr.	May–Jun.	Jul.–Aug.
Adult *Tricholipeurus lipeuroides*					
A (40)	G (49)	D (22)	D (31)	D (26)	—
D (16)	A (13)	C (19)	G (16)	F (21)	—
C (15)	C (12)	A (18)	A (15)	A (19)	—
G (11)	E (9)	G (14)	F (14)	G (10)	—
B (11)	D (8)	E (11)	C (9)	B (9)	—
E (4)	B (4)	B (8)	E (8)	E (8)	—
F (3)	F (4)	F (7)	B (7)	C (5)	—
H (<1)	H (<1)	H (<1)	H (<1)	H (2)	—
Adult *T. parallelus*					
D (26)	G (34)	A (36)	A (35)	A (27)	B (34)
F (24)	F (26)	E (28)	C (21)	E (17)	F (22)
E (16)	E (21)	B (18)	E (14)	C (15)	A (17)
A (15)	A (6)	D (14)	D (10)	F (12)	E (10)
B (9)	D (6)	C (4)	B (8)	B (12)	D (8)
C (7)	B (4)	F (0)	G (8)	D (11)	C (6)
G (3)	C (3)	G (0)	F (3)	G (5)	G (2)
H (<1)	H (0)	H (0)	H (<1)	H (<1)	H (1)
Immature *T. lipeuroides* and *T. parallelus*					
A (30)	C (27)	C (30)	G (19)	E (24)	H (49)
C (24)	G (27)	E (20)	C (18)	F (21)	A (31)
E (16)	E (16)	G (15)	E (17)	G (13)	F (20)
G (11)	A (15)	D (12)	A (14)	A (12)	G (0)
D (9)	D (9)	F (10)	F (14)	C (11)	E (0)
F (6)	F (4)	A (8)	D (14)	D (10)	D (0)
B (4)	B (2)	B (4)	B (3)	B (8)	C (0)
H (<1)	H (<1)	H (<1)	H (<1)	H (<1)	B (0)
Adult *Solenopotes ferrisi*					
G (43)	G (60)	H (60)	H (51)	H (70)	G (94)
H (21)	H (30)	G (13)	F (13)	G (27)	E (3)
C (16)	E (5)	F (12)	E (13)	F (3)	H (2)
E (6)	C (3)	E (7)	G (12)	E (0)	F (<1)
A (5)	D (1)	C (3)	B (5)	B (0)	B (<1)
D (5)	F (1)	B (2)	C (4)	C (0)	C (0)
F (4)	B (0)	D (2)	D (1)	D (0)	D (0)
B (0)	A (0)	A (1)	A (1)	A (0)	A (0)
Immature *S. ferrisi*					
C (33)	C (32)	E (41)	C (31)	G (52)	H (100)
A (23)	E (29)	F (22)	A (25)	F (48)	A (0)
G (23)	G (20)	C (14)	E (15)	A (0)	B (0)
E (18)	A (14)	G (11)	G (14)	B (0)	C (0)
B (1)	D (4)	D (6)	F (11)	C (0)	D (0)
D (1)	F (1)	B (2)	D (2)	D (0)	E (0)
H (<1)	B (<1)	A (2)	B (1)	E (0)	F (0)
F (<1)	H (0)	H (2)	H (<1)	H (0)	G (0)

*Body regions (A–H) ranked in order of decreasing infestation expressed as % of total density (in parentheses). A, rump; B, hindlegs and groin; C, back; D, belly; E, shoulders; F, forelegs and brisket; G, neck; H, head.

(G), and shoulders (E) (Table 2). During this period immature lice were always relatively scarce on the head (H) and the hindlegs and groin (B). During the periods when immature lice were relatively scarce (Fig. 3, May–August), the preferred sites appeared to be the shoulder (E), head (H), forelegs and brisket (F), and rump (A). During winter months (October to December), preferred sites appeared to be the rump (A), back (C), shoulders (E), and neck (G);

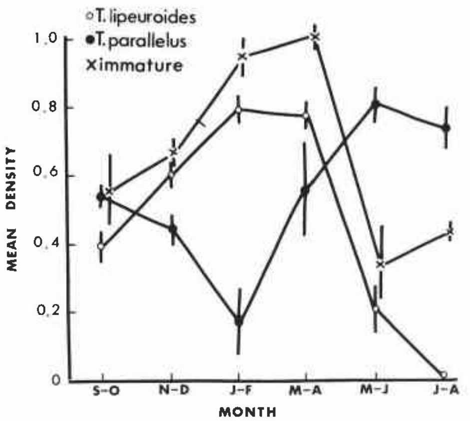

FIG. 3. Mean density (lice/cm^2) of females of *Tricholipeurus lipeuroides* and *T. parallelus* and immature *Tricholipeurus* spp. collected from white-tailed deer (*Odocoileus virginianus*) from Long Point, Ontario, September 1972 to August 1973. The vertical bars represent the mean ± one standard error.

during this period immature lice were relatively scarce on the head (H), hindlegs and groin (B), forelegs and brisket (F), and belly (D).

Solenopotes ferrisi (Fahrenholz) (Anoplura: Linognathidae)

Adults were most prevalent on deer from February to April (Table 1) and they were always present in higher densities than immatures. Fluctuations in total adult and immature populations during the study period (Figs. 4, 5) were not statistically significant. Also there were no significant differences in fluctuations between adult males and females.

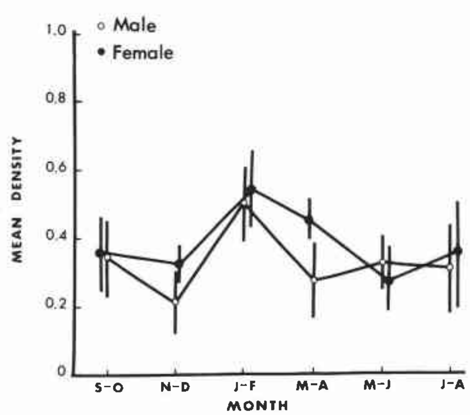

FIG. 4. Mean density (lice/cm^2) of adult male and female *Solenopotes ferrisi* collected from white-tailed deer (*Odocoileus virginianus*) from Long Point, Ontario, September 1972 to August 1973. The vertical bars represent the mean ± one standard error.

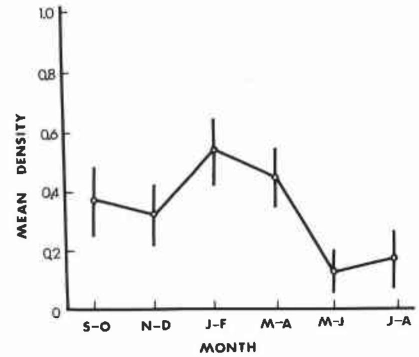

FIG. 5. Mean density (lice/cm^2) of immature stages of *Solenopotes ferrisi* collected from white-tailed deer (*Odocoileus virginianus*) from Long Point, Ontario, September 1972 to August 1973. The vertical bars represent the mean ± one standard error.

Regions anterior to the midbody seemed to be preferred sites for adult sucking lice (Table 2), particularly the head (H) and neck (G). Such regions as the rump (A), hind legs and groin (B), and belly (D) were never preferred sites. More adults were found on the shoulders (E) and forelegs and brisket (F) from February to April than during the rest of the study period. Adults were relatively numerous on the back (C) only in October. During May–June, preferred sites of adults seemed to be the head (H) and neck (G). In July–August the preferred site was the neck (G).

Relatively few immature lice were found on the head (H), the preferred sites being various other regions of the body such as the rump (A), back (C), shoulders (E), forelegs and brisket (F), and the neck (G) (Table 2).

Discussion

Tricholipeurus lipeuroides and *T. parallelus* have previously been reported from Ontario (Scholten *et al.* 1962; Walker and Becklund 1970). Spencer (1938) collected *T. parallelus* and *T. lipeuroides* (=*T. virginianus*) from *Odocoileus hemionus columbianus* (Columbian black-tailed deer) and *O. hemionus hemionus* (mule deer), but only once found concurrent infestations of the two louse species. Concurrent infestations by both species were not reported on white-tailed deer by Scholten *et al.* (1962), Scanlon (1960) (New York), Samuel and Trainer (1971) (Texas), or on mule deer by Cowan (1946) (British Columbia).

Tricholipeurus lipeuroides was most numerous on deer from November 1972 to April 1973 whereas *T. parallelus* was most numerous in September–October and from May to August. The temporal separation in abundance of these two species may have been the result of competition or regulatory environmental factors such as solar radiation and (or) hair quality and density. In this study, numbers of *T. lipeuroides* declined and those of *T. parallelus* increased when deer were noticeably shedding their winter coat (April). Murray (1963*a*, 1963*b*, 1963*c*, 1963*d*, 1968) showed that decreased host pelage, increased solar radiation, and increased rainfall caused high louse mortality on sheep and horses.

Cowan and Raddi (1972) have shown that on *O. hemionus hemionus* hair diameters and density vary annually. Murray (1957*a*, 1957*b*) found that in *Damalinia ovis* and *D. equi* oviposition must occur on hair of a particular diameter. In the present study, hair diameter may have been important in restricting high populations of both species to times when there was an abundance of hair of the appropriate diameter for clasping and oviposition. *T. parallelus* may also be able to withstand higher ambient temperatures than *T. lipeuroides* since the former was more abundant during the summer.

In the present study, as solar radiation increased and hair was shed in the spring and summer (April to August), lice density was depressed on exposed regions (neck and back) where hair may have been shed initially, but remained high on sheltered regions (brisket, belly, forelegs). Craufurd-Benson (1941) found that *Bovicola bovis* infested only the tail region during the summer. *T. lipeuroides* and *T. parallelus* were found on the rump region during the summer, possibly localized in sheltered tail and perianal regions. Stability of the microclimate, insulated at the skin by the winter coat, and inefficient rubbing and grooming of the upper body regions may account for adult *T. lipeuroides* occurring on these upper regions during the colder months. No adult *T. lipeuroides* were found in July–August and high summer temperatures may have been a factor. During the summer, adult *T. parallelus* primarily infested sheltered regions, i.e. legs, brisket, and groin.

In the present study, adult *T. lipeuroides* and *T. parallelus* appear not to adhere to the general rule that in natural populations of Trichodectidae females exceed males when infestations are increasing (Hopkins 1949). Samuel (1969) found this rule to hold for *T. parallelus* on white-tailed deer in Texas.

Analysis of the data on immature biting lice was difficult and not very productive since overlapping of generations of both species occurred. Immature biting lice were most abundant on the back, shoulders, and neck from October 1972 to April 1973, when hair density of the winter coat would afford protection from environmental fluctuations; these regions are also difficult to groom. The presence of high numbers of immature biting lice on upper regions of the body suggests they may be primary oviposition and breeding sites, especially the neck and shoulders. Few immature lice were found on the head, hindlegs, and groin throughout the study period. The hair density is light in these regions and biting lice probably are exposed to the environment and often susceptible to grooming activities of the host.

During the summer (July–August), 80% of immature specimens infested the brisket and forelegs, probably in sheltered parts of these regions. Presumably, immature lice could move onto remaining and newly formed hairs and thereby survive on sheltered sites over the summer. Brisket and foreleg infestations by lice increased from October 1972 to June 1973. These regions provide warmth in winter and shelter from solar radiation and rainfall in the spring and summer.

From this study it appears that biting lice do not migrate to favored sites. Examination of the densities of lice on various regions indicated that under adverse conditions there was an overall decline of populations of lice. This decline appears to occur at a faster rate on exposed regions. Populations of biting lice declined on all regions, including those sites which may provide some degree of shelter, as higher summer temperatures were reached.

Solenopotes ferrisi has previously been reported on white-tailed deer in Ontario but parasite prevalence and abundance were not studied (Scholten 1962). Craufurd-Benson (1941) found that populations of *S. capillatus* and *Haematopinus eurysternus* on cattle were high in winter and low in summer. Murray (1960, 1963*a*, 1963*b*) found that the numbers of adults of *Linognathus pedalis* and *L. ovillus* fluctuated over the year on sheep and were influenced by solar radiation, rainfall, and shearing. *S. ferrisi* appears to follow slight seasonal variations similar to those reported by Craufurd-Benson (1941) and Murray (1960, 1963*a*, 1963*b*), i.e. lice tended to be slightly more numerous in winter than at other times of the year.

Scholten (1962) stated that he found *S. ferrisi* primarily infested the edges and internal surfaces of the ears but were also found on the forehead, base of the ears, and in the neck hair. In the present study, adults of *S. ferrisi* primarily infested the head (edges and bases of the ears, muzzle, and forehead) and neck regions. During winter, when populations increased slightly and ambient temperatures declined, adults spread onto the shoulders, brisket, and forelegs. Adults persisted on highly exposed regions throughout the winter. Murray (1960, 1963*a*, 1963*b*) found *L. pedalis* could survive longer in much colder temperatures than *L. ovillus* but oviposition by both species took place in warmer regions of the host's body.

Immature specimens of *S. ferrisi* were found on the upper body regions in the fall. In winter, lice were found on these regions and also apparently spread onto the brisket and forelegs. Like *L. pedalis*, *S. ferrisi* appears to oviposit on regions where the microclimate is probably warmer and most stable. Most immature lice were spatially separated from adults. Immature specimens may be sensitive to ambient temperatures since few were found on the head. Lack of hair and increased grooming efficiency of the groin by deer may make this latter region poor as a site for reproduction. Craufurd-Benson (1941) found *S. capillatus* adults and nymphs clustered in areas anterior to the shoulders. Clustering may occur with *S. ferrisi*. Adult breeding and feeding may take place primarily on the head but gravid females appear to move to warmer body areas to oviposit. The presence of adults (more males than females) in October and January–February on the rump may indicate secondary breeding sites in the tail and perianal region. Craufurd-Benson (1941) found that this region was a secondary breeding site of *Haematopinus eurysternus*. Mortality or perhaps only migration of nymphs of *S. ferrisi* may occur, since few adults were found on the rump and back from January to April, yet immature lice were abundant on these sites.

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