THE DESCRIPTION OF A NEW SPECIES OF *GEOMYLICHUS* FAIN AND RATES OF INFESTATIONS ON ONE OF ITS HOSTS *GEOMYS BURSARIUS BURSARIUS* IN SOUTH DAKOTA

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In a recent publication, FAIN (1970 *a*), increased the genera within the family Listrophoridae with the establishment of the genus *Geomylichus* for *Listrophorus dipodomius* Radford (1953). Fain characterized *Geomylichus* by the absence of a non-punctated area on the post-scapular shield, the shape of the external scapular setae (sc e) and the presence on the male of membranous setae on the posterior lobes of the body. A key to all the genera erected by FAIN (1970) is contained in " Les Listrophorides en Afrique au Sud du Sahara ", FAIN 1971. In this work Fain utilizes the shape of the external scapular setae and the membranous lobes as distinguishing characters for *Geomylichus*.

Geomylichus geomydis n. sp.

MALE (Fig. 1 & 2) : General body shape cylindrical, especially the podosoma. Gnathosoma narrower than podosoma, tapering gradually anteriorly. Opisthosoma dorso-ventrally flattened, tapering posteriorly.

Legs well-developed, each with five movable segments, terminated by large tarsal sucker. A heavily-sclerotized plate covers each leg segment. Femora of Legs I and II enlarged, those of legs I longest. Legs III and IV thicker, longer than legs I and II. Rank of legs in order of increasing size : II, I, III, and IV. Two prominent thickened setae arise antero-dorsally from tibiae and tarsi of legs I and II. These setae approximately same thickness, but the ones on tibiae slightly more than twice as long as ones on tarsi.

Gnathosoma heavily sclerotized and smooth, enclosing mouthparts dorsally and laterally. Highly modified flaps, used for clasping hair of host, located ventrally on gnathosoma between first pair of legs.

Dorsal and lateral surface of propodosoma characterized by transverse annulations ($\pm$ 33). There are two pairs latero-dorsal setae on the propodosoma, one pair near anterior margin the other pair near posterior margin. Setae sc e, located on the postero-dorsal apices of heavily-sclerotized plates immediately posterior to first coxae, highly modified into heavy spines. Antero-

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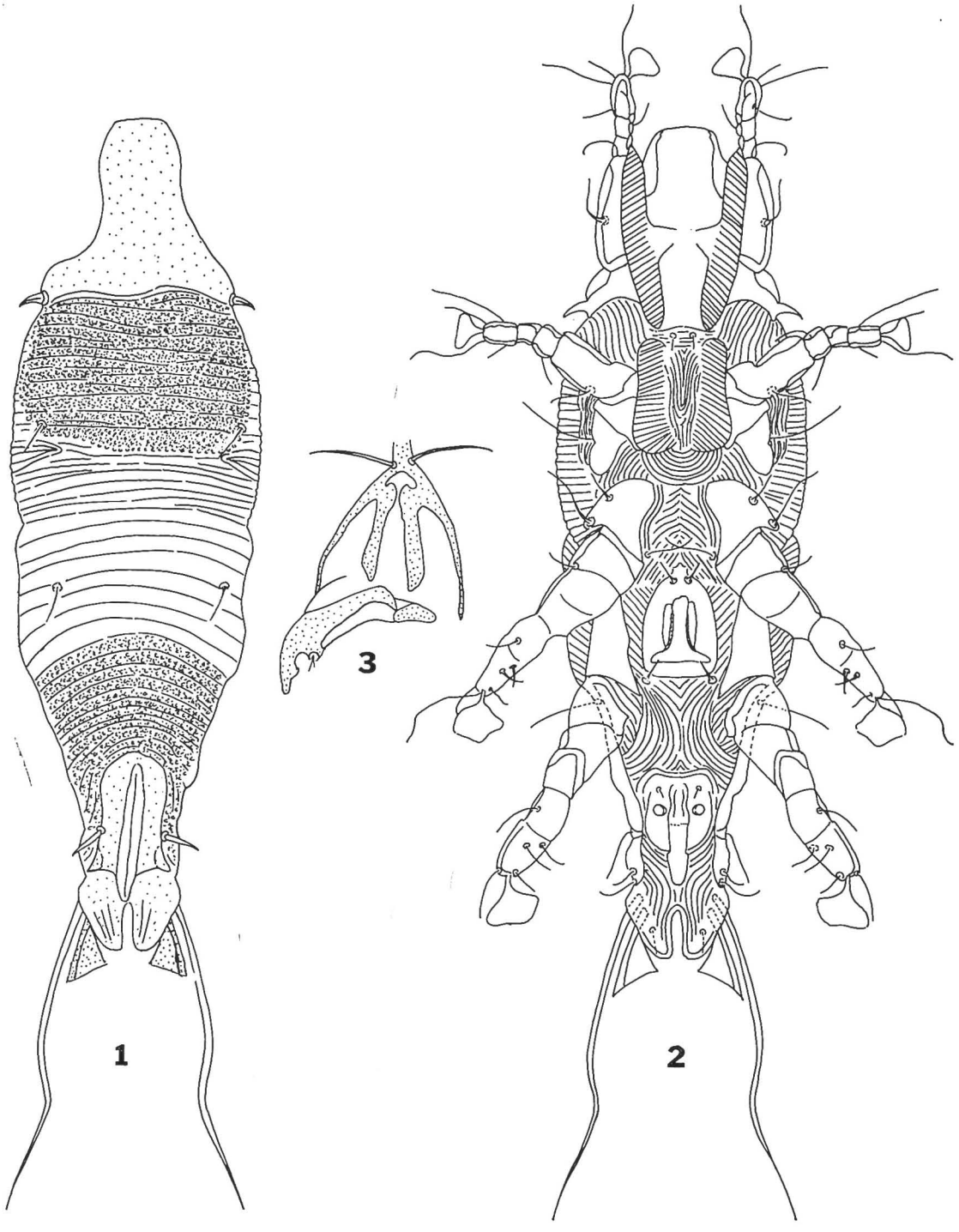
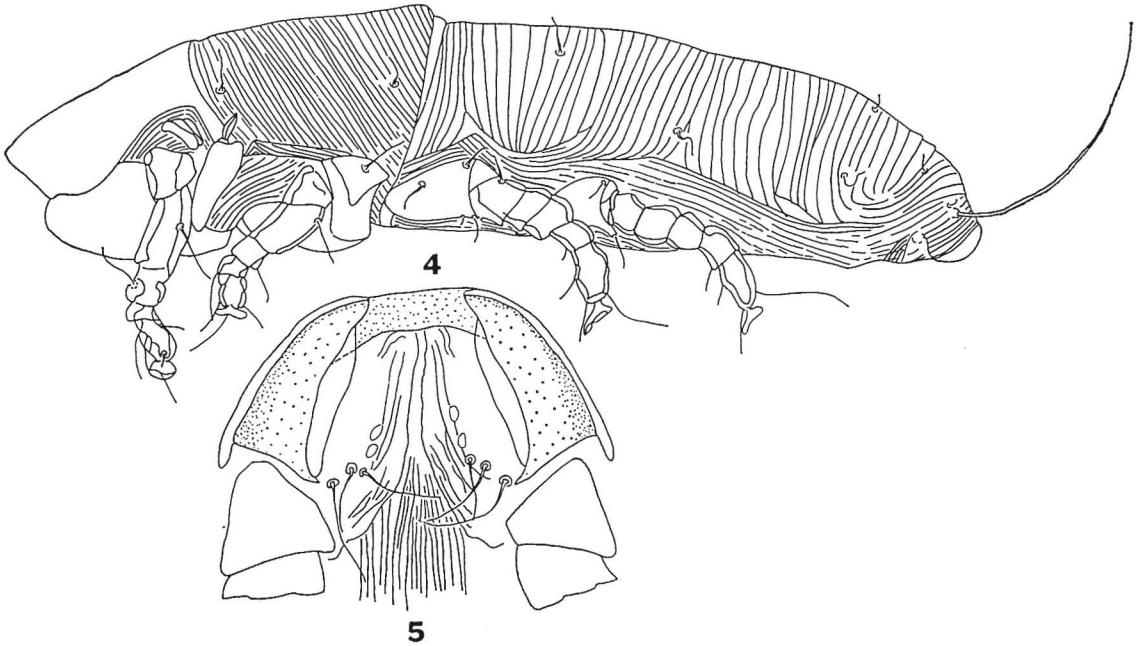


FIGS. 1-3. — **Geomylichus geomydis** n. sp.
1) Holotype male dorsal view ; 2) Holotype male and aedeagus ; 3) ventral view.

dorsal to apices of same plates, immediately above first coxae, are large supracoxal gland openings (KRANZT, 1970). Ventral surface of propodosoma, between legs II, carries a second pair of flaps that aid gnathosomal flaps in grasping hair of host. A pair of setae present between the two pairs of flaps. Inner surface of both pair of flaps covered by fine annulations. Sclerotized plates extend posteriorly behind coxae of legs II to posterior margin of propodosoma. These plates carry a single seta near dorsal edge.

Dorsal and lateral surface of hysterosoma characterized by transverse annulations (± 44). Lateral annulations toward posterior part of hysterosoma run more longitudinally. Coxal apodemes of legs III extend forward in an arch to junction of hysterosoma and propodosoma. Lateral plate areas behind arch sclerotized, median area annulated. Genital area located ventrally between third and fourth pair of legs. Sclerotized plates extend from coxae of legs III to coxae of legs IV, lateral to genital area. A pair of setae present between coxae of legs III and a similar pair found between coxae of legs IV. Posteriorly opisthosoma divided into two lobes, each with three dorsal setae. The most anterior seta of this group is long and tapering to apex (Fig. 12). Middle seta of group highly modified. Its outer margin thickened, inner margin expanded into a thin, blade-like hyaline membrane (Fig. 12). Last seta of group unmodified, shorter than middle seta. Immediately anterior to first pair of setae on lobes are two pairs of short setae that arise ventrally and protrude laterally from the body. An additional pair of longer setae, that arise dorsally, are situated a short distance anteriorly and also protrude laterally. Lateral edge of opisthosoma sclerotized posteriorly from level of coxae IV. A seta arises from near anterior margin of each edge. Two lobes, each having a large sucker and a microseta, located on ventral surface posterior to fourth pair of legs.

The aedeagus rests in a slit (Figs. 2 and 3) between two thick sclerotized plates. Two pairs of genital discs are located at the anterior margins of the two thick plates. Enclosing these structures anteriorly and laterally are two, thick sclerotized plates. Posterior base of aedeagus



FIGS. 4 & 5. — **Geomylichus geomidis** n. sp., Allotype female lateral view and genital area.

sclerotized, as is portion of aedeagus itself. A pair of microsetae occur on a slightly elevated base below apex of aedeagus.

Measurements of the following male characters were analyzed (Table 1) : total body length, dorsal length of propodosoma, and length of seta sc e.

FEMALE (Fig. 4) : Body shape similar to male except for opisthosoma which is more cylindrical and slightly more elongate in female. Opisthosoma tapers gradually posteriorly. All legs same as in male. Setae arising from antero-dorsal apices of tibiae of legs I and II approximately equal to similar setae on tarsi, instead of being slightly more than twice as long as they are in male. Gnathosoma and associated structures same as in male. Propodosoma similar to male including setae sc *e*. Number of propodosomal annulations (± 40) greater than in male.

Annulations on hysterosoma, except those near posterior end, run transversely over dorsal and lateral surface, then curve in a longitudinal direction on ventral surface. The annulations on postero-dorsal surface of hysterosoma curve transversely over lateral surface and extreme postero-ventral area. Number of hysterosomal annulations (± 56) greater than in male. Large sclerotized plates are located anterior to coxae of legs III and IV. Posteriorly there is a long prominent seta on each side of anal opening. These setae originate laterally from dorsal apex of enlarged anal lobes. The lobes lie in a vertical plane and are surrounded by a number of smaller setae.

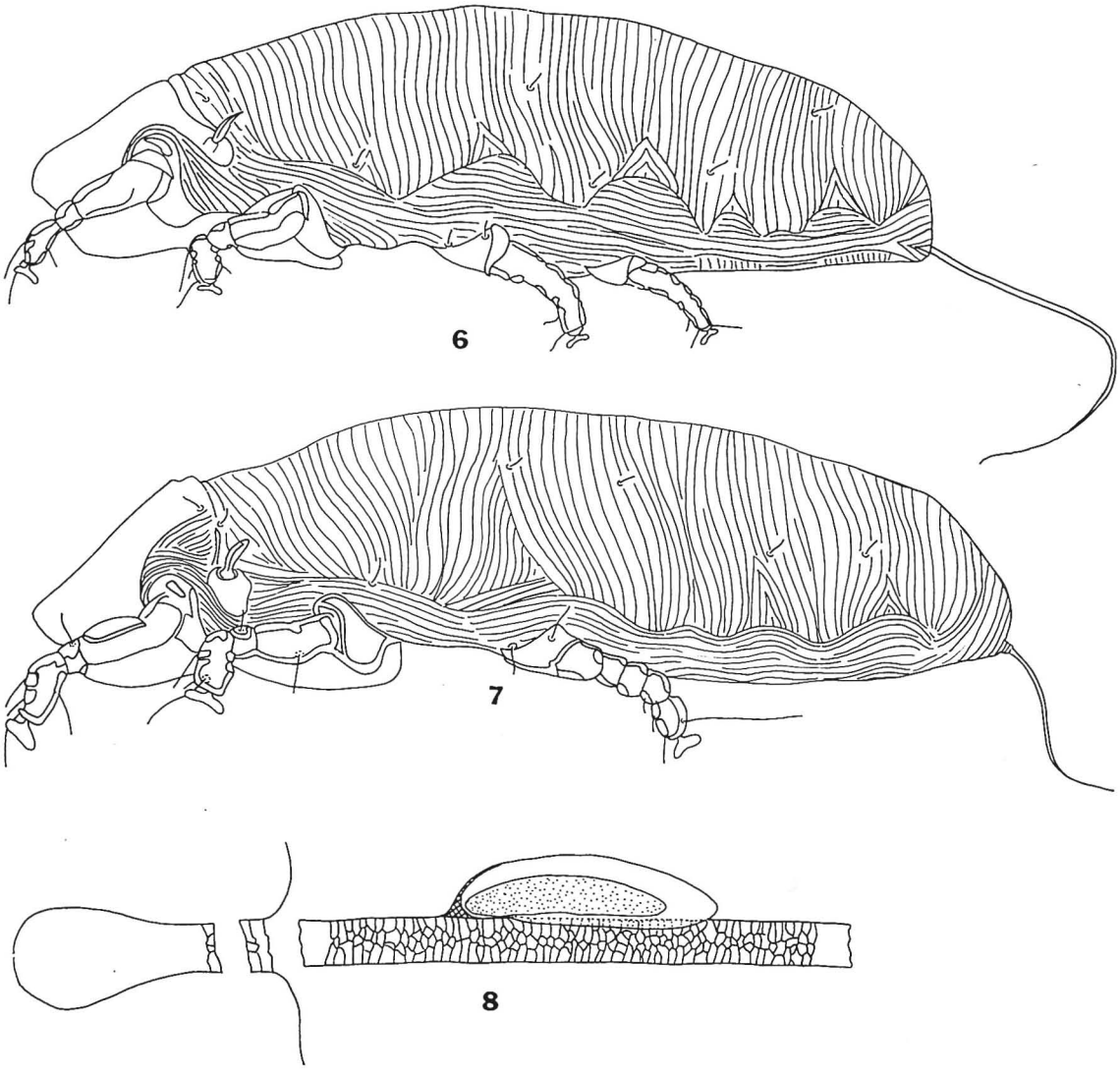
Enclosed within the arch of coxal apodemes of legs III is the genital opening (Fig. 5), flanked on both sides by a pair of genital discs. The integument posterior and lateral to the opening wrinkled. Three setae are located on each side of opening postero-lateral to genital discs.

Female character measurements analyzed (Table 1) were the same as those used for males.

TABLE 1. — Measurements of male, female, and developmental stages of **Geomylichus geomydis** n. sp.

Stage and Character [1]	n	Microns Min	Max	Mean	SE	CV
Male						
TBL	25	484	526	508.4	1.88	1.85
DLP	25	120	126	122.6	0.35	1.40
Seta sc e	25	18.5	23.1	20.8	0.27	6.40
Female						
TBL	25	540	578	555.5	1.98	1.78
DLP	25	127	134	130.7	0.39	1.47
Seta sc e	25	20.0	22.0	21.1	0.14	3.20
Nymph						
TBL	50	351	540	439.8	7.95	12.77
Seta sc e	50	15.0	21.1	17.8	0.22	8.64
Larva						
TBL	50	251	352	302.6	4.37	10.20
Setae sc e	50	12.3	16.5	13.8	0.14	6.93
Egg						
TL	50	269	323	290.1	2.25	3.88

1. TBL = Total body length from anterior tip of gnathosoma to posterior extremity of opisthosoma. DLP = Dorsal length of propodosoma from anterior (junction with head plate) to posterior edge. Seta sc e (thick, peg-like lateral spine) = Length from edge of socket to tip. TL = Total length end to end. n = Number of specimens measured. SE = Standard error of the mean. CV = coefficient of variation.



FIGS. 6-8. — Geomylichus geomydis n. sp.,
6) Nymph, lateral view ; 7) larvae, lateral view ; 8) egg attached to hair of *Geomys b. bursarius*.

NYMPH (Fig. 6) : Body shape similar to female except no evidence of demarcation between propodosoma and hysterosoma. Reproductive structures absent. Entire length cylindrical. All legs with five movable segments as in adults. Setal arrangement on legs similar to female. Body setae sparse, arranged similar to female.

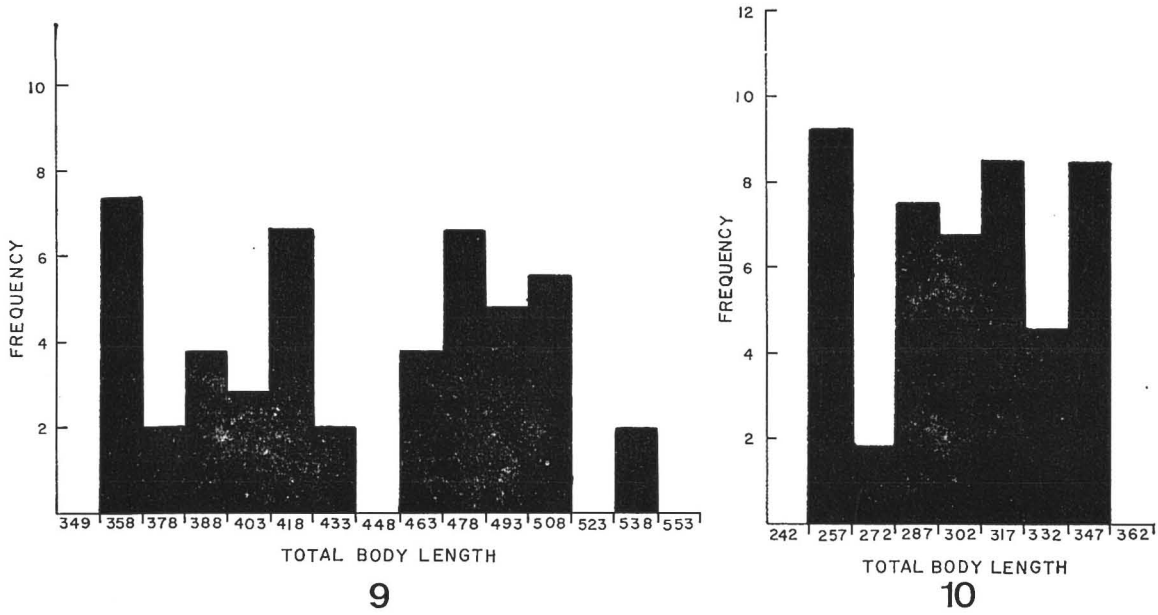
Gnathosoma and associated structures similar to female. Setae sc e arise from elevated plates postero-dorsal to coxae I. Coxo-sternal flaps between legs II similar to female. Dorsal and lateral annulations ($\pm$ 98) of idiosoma transverse. Ventral and ventro-lateral annulations of idiosoma primarily longitudinal, some transverse. Posterior extremity of idiosoma terminated by a pair of long setae.

Nymphal character measurements analyzed (Table 1) were total body length and length of seta sc e. In addition, a histogram (Fig. 9) depicting frequency of occurrence of total body

length measurements, using 15 micron intervals, was constructed and compared with a similar histogram (Fig. 10) for larval total body length measurements.

LARVA (Fig. 7) : General body configuration similar to nymph. Reproductive structures absent. Three pairs of legs with five movable segments terminating in a tarsal sucker as in nymph and adults. Setal arrangement on legs and body similar to nymph. Gnathosoma, setae sc e, and coxo-sternal flaps well developed. Pattern of idiosomal annulations similar to nymphal pattern. Number of annulations (± 85) less than in nymph. Posterior extremity of idiosoma terminated by a pair of long setae.

Larval character measurements analyzed (Table 1) were the same as those used for nymphs.



FIGS. 9-10. — Frequency of occurrence of total body length measurements of **Geomylichus geomydis** n. sp. ; 9) 50 nymphs, Measurements in microns ; 10) 50 larvae, Measurements in microns.

EGG (Fig. 8) : The shape is elongate and narrow. Chorion smooth and transparent. Contents white. Anterior end covered by cementing substance that adheres to surface of hair.

The egg character measurement analyzed (Table 1) was total length.

Geomylichus geomydis n. sp. is distinguished from all other members of the genus *Geomylichus*, except *G. floridanus* (Radford), by the shape of the hyaline membrane expanded from the inner and outer edges of the middle pair of modified anal lobe setae of the male. In *G. floridanus* the middle pair of modified anal lobe setae of the male are not expanded into thin hyaline membranes, but instead have truncated, ax-like distal ends.

Type host : Geomys b. bursarius (Shaw), the plains pocket gopher, (Mammalia : Rodentia : Geomyidae), (Hall and Kelson, 1959).

Holotype : Male, 3.5 mi. S and 1.5 mi. W of Volga, Brookings Co., South Dakota. 13 May 1971 (C. C. Coffman, Host No. CCC-Ml.58).

Allotype : Female, 3.5 mi. S and 1.5 mi. W of Volga, Brookings Co., South Dakota. 13 May 1971 (C. C. Coffman, Host No. CCC-Ml.58).

Paratypes : Slide material : 22 males and 9 females from same host as holotype ; 30 males, 32 females, 50 nymphs, and 50 larvae from type locality but different host (CCC-Ml.57) than holotype. An undetermined number of specimens of all stages from same host as holotype preserved in 70 % ethyl alcohol.

Holotype, allotype, and one male paratype (CCC-Ml.58) deposited in the United States National Museum, Washington, D.C.

Distribution Records for *Geomylichus geomydis* n. sp.

Geomylichus geomydis n. sp. has been recorded from a total of four different hosts in five states. Distribution records of specimens identified that were collected from freshly trapped hosts, as opposed to museum study skin records, include the following : Davis, Yolo Co., California, August 27, 1971 (R. W. Rust, Host : *Thomomys umbrinus agricolaris*) ; 4 mi. E of Riviera, Kleberg Co., Texas, February 18, 1966 (R. S. Zimmerman and B. McDaniel, Host : *Geomys personatus megapotamus*) ; Willow Slough, Newton Co., Indiana, October 19, 1969 (J. O. Whitaker, Jr., Host No. JOW-5321, Host : *Geomys bursarius illinoensis*) ; Brookings Co. and Moody Co., South Dakota, April 18 and August 5, 1969, September-October 1970, May and July 1971 (C. C. Coffman, Host : *Geomys b. bursarius*). Host nomenclature follows Hall and Kelson (1959).

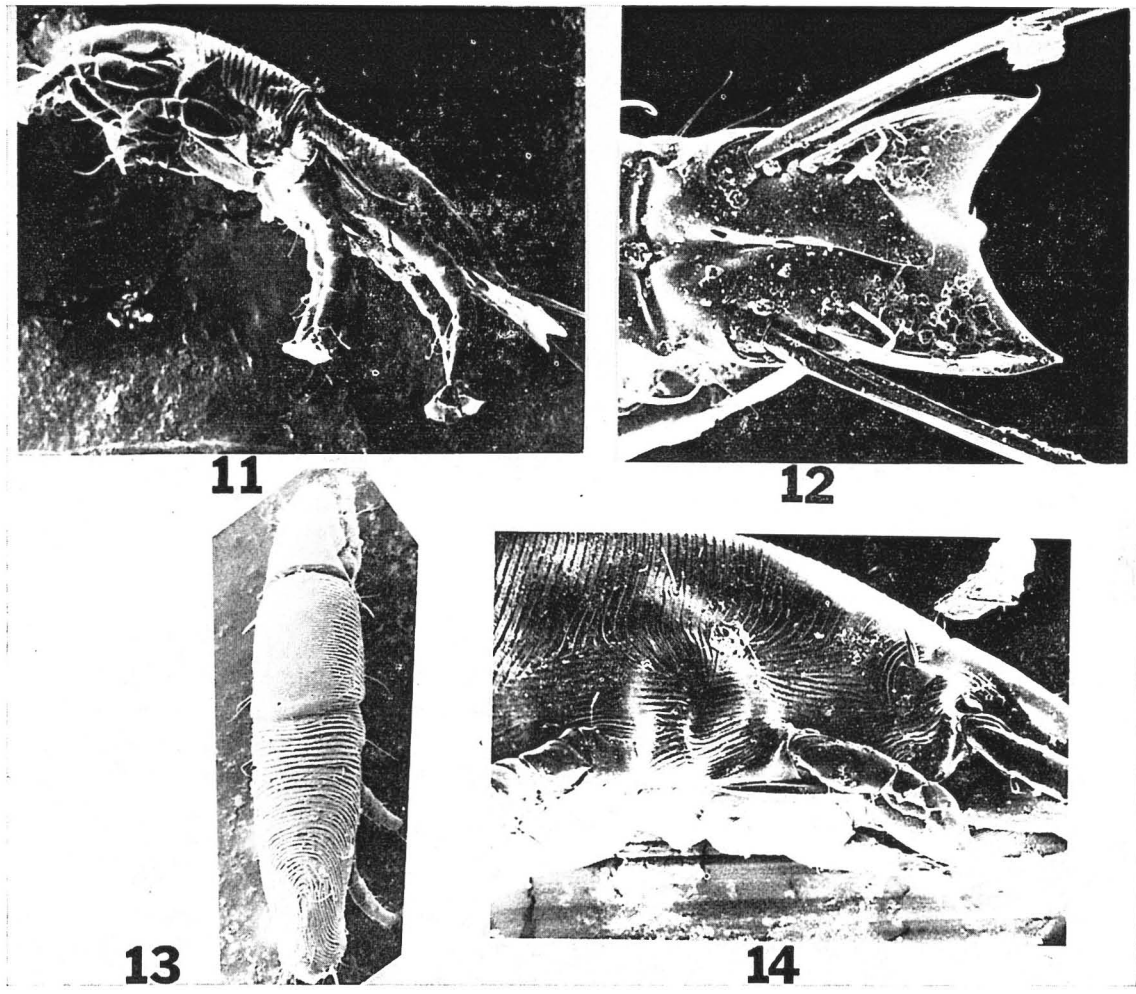
Distribution records determined from examination of pocket gopher museum study skins include the following : 1 mi. E of Hardwick, Rock Co., Minnesota, October 20, 1960 (South Dakota Stage College Catalog No. 622, *Geomys b. bursarius*) ; Sioux Falls, Minnehaha Co., South Dakota, November 14, 1960 (SDSC Catalog No. 653, *G. b. bursarius*) ; 7.5 mi. E and 1 m. S of Pipestone, Pipestone Co., Minnesota, September 19, 1968 (South Dakota State University Catalog No. 1483, *G. b. bursarius*).

Specimens from all the above hosts and locations were determined to be conspecific with the type series of *Geomylichus geomydis*. Scanning electron microscope photographs (Figs. 11, 12, 13, 14) are from specimens from *Thomomys umbrinus agricolaris* trapped at Davis, Yolo Co., California.

Table 2. — Infestation rates for *Geomylichus geomydis* on *Geomys b. bursarius*.

	Season			Sex of Host		Age of Host		
	Fall	Spring	Summer	Male	Female	Juvenile	Adult	Total
Number Examined	30	32	20	38	44	12	70	82
Number Infested	20	23	19	30	32	9	53	62
% Infested	67	72	95	79	73	75	76	76

Geomylichus geomydis population rates of infestation were calculated for seasons of the year, sexes of the host, and ages of the host (Table 2) and exhibited decreasing variation respectively. Seasonal rate was lowest in the fall at 67 %. This increased to 72 % in the spring and was highest at 95 % in the summer. A chi-square test was used to determine if these differences



FIGS. 11-14. — **Geomylichus geomydis** n. sp. ; 11) adult male, lateral view, from *Thomomys umbrinus agricolaris* Davis, Yolo Co. California ; 12) posterior end of adult male, dorsal view, from *Thomomys umbrinus agricolaris*, Davis, Yolo. Co. California ; 13) adult female, dorsal-lateral view, from *Thomomys umbrinus agricolaris*, Davis, Yolo. Co. California ; 14) Nymph, lateral view of anterior region showing external subscapular setae.

were significant. The chi-square value of 5.62 with two degrees of freedom was not significant at the 95 % level, but was at the 90 % level. Further scrutiny of seasonal infestation rates revealed that 40.0 % (8) of hosts infested in the fall sample had populations of less than five individuals compared with 4.3 % (1) in the spring sample and 10.5 % (2) in the summer sample.

The infestation rate for female gophers was 73 % compared to 79 % for males. A chi-square value of 0.0592 with one degree of freedom was obtained in a test for significance in this difference. This value was not significant. Approximately equal percentages of males and females, 16.7 % (5) and 18.8 % (6), respectively, had populations of less than five individuals.

A difference in infestation rate of only 1.0 % was observed between juvenile and adult gophers. Specificially, the juvenile rate was 75 % and the adult rate 76 %. The size of this difference did not warrant a test of significance. Detailed examination of age class infestation rates showed

22.2 % (2) of infested juveniles and 17.0 % (9) of infested adults with less than five individuals. Out of a total of 82 gophers examined 62 were infested with *Geomylichus geomydis* for a total infestation rate of 76 %.

The main sources of variation tested in this analysis were season of the year, sex of the host, and age of the host. Tests for interaction between these variables were also included. The residual mean square was used to test for significance. A highly significant ($P < .01$, $F = 7.290$) difference in total population density/host between seasons was disclosed by the analysis.

The .01 level of significance, even though less than the customarily chosen .05 level, deserves consideration since it is still relatively high. In view of this, there was a significant ($P < .10$, $F = 3.123$) interaction between sex and age of the host for total population density/host. In addition, the variation in density between age classes of the host was very close to significance at the .10 level with an F value of 2.735.

The highly significant seasonal differences in total population density/host are reflected in the seasonal LSM(s) [3]. The data show a better than nine-fold increase from the fall LSM (101) to the spring LSM (952). Following the spring peak, the summer LSM declined to 672, but was still at a high level relative to the fall LSM. The differences in total density/host indicated by the F values significant at or near the .10 level were reinforced by their respective LSM densities/host. The largest *G. geomydis* population (3,834) was collected from an adult male gopher.

A detailed examination of the *G. geomydis* population age structure/host was conducted using a least-squares analysis of variance. The same sources of variation were tested for significance as were used in the analysis of total population density/host. Only those hosts with populations greater than 100 individuals were used in this analysis. This established a better standard for evaluating population age structure by eliminating those populations with the most aberrant age structures. Results of the analysis (Table 3) show only one significant ($P < .05$) source of variation for one of the developmental stages and that was seasonal variation in total larvae/host. The F value was 4.858.

TABLE 3. — Mean squares [1] from the least-squares analysis of variance of the *Geomylichus geomydis* population age structure/host [2] and the adult sex structure/host [2].

Source	D. F.	Males	Females	Adults	Nymphs	Larvae	Immatures	Adult Sex Ratio [3]
Season	2	594	874	2,909	1,308	2,126**	6,763*	0.062
Sex	1	101	404	911	684	310	1,918	0.161**
Age	1	23	155	299	720	552	2,536	0.086*
Season × Sex	1	91	29	223	318	264	1,162	0.061
Season × Age	1	39	22	120	67	3	39	0.060
Sex × Age	1	191	451	1,230	2,444	734	5,859	0.049
Remainder	32	303	370	1,336	910	437	2,473	0.027

1. Mean squares presented here for population age structure/host have all been reduced by dividing by 100 and dropping decimals.
2. Hosts with less than 100 individuals were not included in the analysis of variance.
3. Males/females.
* Significant ($P < .10$).
** Significant ($P < .05$).

3. Least-square mean(s).

Even though not significant at the .05 level, the F values for seasonal variation in total females/host and the sex-age interaction in total nymphs/host were near significance at the .10 level. The value of the former was 2.358 ($F = 2.48 \alpha .10$ level) and the latter 2.685 ($F = 2.87 \alpha .10$ level). In addition to these two being near significance at the .10 level, seasonal variation in total immatures/host was significant at the .10 level with an F value of 2.735.

Careful scrutiny of the LSM densities/host of population age classes (Table 4) disclosed the following notable differences : females exceeded males in every variable category, nymphs exceeded larvae in every variable category, and immatures exceeded adults in every variable category except three. The three exceptions where the order of density magnitude of immatures and adults was reversed were (1) female gophers in the fall, (2) adult gophers in the fall, and (3) adult male gophers.

Results of the least-squares analysis of variance of adult sex structure/host for *G. geomydis* were combined with results of the analysis of population age structure (Table 3). Sources of variation tested were indentical with those in the other analyses. As in the analysis of population age structure, only hosts with more than 100 individuals were used. A significant ($P < .05$) difference was observed in the adult sex ratio/host between sexes of the host. The corresponding F value was 5.860.

Again, as in the analysis of population age structure, one F value in the analysis of adult sex structure was significant at a slightly lower level ($P < .10$). This value, 3.145, was obtained for variation in adult sex ratio/host between ages of the host. Also, the F value, 2.273, for seasonal differences in adult sex ratio/host was reasonably close to significance at the .10 level. When the LSM adult sex ratios/host (Table 4) were studied, it was evident that relatively large differences did exist in these variables.

TABLE 4, PART I. — Least-squares mean densities [1]/host [2] of the *Geomylichus geomydis* population age classes and least-squares mean sex ratios/host [2].

Independent Variable	Males	Females	Adults	Nymphs	Larvae	Immatures	Adult Sex Ratio [3]
Season							
Fall	116	155	271	240	73	313	0.69
Spring	248	305	553	452	356	808	0.75
Summer	147	172	319	323	211	534	0.92
Sex							
Male	203	276	480	424	271	695	0.66
Female	138	145	282	253	156	408	0.92
Age							
Juvenile	187	252	439	428	292	720	0.69
Adult	154	169	323	248	135	383	0.89

1. Rounded to nearest whole number except for adult sex ratio which was rounded to two decimal places.
2. Hosts with less than 100 individuals were not included.
3. Males/females.

TABLE 4, PART II. — Least squares mean densities [1]/host [2] of the *Geomylichus geomydis* population age classes and least-squares mean sex ratios/host [2].

Independent Variable [3]	Males	Females	Adults	Nymphs	Larvae	Immatures	Adult Sex Ratio
Season × Sex							
Fall Females	83	89	172	154	16	170	0.82
Spring Males	261	359	620	500	380	879	0.57
Spring Females	235	250	486	404	333	737	0.94
Summer Males	200	249	450	446	303	749	0.85
Summer Females	94	95	189	200	119	319	1.00
Season × Age							
Fall Juveniles	108	178	286	297	159	457	0.49
Fall Adults	125	131	256	182	13	169	0.88
Spring Adults	232	263	495	362	278	640	0.85
Summer Juveniles	188	232	420	445	282	727	0.92
Summer Adults	106	112	218	201	139	341	0.93
Sex × Age							
Male Juveniles	269	393	662	688	446	1,134	0.48
Male Adults	138	159	298	159	97	256	0.83
Female Juveniles	105	111	216	168	139	306	0.90
Female Adults	170	178	348	173	338	510	0.94

1. Rounded to nearest whole number except for adult sex ratio which was rounded to two decimal places.
2. Hosts with less than 100 individuals were not included.
3. Some variables missing due to lack of appropriate samples.
4. Males/females.

RÉSUMÉ

La description et le mesurage des étapes de cycles physiologiques de *Geomylichus geomydis* n. sp. sont donnés. Les taux d'infestation furent déterminés selon la saison de l'année et selon le sexe et l'âge de l'hôte. Une analyse des plus petits carrés de variance fut employée pour étudier la population des espèces en trois catégories de variables : saison de l'année, sexe de l'hôte, âge de l'hôte. Des différences significatives furent remarquées pour la population de *Geomylichus geomydis* n. sp. en densité totale/hôte, structure de l'âge de la population/hôte et structure du sexe adulte/hôte. Des photographies faites sous le microscope électronique à balayage y sont inclus.

SUMMARY

Descriptions and measurements of life cycle stages of *Geomylichus geomydis* n. sp. are given. Infestation rates for *G. geomydis* n. sp. were determined for seasons of the year and sexes and ages of the host. A least-squares analysis of variance was used to analyze species populations in three variable categories : seasons of the year, sexes of the host, ages of the host. Significant differences were identified for G. *geomydis* n. sp. populations in total density/host, population age structure/host and adult sex structure/host. Scanning electron microscope photographs for *G. geomydis* n. sp. are included.

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