J. Med. Entomol. Vol. 16, no. 4: 265–274 7 November 1979

A REVIEW OF THE *GEOMYDOECUS TOLUCAE* COMPLEX (MALLOPHAGA: TRICHODECTIDAE) FROM *THOMOMYS* (RODENTIA: GEOMYIDAE), BASED ON QUALITATIVE AND QUANTITATIVE CHARACTERS[1]

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Abstract. *Geomydoecus tolucae* is redescribed and illustrated; its known host range is 5 subspecies of *Thomomys umbrinus* from the Mexican states of Puebla, Veracruz, and Mexico. Four new species and subspecies of *Geomydoecus* are described from Arizona (USA) and Mexico: *G. fulvi* from *T. bottae fulvus* from Arizona; *G. chihuahuae chihuahuae* from 4 subspecies of *T. umbrinus* and *T. bottae* from Chihuahua and Arizona (type-host: *T. u. madrensis*); *G. chihuahuae emersoni* from *T. u. chihuahuae* from Durango and southern Chihuahua; and *G. pattoni* from *T. u. chihuahuae* from Durango. Distinctions between these taxa are shown using qualitative and quantitative characters and principal components analysis of quantitative characters. Discriminant functions for 2 or 3 characters are provided in instances where they are shown to offer enhanced differentiation over single characters. Keys are given to identify these 5 taxa.

Price & Emerson (1971) described *Geomydoecus tolucae* for a series of 12 adult lice from several specimens of *Thomomys umbrinus tolucae* Nelson & Goldman from central Mexico. Extensive collecting since then from many additional individuals of *Thomomys* has shown members of the *tolucae* complex to occur on at least 10 subspecies of pocket gophers from central Mexico northward into Arizona, USA. This abundance of *tolucae* complex material has allowed a thorough re-examination of the entire group and has resulted in the recognition of 4 new species and subspecies. It is our purpose here to describe and illustrate these taxa and to provide keys for their identification.

Quantitative data for the *tolucae* complex lice combined with their host and locality information are included as part of a computerized pocket gopher louse data base which is maintained at the University of Minnesota. These data have been obtained from about 6000 adult lice taken from over 1950 host pocket gophers identified to 215 subspecies of *T. bottae* (Eydoux & Gervais) and *T. umbrinus* (Richardson) collected from more than 1000 localities. Because of the quantity and complexity of the data which form the basis of this and other studies on the *bottae-umbrinus* lice, we have automated our handling of these data as well as some portions of the taxonomic decision-making process.

The retrieval and analysis of stored louse data were performed with an integrated group of computer programs which we developed and called the BUG system. This system provides for the definition of tentative taxonomic louse groups, the extraction of data for lice within these groups, and the analysis or comparison of these data within a group or between groups. Group definitions may be based on preliminary louse identification, host identification, host locality, specific host, specific louse, or any combination of these criteria. The kinds of analyses built into the system include general data summarization, character correlations, analysis of variance with 1-way, 2-way, and nested designs, principal components analysis, and agglomerative clustering. The system also has some graphics capabilities, including character distribution graphs, principal components scattergrams, and dendrograms, and can select and format louse data for use with general statistical analysis computer program packages such as BMD—Biomedical Computer Programs and Statistical Package for the Social Sciences (SPSS).

For the lice of the *tolucae* complex, the system was used to evaluate character homogeneity within groups of lice, make comparisons between groups, and identify taxonomically useful characters for

[1]Paper No. 10,617, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul, Minnesota 55108, USA. Partial support for this study was supplied by a grant to the University of Minnesota from the National Science Foundation (Grant No. DEB77-10179).

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descriptions. The evaluation of character homogeneity included an analysis of variance of each of 25 male and 30 female characters among lice collected from different host taxa, among lice obtained from different localities within each host taxon, and, where warranted, among lice from different hosts within specific localities. Decisions on group similarity were based on comparisons of character means, coefficients of intraclass correlation, and estimates of variance components for among and within groups. The calculation of these parameters is explained in Sokal & Rohlf (1969). In general, the requirements for group distinction were a significant difference between means at the 0.01 probability level for 1 or more characters of both sexes, coefficients of intraclass correlation of at least 0.60, and square roots of estimated variance components of at least 5% of character means for among and no more than 50% of character means for within groups.

These grouping criteria were developed from a comprehensive study of pocket gopher louse variation using a 5-level nested analysis of variance model (Hellenthal, Price & Martin, in prep.). Significant difference between character means was not used as the sole criterion for group distinction because the degree of resolution of the comparisons is dependent on sample size (Sokal 1965); the large numbers of lice compared frequently showed significant but trivial distinctions for many characters, probably because of minor genetic differences between populations.

Many more lice were examined for qualitative morphological features than were considered numerically. Louse groupings based on these qualitative characters were compared with those developed from quantitative distinctions. In general, taxa which show both qualitative and quantitative distinctions from other taxa are described as species, whereas those based primarily on numerical characters are described as subspecies.

In the following descriptions, measured or counted characters are followed by the minimum and maximum observed values and the sample size, mean, and standard deviation in parentheses. All measurements are in millimeters. In evaluating character usefulness for specific and subspecific discrimination, critical values for each character were calculated at the point where the likelihood of single character misidentification of the 2 compared taxa was equal, given normality and equal variance, and ignoring probability of collection. For characters offering moderately good discriminating ability, these critical values and the corresponding probabilities of misidentification are given.

Abbreviations used for host accession numbers in the "Specimens examined" section are KU (University of Kansas Museum of Natural History), LA (Los Angeles County Museum of Natural History), SD (San Diego Natural History Museum), UA (University of Arizona), UC (University of California Museum of Vertebrate Zoology), and USNM (U.S. National Museum of Natural History). In the same section, a number in parentheses following a locality represents the total gophers from which lice were taken. Original locality data expressed in miles are followed parenthetically by the metric equivalent to 0.1 km. The English figure, rather than the metric, expresses the precision of the location estimate.

The discriminant functions given in this paper were calculated using the U.C.L.A. BMD computer program BMD04M (Discriminant Analysis for Two Groups), as described in Dixon (1973). The principal components analysis used a computer program adapted from program PCFLOR in Goldstein & Grigal (1972). Most other calculations for this study were done using computer programs written by the junior author.

Geomydoecus tolucae Price & Emerson

FIG. 1–9

Geomydoecus tolucae Price & Emerson, 1971, J. Med. Entomol. **8:** 245.

Type-host. Thomomys umbrinus tolucae Nelson & Goldman.

♀. As in FIG. 3. Temple width (TW) 0.415–0.465 (32: 0.435 ± 0.0147); head length (HL) 0.280–0.340 (32: 0.301 ± 0.0153); submarginal and inner marginal temple setae (STS, MTS: FIG. 1) 0.065–0.095 (26: 0.084 ± 0.0075) and 0.035–0.065 (32: 0.051 ± 0.0069) long, respectively, with STS lateroanterior to inner MTS. Prothorax width (PW) 0.295–0.340 (35: 0.313 ± 0.0125). *Tergal setae.* I, 2; II, 14–21 (37: 17.5 ± 1.46); III, 20–28 (36: 24.6 ± 1.93); IV, 21–32 (36: 26.6 ± 2.69); V, 19–30 (35: 25.5 ± 3.02); VI, 19–30 (37: 25.6 ± 3.01); tergal and pleural setae on VII, 34–45 (37: 40.0 ± 2.92). Longest seta of medial 10 on tergite VI, 0.095–0.130 (34: 0.106 ± 0.0077); on tergite VII, 0.090–0.125 (34: 0.106 ± 0.0068), with 0–4 (33: 1.0 ± 1.19) of these longer than 0.100. Longest seta of medial pair on tergite VIII, 0.075–0.120 (35: 0.098 ± 0.0101). Last tergite with 3 lateral setae (LS: FIG. 5) close together on each side; outer seta generally shorter, 0.060–0.100 (28: 0.074 ± 0.0106) long, and middle and inner setae subequal in length, 0.080–0.130 (31: 0.101 ± 0.0098) and 0.080–0.115 (31: 0.102 ± 0.0077) long, respectively. *Sternal setae.* II, 12–20 (36: 14.5 ± 1.75); III, 11–18 (36: 14.4 ± 1.46); IV, 11–17 (36: 13.7 ± 1.41); V, 10–15 (37: 12.6 ± 1.14); VI, 8–14 (37: 11.8 ± 1.34); VII,

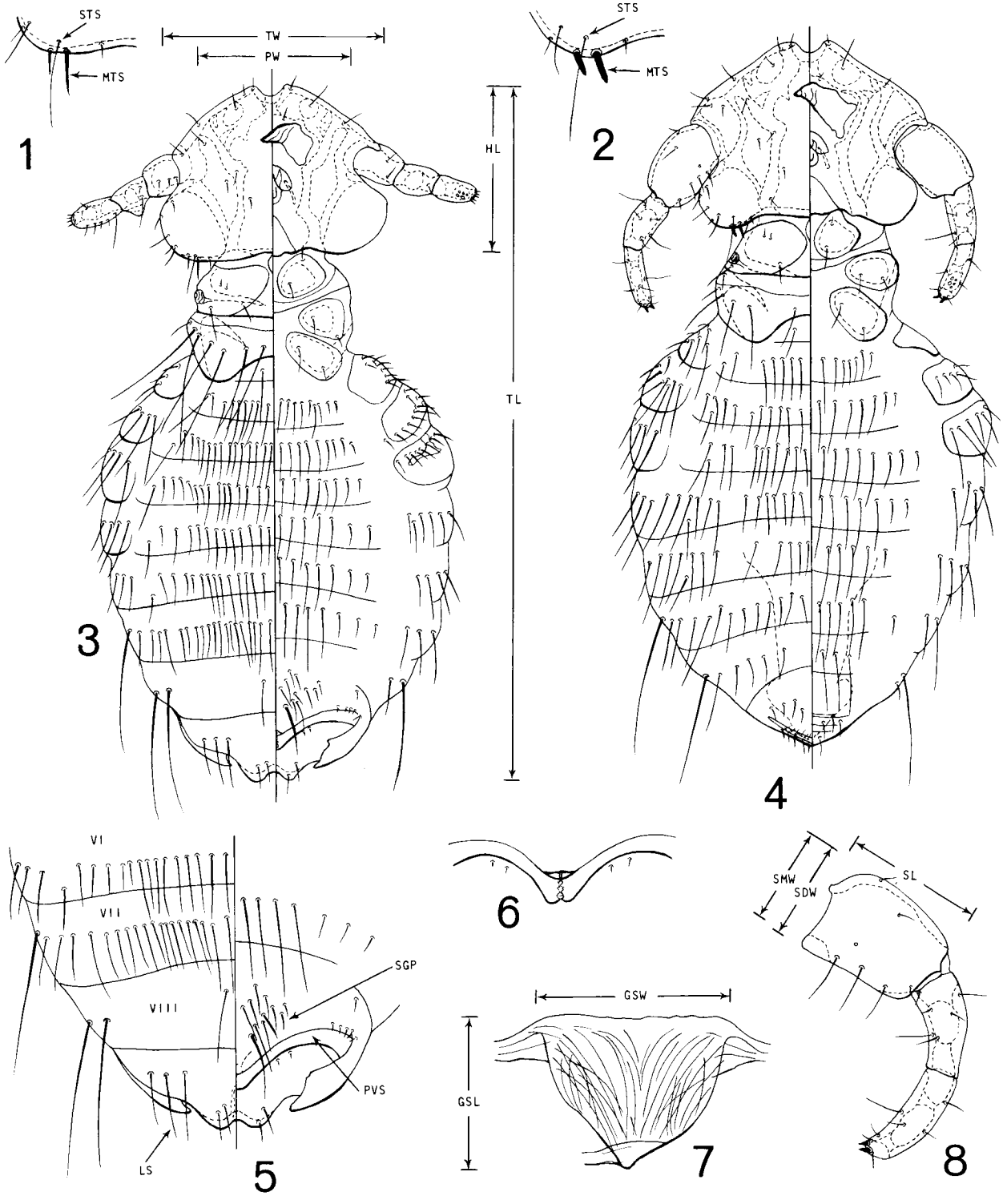

FIG. 1–8. *Geomydoecus tolucae*: (1) ♀ marginal temple (MTS, marginal temple seta; STS, submarginal temple seta); (2) ♂ marginal temple (MTS, marginal temple seta; STS, submarginal temple seta); (3) ♀ (HL, head length; PW, prothorax width; TL, total length; TW, temple width); (4) ♂; (5) ♀ terminalia (LS, lateral setae of last tergite; PVS, postvulval sclerite; SGP, subgenital plate); (6) ♀ postvulval sclerite; (7) ♀ genital sac (GSL, genital sac length; GSW, genital sac width); (8) ♂ dorsal antenna (SDW, scape distal width; SMW, scape medial width; SL, scape length).

10–14 (37: 11.6 ± 0.80). Subgenital plate (SGP: FIG. 5) with 19–25 (35: 21.8 ± 1.34) setae, with distribution and lengths as shown, with 1 seta on each side distinctly thicker and longer than others. Total length (TL) 1.090–1.405 (31: 1.290 ± 0.0759). Postvulval sclerite (PVS: FIG. 5) as in FIG. 6, with relatively short median portion 0.030–0.050 long and 2 very short associated setae on each side, longest only 0.010–0.015 long. Genital sac as in FIG. 7, width (GSW) 0.260–0.350 (35: 0.305 ± 0.0219), length (GSL) 0.165–0.255 (36: 0.210 ± 0.0194), without loops, but with only irregular posteriorly directed lines.

♂. As in FIG. 4. Temple width 0.380–0.425 (42: 0.401 ± 0.0097); head length 0.280–0.340 (42: 0.307 ± 0.0122); submarginal and inner marginal temple setae (STS, MTS: FIG. 2) 0.080–0.105 (34: 0.091 ± 0.0067) and 0.025–0.035 (39: 0.029 ± 0.0028) long, respectively, with STS lateroanterior to inner MTS; both inner and outer MTS blunt, spiniform. Antenna (FIG. 8) with scape length (SL) 0.135–0.160 (42: 0.152 ± 0.0070), scape medial width (SMW) 0.090–0.125 (42: 0.102 ± 0.0060), scape distal width (SDW) 0.095–0.125 (42: 0.105 ± 0.0052). Prothorax width 0.270–0.310 (45: 0.291 ± 0.0084). *Tergal setae.* I, 2; II, 11–18 (42: 14.1 ± 1.48); III, 18–25 (44: 21.5 ± 1.76); IV, 20–28 (45: 24.0 ± 1.54); V, 18–26 (44: 22.0 ± 1.78); VI, 14–23 (44: 17.7 ± 1.80); tergal and pleural setae on VII, 23–32 (45: 27.5 ± 1.90). *Sternal setae.* II, 11–19 (45: 14.8 ± 1.91); III, 12–18 (42: 14.7 ± 1.36); IV, 11–19 (42: 15.0 ± 1.70); V, 9–14 (42: 11.5 ± 1.27); VI, 9–12 (45: 10.6 ± 0.65); VII, 8–12 (45: 9.9 ± 0.89); VIII, 6–8 (43: 6.2 ± 0.45). Total length 1.235–1.425 (40: 1.317 ± 0.0500). *Genitalia* as in FIG. 9, with sac having 6 large spines (GSS), outer pair elongate, slender, usually transversely oriented; parameral arch (PA) with lateroposterior expanded portion, width (PAW) 0.145–0.175 (45: 0.163 ± 0.0075); endomeral plate (EP) roughly triangular, apically tapered with distinct division, width (EPW) 0.075–0.100 (44: 0.089 ± 0.0046), length (EPL) 0.085–0.105 (41: 0.095 ± 0.0052).

Specimens examined. MEXICO: 9♀,12♂, *T. u. tolucae,* Mexico: Ojo de Agua, NW slope of Nevado de Toluca (4), 18 km S, 12 km W of Toluca (2), 4 mi. (6.4 km) S of Raices (1). 10♀,28♂, *T. u. orizabae* Merriam, Veracruz: vicinity of Maltrata (3); Puebla: Pico de Orizaba (1). 2♀,1♂, *T. u. peregrinus* Merriam, Mexico: Salazar (3). 9♀,7♂, *T. u. umbrinus,* Puebla: Boca del Monte (4). 19♀,32♂, *T. u. vulcanius* Nelson & Goldman, Mexico: N slope of Popocatepetl (5), 5.5 km S, 13 km E of Amecameca (5).

Geomydoecus fulvi Price & Hellenthal, **new species** FIG. 10–13

Type-host. Thomomys bottae fulvus (Woodhouse).

♀. Much as for *G. tolucae,* except as follows. Temple width 0.405–0.450 (30: 0.420 ± 0.0106); submarginal and inner marginal temple setae 0.075–0.130 (26: 0.106 ± 0.0117) and 0.030–0.060 (30: 0.044 ± 0.0077), respectively, with shorter slender outer MTS (FIG. 10). Prothorax width 0.290–0.330 (31: 0.303 ± 0.0100). *Tergal setae.* II, 14–19 (31: 16.5 ± 1.46); III, 19–26 (31: 21.9 ± 1.72); IV, 19–30 (31: 23.0 ± 1.85); V, 17–26 (31: 20.8 ± 2.37); VI, 17–27 (31: 21.6 ± 2.69). Longest seta of medial 10 on tergite VII, 0.105–0.130 (30: 0.117 ± 0.0076), with 1–7 (29: 3.2 ± 1.47) of these longer than 0.100. Longest seta of medial pair on tergite VIII, 0.095–0.120 (29: 0.107 ± 0.0067). Last tergite with outer of 3 lateral setae only 0.050–0.075 (28: 0.063 ± 0.0074) long. *Sternal setae.* II, 9–16 (31: 12.7 ± 1.62); III, 8–14 (31: 12.0 ± 1.38); V, 8–14 (31: 11.5 ± 1.23). Total length 1.085–1.290 (29: 1.189 ± 0.0506). Postvulval sclerite (FIG. 12) with longest associated seta 0.020–0.025 long. Genital sac width 0.290–0.360 (31: 0.326 ± 0.0145).

♂. Much as for *G. tolucae,* except as follows. Temple width 0.385–0.410 (43: 0.395 ± 0.0064); head length 0.280–0.320 (43: 0.299 ± 0.0083); submarginal temple seta 0.090–0.135 (35: 0.111 ± 0.0102) long; outer marginal temple seta more slender, pointed (FIG. 11). Antenna with scape medial width 0.090–0.105 (38: 0.096 ± 0.0038), scape distal width 0.095–0.105 (38: 0.100 ± 0.0032). Prothorax width 0.275–0.305 (44: 0.285 ± 0.0081). *Tergal setae.* II, 11–17 (45: 13.2 ± 1.26); III, 16–23 (45: 19.7 ± 1.81); IV, 18–28 (44: 21.6 ± 2.10); V, 16–24 (44: 19.8 ± 1.75); VI, 12–19 (45: 15.9 ± 1.72); tergal and pleural setae on VII, 19–29 (45: 23.0 ± 2.06). *Sternal setae.* II, 10–15 (45: 12.3 ± 1.25); III, 9–17 (44: 12.5 ± 1.55); IV, 10–16 (45: 13.1 ± 1.07); V, 8–13 (45: 10.4 ± 0.92); VI, 8–11 (45: 9.5 ± 0.97); VII, 6–11 (45: 8.7 ± 1.04). Total length 1.180–1.390 (43: 1.273 ± 0.0508). *Genitalia* as in FIG. 13, with sac spines shaped and oriented as shown.

Remarks. Both sexes of *G. fulvi* are close to those of *G. tolucae,* but a number of qualitative and quantitative characters enable separation. The slender outer marginal temple seta for the female and male (FIG. 10, 11 vs FIG. 1, 2), the longer setae associated with the female postvulval sclerite (FIG. 12 vs FIG. 6), and the orientation of the large spines on the male genital sac (FIG. 13 vs FIG. 9) represent the best qualitative features to identify *G. fulvi.* Both sexes tend to be smaller and to have fewer tergal and sternal setae.

For females, critical values for discrimination and probabilities of misidentification for the best discriminating quantitative characters are the length of submarginal temple seta (LSTS) 0.948 (0.127), number of setae on sternite III (SST3) 13.206 (0.192), and number of setae on tergite V (STG5) 23.146 (0.196). For males, the best characters are the number of tergal and pleural setae on tergite VII (STG7) 25.233 (0.128), length of submarginal temple seta (LSTS) 0.101 (0.139), and number of setae on sternite II 13.511 (0.220). Because of the high probability of error using any 1 of these quantitative characters, discriminant functions were calculated using the best 3 and each combination of 2 of the best 3 characters for each sex. An explanation of the use of discriminant functions for louse identification is given in Price & Hellenthal (1975). For females, discriminant functions based on all 3 characters (LSTS, SST3, STG5), with respective coefficients of −0.005, 0.021, and 0.013, showed discriminating ability superior to functions based on 2 characters. Discrim-

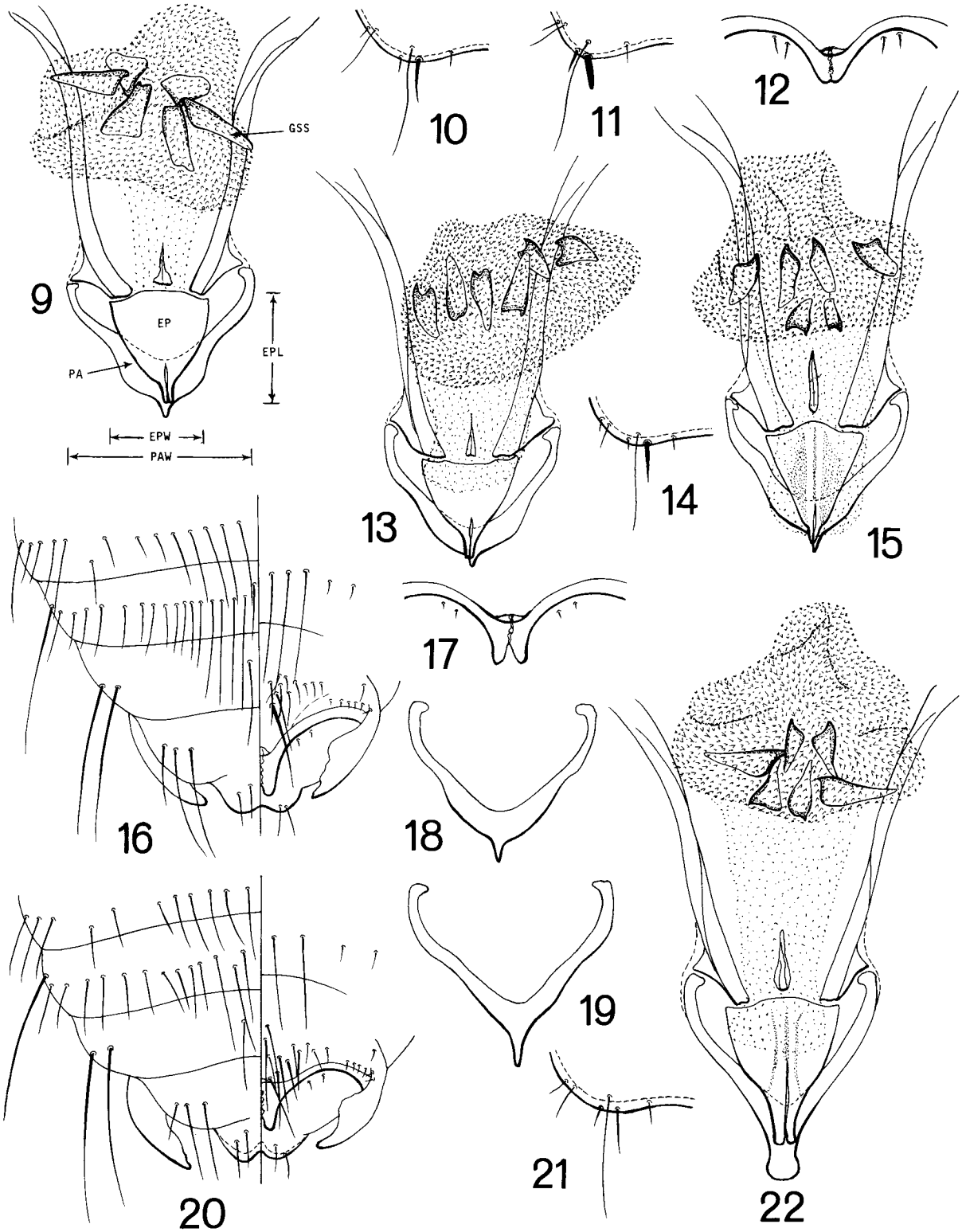

FIG. 9–22. (9) *Geomydoecus tolucae*: ♂ genitalia (EP, endomeral plate; EPL, endomeral plate length; EPW, endomeral plate width; GSS, genital sac spines; PA, parameral arch; PAW, parameral arch width). 10–13. *G. fulvi*: (10) ♀ marginal temple; (11) ♂ marginal temple; (12) ♀ postvulval sclerite; (13) ♂ genitalia. 14–18. *G. chihuahuae chihuahuae*: (14) ♂ marginal temple; (15) ♂ genitalia; (16) ♀ terminalia; (17) ♀ postvulval sclerite; (18) ♂ parameral arch. (19) *G. chihuahuae emersoni*: ♂ parameral arch. 20–22. *G. pattoni*: (20) ♀ terminalia; (21) ♂ marginal temple; (22) ♂ genitalia.

inant means and standard deviations for *G. tolucae* were 0.221 ± 0.0704 and for *G. fulvi* 0.005 ± 0.0640, with a critical value for the discriminant of 0.113 and a resulting probability of misidentification of 0.054. For males, the discriminant function based on STG7 and LSTS, with respective coefficients of 0.018 and −0.004, had a discriminating ability nearly equal to that based on the 3 best characters. The discriminant means and standard deviations for *G. tolucae* were 0.121 ± 0.0412 and for *G. fulvi* −0.037 ± 0.0548. The critical value for the discriminant was 0.042 with a probability of misidentification of 0.052.

Specimens examined. Holotype ♂, *T. b. fulvus*, USA: Arizona: Coconino Co.: Potato Lake, 3 mi. (4.8 km) S, 4 mi. (6.4 km) E of Clints Well, 25.VIII.1971, J.L. Patton, UC-140929 (in University of Minnesota coll.). Paratypes (all from type-host): Arizona: Coconino Co.: 9♀,12♂, same as holotype; 3♀,14♂, same, except UC-140930, 140931; 5♀,6♂, same, except 1.VIII.1973, UC-144158; 10♀,24♂, 2 mi. (3.2 km) W of Bismark Lake, San Francisco Mts, 12.VIII.1969, J.L. Patton, UC-137852, 137854, 137856, 137858; 14♀,14♂, Coyote Basin, 3 mi. (4.8 km) E of Mormon Lake, 26.VIII.1971, J.L. Patton, UC-140953, 140954; 18♀,10♂, Whitehorse Lake, Bill Williams Mts, 7.VIII.1973, J.L. Patton, UC-144186, 144188; 2♀,2♂, Little Spring, San Francisco Mts, 27.VII.1932, L. Kellogg, UC-55453; 1♀,1♂, Fern Mt, W slope of San Francisco Mts, 3.VIII.1973, J.L. Patton, UC-144181, 144185; 1♀, SW side of San Francisco Mts, 18.VIII.1958, T.P. Kendrick, KU-80331; 1♀,1♂, San Francisco Mts, 21.VI.1929, L.M. Huey, SD-7249. Apache Co.: 4♀,5♂, 7 mi. (11.3 km) N of Big Lake, 17.VII.1933, A.M. Alexander, UC-60525, 60528; 1♀,4♂, 30 mi. (48.3 km) SSW of Springerville, White Mts, 8.IX.1940, W. Longhurst, UC-94724; 2♀, W fork of Black River, 15.VIII.1958, E.L. Cockrum, UA-1600; 1♀,3♂, same, except 16.VIII.1958, UA-1619; 3♀,2♂, N fork of White River, White Mts, 1.VII.1933, L.M. Huey, SD-10686; 1♂, same, except 21.VII.1933, SD-10771; 1♂, Phelps Botanical Area, 10.X.1966, C.S. Schroder, UA-16035; 2♂, 2 mi. (3.2 km) N of Phelps Botanical Area, 30.IX.1967, R.L. Wadleigh, UA-17443. Greenlee Co.: 5♀,3♂, Hannagan Creek, 23.IX.1932, L. Kellogg, UC-55507; 2♀,7♂, 8.2 mi. (13.2 km) N of Hannagan Meadows, 17.VIII.1971, J.L. Patton, UC-140905, 140908. Navajo Co.: 1♂, Buck Springs, 25.VI.1942, C.T. Vorhies, UA-865.

Geomydoecus chihuahuae Price & Hellenthal, **new species** FIG. 14–19

Type-host. Thomomys umbrinus madrensis Nelson & Goldman.

♀. Generally as for *G. tolucae* (FIG. 3). Temple width 0.365–0.410 (51: 0.391 ± 0.0115); head length 0.255–0.295 (52: 0.273 ± 0.0090); submarginal and inner marginal temple setae 0.055–0.105 (31: 0.083 ± 0.0109) and 0.030–0.050 (50: 0.039 ± 0.0049) long, respectively. Prothorax width 0.275–0.315 (56: 0.293 ± 0.0092). *Tergal setae.* II, 13–19 (57: 16.2 ± 1.44); III, 16–25 (56: 19.8 ± 2.08); IV, 17–28 (55: 20.9 ± 2.24); V, 15–26 (55: 18.8 ± 2.51); VI, 15–25 (55: 19.0 ± 2.41); tergal and pleural setae on VII, 26–51 (57: 35.2 ± 4.69). Longest seta of medial 10 on tergite VI, 0.080–0.125 (53: 0.104 ± 0.0100); on tergite VII, 0.115–0.170 (54: 0.144 ± 0.0119), with 1–10 (50: 5.1 ± 2.01) of these longer than 0.100. Longest seta of medial pair on tergite VIII, 0.090–0.140 (47: 0.114 ± 0.0109). Lengths of 3 lateral setae on last tergite, respectively, outer to inner, 0.050–0.105 (42: 0.066 ± 0.0125), 0.085–0.150 (45: 0.115 ± 0.0171), 0.085–0.140 (50: 0.117 ± 0.0149). *Sternal setae.* II, 8–15 (56: 11.0 ± 1.50); III, 8–15 (56: 11.1 ± 1.31); IV, 7–14 (55: 10.8 ± 1.83); V, 6–12 (54: 9.2 ± 1.46); VI, 6–13 (56: 8.9 ± 1.45); VII, 7–14 (57: 9.7 ± 1.43). Subgenital plate with 16–24 (57: 20.6 ± 1.98) setae. Total length 1.040–1.280 (52: 1.155 ± 0.0626). Postvulval sclerite as in FIG. 17, with elongate median portion 0.055–0.075 long. Genital sac as in FIG. 7, width 0.225–0.325 (57: 0.276 ± 0.0240), length 0.150–0.245 (57: 0.189 ± 0.0173).

♂. Much as for *G. tolucae* (FIG. 4). Temple width 0.350–0.385 (61: 0.368 ± 0.0092); head length 0.265–0.305 (62: 0.281 ± 0.0079); submarginal and inner marginal temple setae 0.065–0.095 (46: 0.081 ± 0.0073) and 0.020–0.035 (62: 0.029 ± 0.0037) long, respectively, with inner MTS often tapered, pointed, and outer MTS very short, slender (FIG. 14). Antenna with scape length 0.120–0.145 (55: 0.132 ± 0.0064), scape medial width 0.075–0.095 (55: 0.085 ± 0.0044), scape distal width 0.080–0.100 (55: 0.090 ± 0.0046). Prothorax width 0.260–0.295 (68: 0.276 ± 0.0086). *Tergal setae.* II, 11–16 (71: 12.9 ± 1.09); III, 14–20 (71: 18.2 ± 1.10); IV, 17–24 (72: 19.9 ± 1.75); V, 15–22 (71: 18.6 ± 1.48); VI, 11–20 (72: 16.1 ± 1.91); tergal and pleural setae on VII, 18–27 (73: 22.6 ± 2.33). *Sternal setae.* II, 9–13 (71: 11.0 ± 1.05); III, 8–13 (73: 11.3 ± 0.99); IV, 9–14 (72: 11.6 ± 1.36); V, 7–13 (72: 9.1 ± 1.17); VI, 6–11 (72: 8.5 ± 1.07); VII, 6–10 (71: 7.7 ± 0.79); VIII, 4–7 (72: 5.9 ± 0.50). Total length 1.090–1.325 (58: 1.215 ± 0.0627). *Genitalia* much as in FIG. 15; parameral arch variable, either rounded (FIG. 18) or tapered (FIG. 19), width 0.140–0.160 (73: 0.151 ± 0.0052); endomeral plate triangular, subapically broader than those in FIG. 9 or 13, width 0.070–0.090 (72: 0.084 ± 0.0038), length 0.085–0.110 (60: 0.099 ± 0.0073).

Remarks. The best qualitative characters for recognizing *G. chihuahuae* from *G. tolucae* and *G. fulvi* are the elongate median portion of the female postvulval sclerite (FIG. 17 vs FIG. 6, 12), the slender pointed inner and fine outer marginal temple setae of the male (FIG. 14 vs FIG. 2, 11), and the structure of the male genitalia, including the shape of the sac spines and the endomeral plate (FIG. 15 vs FIG. 9, 13). Both sexes also tend to be smaller and to have fewer tergal and sternal setae.

For females, critical values for discrimination and probabilities of misidentification for the best discriminating quantitative characters are length of the longest seta of the medial 10 on tergite VII 0.127 (0.057), the temple width 0.410 (0.088), the number of setae on sternite V 10.62 (0.146), and the number of setae on sternite VI 10.24 (0.156). For males, the best characters are the temple width 0.383 (0.049), the scape length 0.141 (0.078), and the scape distal width 0.096 (0.091).

Geomydoecus chihuahuae chihuahuae Price & Hellenthal FIG. 14–18

♀. Temple width 0.370–0.410 (38: 0.395 ± 0.0095). Prothorax width 0.280–0.315 (41: 0.296 ± 0.0088). *Tergal setae.* II, 14–19 (42: 16.5 ± 1.33); III, 16–25 (41: 20.5 ± 1.90); IV, 17–28 (40: 21.5 ± 1.99); V, 15–26 (40: 19.6 ± 2.36); VI, 16–25 (40: 19.7 ± 2.33); tergal and pleural setae on VII, 31–51 (42: 36.9 ± 3.98). Longest seta of medial 10 on tergite VI, 0.090–0.125 (38: 0.107 ± 0.0082); on tergite VII, 0.115–0.170 (40: 0.146 ± 0.0108), with 2–10 (36: 5.6 ± 1.96) of these longer than 0.100. *Sternal setae.* II, 9–15 (41: 11.4 ± 1.44); III, 8–15 (41: 11.4 ± 1.30); IV, 8–14 (41: 11.4 ± 1.52); V, 6–12 (40: 9.6 ± 1.38); VI, 7–13 (41: 9.2 ± 1.39). Subgenital plate with 18–24 (42: 21.2 ± 1.79) setae. Genital sac width 0.245–0.325 (42: 0.286 ± 0.0184), length 0.165–0.245 (42: 0.195 ± 0.0155).

♂. Temple width 0.355–0.385 (46: 0.371 ± 0.0077); submarginal temple seta 0.070–0.095 (34: 0.083 ± 0.0067) long. *Tergal setae.* II, 11–16 (55: 13.1 ± 1.09); III, 16–20 (56: 18.4 ± 0.97); IV, 17–24 (57: 20.3 ± 1.65); V, 16–22 (56: 18.9 ± 1.42); VI, 13–20 (56: 16.7 ± 1.55); tergal and pleural setae on VII, 18–27 (57: 23.1 ± 2.27). *Sternal setae.* III, 10–13 (57: 11.6 ± 0.75); V, 7–13 (57: 9.3 ± 1.12). Total length 1.110–1.325 (44: 1.234 ± 0.0552). *Genitalia* with parameral arch usually as in FIG. 18.

Specimens examined. Holotype ♂, *T. u. madrensis,* MEXICO: Chihuahua: Valle Moctezuma, 11.6 mi. (18.7 km) SE of Colonia Garcia, 27.VII.1976, J.L. Patton, UC-150582 (in University of Minnesota coll.). Paratypes (all from type-host): Chihuahua: 2♂, same as holotype; 1♀,4♂, same, except UC-150579; 6♀,10♂, same, except 13.IX.1971, UC-140996, 140997, 140998, 140999, 141000, 141001; 1♀, Water Canyon, 3 mi. (4.8 km) S of Colonia Garcia, 20.V.1936, S.B. Benson, UC-75023; 1♀, same, except 21.V.1936, UC-75027; 1♀,5♂, Meadow Valley, 5 mi. (8.0 km) S of Colonia Garcia, 28.VIII.1948, W.C. Russell, UC-109651; 2♀,1♂, same, except 30.VIII.1948, UC-109654; 4♀,5♂, 1 mi. (1.6 km) W of Colonia Garcia, 17.IX.1971, J.L. Patton, UC-141002, 141003, 141004, 141005; 1♂, 9 mi. (14.5 km) SE of Colonia Garcia, 22.V.1936, S.B. Benson, UC-75020; 1♂, Colonia Garcia, 28.VII.1899, Nelson & Goldman, USNM-98210; 4♀,4♂, same, except 25.V.1936, S.B. Benson, UC-75018; 1♀,4♂, 2.4 mi. (3.9 km) NE of Colonia Garcia, 12.IX.1971, J.L. Patton, UC-140994; 1♂, same, except 28.VII.1976, UC-150607; 3♀, 3 mi. (4.8 km) SW of Pacheco, 2.XI.1954, J.R. Alcorn, KU-63976; 4♀,6♂, 1.5 mi. (2.4 km) NE of Madera, 24.VII.1976, J.L. Patton, UC-150542, 150543; 1♀, 1.3 mi (2.1 km) E of Chuhuichupa, 25.VII.1976, J.L. Patton, UC-150544; 2♂, same, except 26.VII.1976, UC-150599, 150561.

Other material. MEXICO: 7♀,7♂, *T. u. chihuahuae,* Chihuahua: 10 km N of Guachochic (2), 9.6 km W (1) and Rancho El Pajarito, 25 mi. (40.2 km) W (2) of Tomochic, Yaguirachic, 130 mi. (209.2 km) W of Chihuahua (2); 10♀,13♂, *T. u. juntae* Anderson, Arroyo Mesteno, Sierra del Nido (6), 7 mi. (11.3 km) WSW (1) and 8.4 mi. (13.5 km) W (2) of Cuauhtemoc, 4 mi. (6.4 km) S, 1 mi. (1.6 km) W of Santo Tomas (1), 11 mi. (17.7 km) E of La Junta (1), El Rosario (1). USA: 6♀,22♂, *T. b. grahamensis* Goldman, Arizona: Graham Co.: Hospital Flat, Graham Mts (7), Marijilda Canyon, Graham Mts (1).

Geomydoecus chihuahuae emersoni Price & Hellenthal, **new subspecies** FIG. 19

Type-host. Thomomys umbrinus chihuahuae Nelson & Goldman.

♀. Temple width 0.365–0.405 (13: 0.381 ± 0.0111). Prothorax width 0.275–0.295 (15: 0.286 ± 0.0065). *Tergal setae.* II, 13–18 (15: 15.2 ± 1.32); III, 16–21 (15: 18.0 ± 1.41); IV, 17–25 (15: 19.2 ± 2.04); V, 15–20 (15: 16.7 ± 1.53); VI, 15–19 (15: 17.2 ± 1.61); tergal and pleural setae on VII, 26–37 (15: 30.7 ± 3.35). Longest seta of medial 10 on tergite VI, 0.080–0.105 (15: 0.095 ± 0.0089); on tergite VII, 0.115–0.155 (14: 0.137 ± 0.0127), with 1–6 (14: 3.8 ± 1.53) of these longer than 0.100. *Sternal setae.* II, 8–12 (15: 10.0 ± 1.20); III, 9–11 (15: 10.1 ± 0.83); IV, 7–12 (14: 9.1 ± 1.54); V, 6–10 (14: 8.0 ± 1.04); VI, 6–10 (15: 7.9 ± 1.22). Subgenital plate with 16–22 (15: 19.1 ± 1.62) setae. Genital sac width 0.225–0.280 (15: 0.249 ± 0.0142), length 0.150–0.200 (15: 0.174 ± 0.0116).

♂. Temple width 0.350–0.385 (15: 0.362 ± 0.0102); submarginal temple seta 0.065–0.085 (12: 0.075 ± 0.0056) long. *Tergal setae.* II, 11–13 (16: 12.1 ± 0.72); III, 14–19 (15: 17.4 ± 1.24); IV, 17–22 (15: 18.7 ± 1.59); V, 15–19 (15: 17.6 ± 1.24); VI, 11–17 (16: 14.1 ± 1.75); tergal and pleural setae on VII, 18–24 (16: 21.0 ± 1.79). *Sternal setae.* III, 8–12 (16: 10.4 ± 1.21); V, 7–9 (15: 8.1 ± 0.92). Total length 1.090–1.225 (14: 1.154 ± 0.0443). *Genitalia* with parameral arch usually as in FIG. 19.

Remarks. As indicated by our placement of *G. c. emersoni* as a subspecific taxon, there are no good qualitative means of recognition. The parameral arch of the male *G. c. emersoni* does tend to be more tapered than that of the nominate subspecies (FIG.

19 vs FIG. 18), but this is a somewhat variable feature. However, quantitative data support this separation. For females, the best discriminating quantitative characters, with their critical values for discrimination and probabilities of misidentification, are the genital sac width (GSW) 0.267 (0.142), number of tergal and pleural setae on VII (STG7) 33.762 (0.210), and number of setae on sternite IV (SST4) 10.255 (0.219). Discriminant functions were calculated as before, with the combination of all 3 characters giving the best improvement of recognition. The respective discriminant function coefficients of GSW, STG7, and SST4 are 0.002, 0.003, and 0.010, with discriminant means and standard deviations for *G. c. chihuahuae* 0.823 ± 0.0527 and *G. c. emersoni* 0.704 ± 0.0359. The critical value for the discriminant was 0.763 with a probability of misidentification of 0.109. For males, the best discriminating quantitative characters, with their critical values for discrimination and probabilities of misidentification, are the number of setae on tergite VI (STG6) 15.402 (0.212), total length (TL) 1.194 (0.225), and number of setae on sternite III (SST3) 11.017 (0.253). Calculation of discriminant functions showed that the combination of all 3 characters most improved recognition. The respective discriminant function coefficients of STG6, TL, and SST3 are 0.018, 0.0004, and 0.022, with discriminant means and standard deviations for *G. c. chihuahuae* 1.077 ± 0.0388 and *G. c. emersoni* 0.976 ± 0.0548. The critical value for the discriminant was 1.026 with a probability of misidentification of 0.123.

This taxon is named for Dr K. C. Emerson, Arlington, Virginia, in recognition of his numerous contributions to mammalian Mallophaga and of his interest and cooperation in our studies on pocket gopher lice.

Specimens examined. Holotype ♂, *T. u. chihuahuae,* MEXICO: Durango: 7.7 mi. (12.4 km) W of La Ciudad, 21.VII.1970, J.L. Patton, UC-139753 (in University of Minnesota coll.). Paratypes (all from type-host): Durango: 1♀,3♂, same as holotype; 8♀,7♂, same, except UC-139750, 139754; 1♀,5♂, 1 mi. (1.6 km) E of La Ciudad, 13.VII.1976, J.L. Patton, UC-150426, 150427; 2♀,8♂, same, except 14.VII.1976, UC-150431, 150433, 150434, 150437; 2♀,1♂, 10 mi. (16.1 km) SW of El Salto, 26.VI.1955, R.W. Dickerman, KU-67612. Chihuahua: 2♀,6♂, 1.8 mi. (2.9 km) E of El Vergel, 17.VII.1976, J.L. Patton, UC-150475, 150476, 150480.

Geomydoecus pattoni Price & Hellenthal, **new species** FIG. 20–22

Type-host. Thomomys umbrinus chihuahuae Nelson & Goldman.

♀. Much as for *G. tolucae* (FIG. 3). Temple width 0.395–0.430 (7: 0.415 ± 0.0113); head length 0.285–0.300 (7: 0.289 ± 0.0056); submarginal and inner marginal temple setae 0.085–0.090 (3: 0.088 ± 0.0029) and 0.035–0.050 (7: 0.045 ± 0.0072) long, respectively. Prothorax width 0.300–0.330 (8: 0.311 ± 0.0096). *Tergal setae.* II, 15–17 (8: 16.3 ± 0.89); III, 18–21 (7: 19.0 ± 1.15); IV, 18–21 (7: 19.7 ± 1.11); V, 15–19 (7: 17.0 ± 1.73); VI, 15–19 (7: 17.1 ± 1.35); tergal and pleural setae on VII, 30–37 (7: 32.9 ± 2.54). Longest seta of medial 10 on tergite VI, 0.090–0.115 (8: 0.102 ± 0.0078); on tergite VII, 0.095–0.155 (8: 0.132 ± 0.0175), with 0–7 (8: 3.5 ± 2.33) of these longer than 0.100. Longest seta of medial pair on tergite VIII, 0.095–0.120 (8: 0.110 ± 0.0092). Lengths of 3 lateral setae on last tergite, respectively from outer to inner, 0.040–0.065 (8: 0.050 ± 0.0082), 0.080–0.135 (7: 0.105 ± 0.0190), and 0.085–0.125 (6: 0.104 ± 0.0164). *Sternal setae.* II, 8–13 (7: 9.4 ± 1.72); III, 8–10 (7: 8.7 ± 0.76); IV, 8–10 (7: 8.6 ± 0.98); V, 5–8 (7: 6.3 ± 0.95); VI, 6–8 (7: 6.7 ± 0.76); VII, 7–10 (8: 8.3 ± 0.89). Subgenital plate with 22–27 (8: 24.8 ± 1.67) setae, with number of subequally long setae on each side (FIG. 20). Total length 1.135–1.230 (6: 1.186 ± 0.0433). Postvulval sclerite as for *G. chihuahuae* (FIG. 17). Genital sac width 0.305–0.325 (8: 0.312 ± 0.0069), length 0.170–0.210 (8: 0.188 ± 0.0157).

♂. Much as for *G. tolucae* (FIG. 4). Temple width 0.375–0.395 (9: 0.390 ± 0.0068); head length 0.280–0.295 (9: 0.286 ± 0.0051); submarginal and inner marginal temple setae 0.090–0.110 (7: 0.097 ± 0.0085) and 0.040–0.050 (8: 0.045 ± 0.0051) long, respectively; both inner and outer MTS slender, as in FIG. 21. Antenna with scape length 0.125–0.140 (8: 0.137 ± 0.0058), scape medial width 0.085–0.095 (8: 0.090 ± 0.0035), scape distal width 0.090–0.100 (8: 0.095 ± 0.0035). Prothorax width 0.285–0.305 (9: 0.292 ± 0.0068). *Tergal setae.* II, 11–15 (11: 12.9 ± 1.22); III, 15–19 (10: 16.9 ± 1.45); IV, 17–20 (9: 18.7 ± 0.87); V, 15–20 (11: 17.9 ± 1.76); VI, 13–18 (11: 15.2 ± 1.83); tergal and pleural setae on VII, 17–27 (11: 22.6 ± 3.20). *Sternal setae.* II, 8–13 (10: 10.6 ± 1.35); III, 9–13 (10: 10.5 ± 1.35); IV, 9–12 (10: 10.7 ± 1.06); V, 6–10 (10: 7.8 ± 1.23); VI, 6–9 (11: 6.8 ± 0.98); VII, 6–10 (11: 7.8 ± 0.98); VIII, 5–7 (11: 5.8 ± 0.75). Total length 1.135–1.270 (9: 1.219 ± 0.0421). *Genitalia* as in FIG. 22, with large spines on sac much as for *G. tolucae*; parameral arch with median posterior process broadly rounded, width 0.155–0.165 (10: 0.162 ± 0.0037); endomeral plate apically broad, with deep conspicuous division, width 0.090–0.105 (9: 0.098 ± 0.0044), length 0.110–0.115 (8: 0.114 ± 0.0027).

Remarks. The male of *G. pattoni* is readily separated from those of other members of the *tolucae* complex by its uniquely shaped genitalic parameral arch and endomeral plate (FIG. 22 vs FIG. 9, 13, 15) and by having neither of the marginal temple setae stout spiniform or unusually thickened (FIG. 21 vs FIG. 2, 11, 14). Quantitatively, for males, the best discriminating characters, with their critical values for discrimination and probabilities of misidentification, are the length of the inner marginal temple seta 0.037 (0.013), width of the en-

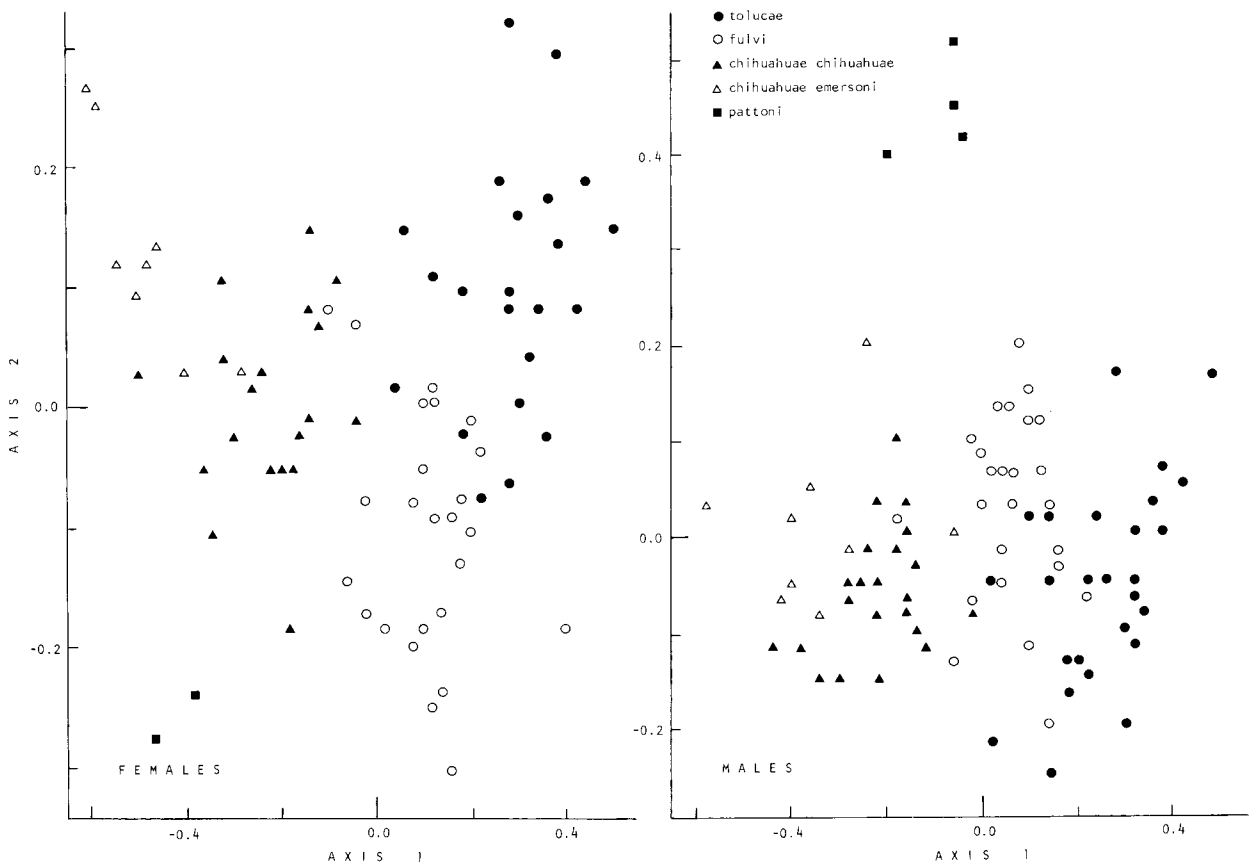

FIG. 23. Scattergrams of principal components axes for *Geomydoecus tolucae* complex individuals.

domeral plate 0.092 (0.082), and length of the endomeral plate 0.105 (0.101). The female of *G. pattoni* is much more difficult to distinguish from females of other species. The principal qualitative feature is the absence of a conspicuously longer, stouter seta on each side of the subgenital plate (FIG. 20 vs FIG. 16). The best discriminating quantitative characters for females, with their critical values for discrimination and probabilities of misidentification, are the number of setae on sternite V (SST5) 8.536 (0.125), number of setae on the subgenital plate (SSGP) 22.895 (0.164), and number of setae on sternite VI 8.543 (0.165). The use of SST5 and SSGP in combination provided the best discrimination, with respective discriminant function coefficients of 0.016 and −0.014, a critical value for the discriminant of −0.190, and a probability of misidentification of 0.038. Discriminant means and standard deviations for *G. pattoni* were −0.131 ± 0.0335 and for the other members of the complex −0.250 ± 0.0289.

This species is named for Dr James L. Patton, University of California, Berkeley, in recognition of his generous cooperation in many aspects of our study.

Specimens examined. Holotype ♂, *T. u. chihuahuae*, MEXICO: Durango: 3 mi. (4.8 km) NW of El Salto, 23.VII.1970, J.L. Patton, UC-139779 (in University of Minnesota coll.). Paratypes (all from type-host): Durango: 1♀,1♂, same as holotype; 2♀,2♂, same, except UC-139781, 139786; 1♂, same, except 22.VII.1970, UC-139774; 3♀,1♂, 6 mi. (9.7 km) SW of El Salto, 1.VI.1963, A.L. Gardner, LA-19241; 1♂, same, except 4.VI.1963, UA-9645; 1♀,2♂, 1.3 mi. (2.1 km) NE of Mil Dios, 31.V.1974, J.L. Patton, UC-147061, 147066; 2♂, same, except 1.VI.1974, UC-147082; 1♀, 83 km SW of Durango, 5.V.1960, A.L. Gardner, LA-12613; 1♂, 3 mi. (4.8 km) E of Las Adjuntas, 29.VI.1955, R.W. Dickerman, KU-67619.

Although the taxa included in the *tolucae* complex generally demonstrated sufficient qualitative character differences to enable their separation, even the best quantitative characters showed some overlap. However, this overlap is not unexpected

given the individual variability and moderate sample sizes. Because of this variability, we felt it desirable to find further supporting evidence for recognition of taxa. Principal components analysis of pooled quantitative data offers added support for our separations. Using the centered R-technique as described by Orloci (1967) for 11 characters each for females and males, the first 3 components were found to account for 78% of the female variation and for 71% of the male variation. Scattergrams with coordinates representing the 1st, 2nd, and 3rd principal axes in reduced character space for each sex all generally supported our separation of taxa. The best separations were achieved by graphing the 1st and 2nd axes for both sexes (FIG. 23).

All females of the 5 taxa interpreted as having a genital sac width of at least 0.30 would key to *G. tolucae* in couplet 18 of the key to females of Price & Emerson (1971). They then could be identified by the following key modification:

18a. Postvulval sclerite with relatively short median portion, 0.030–0.050 long (FIG. 6, 12) 18b
Postvulval sclerite with longer median portion, 0.055–0.075 long (FIG. 17) 18c

18b. Setae associated with postvulval sclerite not over 0.015 long (FIG. 6); longest outer marginal temple seta over ½ length of inner (FIG. 1); on 5 subspp. of *T. umbrinus* . . . (Mexico) ..... **tolucae**
Longer setae associated with postvulval sclerite 0.020–0.025 long (FIG. 12); longest outer marginal temple seta not over ½ length of inner (FIG. 10); on *T. b. fulvus* . . . (USA) ..... **fulvi**

18c. Subgenital plate with 22–27 setae, many of them subequally long (FIG. 20) ..... **pattoni**
Subgenital plate with 16–24 setae, with 1 longer thicker seta on each side (FIG. 16) .. **chihuahuae** . . . 18d

18d. With 31–51 tergal and pleural setae on VII, 8–14 on sternite IV . . . (Chihuahua and Arizona) ..... **chihuahuae chihuahuae**
With 26–37 tergal and pleural setae on VII, 7–12 on sternite IV . . . (southern Chihuahua and Durango) ..... **chihuahuae emersoni**

The females whose genital sac width is measured as less than 0.30 would go to couplet 27. From there, they would likely either pass through the 1st part of 27 to couplet 28 or 30, and would satisfy neither portion of these couplets, but be identifiable as in the above key and/or descriptions; or would go through the 2nd half of 27 to couplet 34 and identify as *G. tolucae,* with differentiation possible as given above.

The males of the *tolucae* complex offer much better qualitative recognition features. *Geomydoecus pattoni* and some *G. chihuahuae* would pass to couplet 6 in the key to males of Price & Emerson (1971) and be identified there by their respective distinctive genitalia (FIG. 22; FIG. 15, 18, 19) and host associations. The remaining individuals would most likely key to *G. tolucae* in couplet 38. From there, they are identifiable as follows:

38a. With 2 stout blunt spiniform temple setae on each side (FIG. 2); genital sac spines shaped and oriented as in FIG. 9 ..... **tolucae**
With only 1 stout blunt spiniform temple seta on each side (FIG. 11); genital sac spines otherwise (FIG. 13, 15) 38b

38b. Endomeral plate of genitalia with narrowed elongate subapical portion (FIG. 13); temple width 0.385–0.410; on *T. b. fulvus* . . . (USA) ..... **fulvi**
Endomeral plate with broader subapical portion (FIG. 15); temple width 0.350–0.385 . . . **chihuahuae**. . . 38c

38c. Genitalic parameral arch as in FIG. 18 . . . (Chihuahua and Arizona) ..... **chihuahuae chihuahuae**
Genitalic parameral arch as in FIG. 19 . . . (southern Chihuahua and Durango) . . . **chihuahuae emersoni**

Acknowledgments. We thank the staff of the University of Minnesota University Computer Center for the use of its facilities; Dr Frank B. Martin, Director of the University of Minnesota Statistical Center, for his advice throughout our study; and the following individuals for permitting us to brush pocket gopher skins or for otherwise assisting in the preparation of this paper: Dr E. Lendell Cockrum, UA; Dr K. C. Emerson, Arlington, Virginia; Dr Robert S. Hoffmann, KU; Dr Robert T. Orr, California Academy of Sciences; Dr James L. Patton, UC; Dr Amadeo M. Rea, SD; Dr Henry W. Setzer, USNM; and Dr Fred S. Truxal, LA.

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