PNEUMOLAELAPS (ACARINA: LAELAPIDAE) MITES FROM NORTH AMERICA AND GREENLAND

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ABSTRACT

Six new species of *Pneumolaelaps* are described from North America and Greenland, and bumble bee hosts and a key to females from this area are given. The subspecies *Pneumolaelaps bombicolens* (Can.) *groenlandica* Trägardh is given species status. Observations on the biology, dispersal, and distribution of these mites are given.

Pneumolaelaps Berlese, 1921 has been considered as a subgenus of *Hypoaspis* (e.g. Berlese 1921, Vitzthum 1943, Costa 1966, Evans and Till 1966, Van Aswegen and Loots 1970) and as a genus (Willmann 1953, Hunter 1966). Genus versus subgenus of "*Hypoaspis*" mites associated with insects has been discussed by Costa and Hunter (1970), Costa (1971), and Hunter and Costa (1971). These authors believe that host association is as discriminatory as morphological characters in separation of taxa of host-mite related groups. On the basis of biological association and morphological characters we are considering *Pneumolaelaps* as a genus consisting of "*Hypoaspis*"-like species which also have the following biological and morphological characteristics in the female: associated only with bumble bees; sternal setae (st 1 - st 4) long and of approximately equal length, st 3 extends beyond base of st 4; stigmata opening and/or peritreme normally wide (generally equal to or almost as wide as base of tritosternum), peritreme extends to area of coxa I; hypostomal setae 3 (internal posterior rostral) longest of hypostomal setae; deutosternum with some teeth normally longer than other teeth, usually with 6 rows of teeth; often with extra dorsal and ventral opisthosomal setae; genu IV with 2 ventral setae.

Three species presently listed in *Pneumolaelaps* should eventually be placed in other taxonomic categories. *Pneumolaelaps greeni* (Oudemans 1902) taken from a carpenter bee from India, differs morphologically from the true *Pneumolaelaps* in leg chaetotaxy, sternal setae characteristics, deutosternal teeth, gnathosomal setae, and other characteristics and may represent a separate generic taxon. However, we are temporarily leaving *greeni* in *Pneumolaelaps* until a more detailed study of the species can be completed. Van Aswegen and Loots (1970) illustrated 2 of Berlese's species—*Hypoaspis atomarius* Berlese, 1917 from a beetle, and *H. hospes* Berlese, 1924 from a termite—as *Pneumolaelaps*. Both species show morphological differences —e.g., reduced dorsal plate, short sternal setae, dorsal chaetotaxy—as well as host associations not in agreement with our restriction of *Pneumolaelaps* and may represent species of *Androlaelaps*. True *Pneumolaelaps* mites probably

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do not occur in most of Africa since bumble bees have been recorded only from those areas adjacent to Spain and Portugal (unpublished data of bumble bee distribution compiled from published records, museum material, and collections from various parts of the world by the junior author).

Pneumolaelaps probably is distributed wherever bumble bees occur, i.e., all major land masses except Australia, Africa, and the Middle East on a line south of the Mediterranean Sea. Three species of *Pneumolaelaps* have been described from North America, 7 species from Europe (see Evans and Till 1966, Fig. 29-35),—one (*P. hyatti*) of which has been recorded in Israel—and 1 variety from Greenland. We are describing 6 new species from North America and Greenland, giving a key to females from these areas, and raising the Greenland variety to species status. In the key and descriptions, dorsal and ventral chaetotaxy follows Lindquist and Evans (1965), and leg chaetotaxy follows Evans (1963). Type disposition notations are as follows: UG—Acarine Collection, Department of Entomology, University of Georgia, Athens 30602; RWH—collection of Dr. Robert W. Husband, Department of Biology, Adrian College, Adrian, Michigan 49221; NMNH—National Museum Natural History, Washington, D. C. 20250; ZMCD—Universitetets Zoologiske Museum, Copenhagen, Denmark; and FSCA—Florida State collection of arthropods.

KEY TO FEMALE *Pneumolaelaps* OF NORTH AMERICA AND GREENLAND

1. Posterior margin of sternal plate concave (Fig. 1B) 2
1′. Posterior margin of sternal plate straight or convex (Fig. 3B) 6
2. Dorsal plate seta j2 extending approximately to base of seta j4 (Fig. 1A; see Fig. 4I, K, and M for setal notations) ..... *groenlandica* (Trägh.)
2′. Seta j2 extending no more than 1/2 the distance between the bases of seta j3 and j4 3
3. Seta j2 extending approximately 1/2 the distance to the base of seta j3 (Fig. 1F) ..... *longanalis*, n. sp.
3′. Seta j2 extending to or slightly beyond the base of seta j3 4
4. Dorsal seta j4 approximately 3 times longer than j5 (Fig. 2A); distance between genital setae bases less than distance between sternal setae st 2 (Fig. 2B) ..... *sinhai*, n. sp.
4′. Dorsal seta j4 equal to or only slightly longer than j5; distance between bases of genital setae equal to or slightly exceeding the distance between sternal setae st 2 5
5. Dorsal seta j3 extending 1/2 to 2/3 of the distance to seta j4 (Fig. 4I); genital plate without striation pattern (Fig. 4J) ..... *aequalipilus* Hunter
5′. Dorsal seta j3 extending almost to base of j4 (Fig. 2F); genital plate with distinct striation pattern (Fig. 2G) ..... *patae*, n. sp.
6. Dorsal setae j2, j3, and j4 approximately equal in length; seta j4 3-4 times length of seta j5 (Fig. 4K); dorsal seta Z4 and Z5 at least 4 times as long as J5; genital setae extending to posterior margin of genital plate (Fig. 4L) ..... *longipilus* Hunter
6′. Dorsal seta j4 less than 3 times length of seta j5; length of seta j2, j3, and j4 variable; setae Z4 and Z5 equal to or only

slightly longer than J5; genital setae not extending to posterior margin of genital plate 7

7. Dorsal seta j3 extending no more than 1/2 the distance to base of seta j4 (Figs. 3A, 3F) 8

7′. Dorsal seta j3 and j4 extending over 1/2 the distance to base of seta j4 (Figs. 4A, 4M) 9

8. Genital plate bearing distinct striation pattern (Fig. 3B); dorsal plate with distinct striation pattern in area of setae J1 to J3 ..... *connieae*, n. sp.

8′. Genital plate without striation pattern (Fig. 3G); dorsal plate without distinct striation pattern in area of setae J1 to J3 ..... *richardsi*, n. sp.

9. Anterior marginal dorsal setae (s and r rows) 2 or more times length of seta j6 (Fig. 4M); genital seta extending 2/3 the distance between setal base and posterior margin of genital plate (Fig. 4N) ..... *mistipilus* Hunter

9′. Anterior marginal dorsal setae (s and r rows) equal to or only slightly longer than seta j6 (Fig. 4A); genital seta extending no more than 1/2 the distance to posterior margin of plate (Fig. 4B) ..... *costai*, n. sp.

Pneumolaelaps groenlandica (Trägardh)

Hypoaspis bombicolens (Can.) variety *groenlandica* Trägardh, 1906. Fauna Arctica IV p. 34. (Zoological Records gives 1905 as the date of publication and stated the paper was issued separately with same pagination in 1904. The publication date in Fauna Arctica was 1906).

Hunter (1966) noted that Trägardh's variety differed in a number of characters from Canestrini's *bombicolens* but because of the poor description and illustration, left the taxonomic status as established by Trägardh. Through the courtesy of Dr. S. L. Tuxen, (Copenhagen), the junior author was able to barrow Trägardh's material; we feel the variety should be given species status and it is described and reillustrated below.

FEMALE. *Dorsum.* Fig. 1A. Covered by a single plate bearing heavy, distinct reticulations over entire surface. Setal type and arrangement as shown; setae j2 and j3 approximately equal in length, j2 reaching beyond midway between bases of j3 and j4; setae j5, j6, z5, and z6 about 1/3 the length of setae at margin and anterior of podonotal region; opisthonotal region bearing only short setae; 43 pairs of setae plus unpaired setae arising from plate. *Venter.* Fig. 1B. Sternal plate strongly concave posteriorly; reticulations over surface of plate; sternal setae long and heavy; metasternal plates absent. Genital plate bearing strong reticulations; plate width and reticulation pattern as shown; genital setae heavy, extending about 1/3 their length beyond base of seta Zv_1. Anal plate striations and setae as illustrated. Two pairs of platelets between metapodal and genital plates. Opisthogastric setae of type and arrangement as shown. Peritremal plate narrow, extending posterior to stigmata a distance equal to or less than diameter of stigmata; peritreme wide, equal to width of base of tritosternum. *Gnathosoma.* Fig. 1C. Deutosternum with 8 transverse rows of teeth, each row with 1-2 larger teeth plus smaller teeth; hypostomal setae 3 extending almost to posterior margin of gnathosoma. Chelicera (Fig.

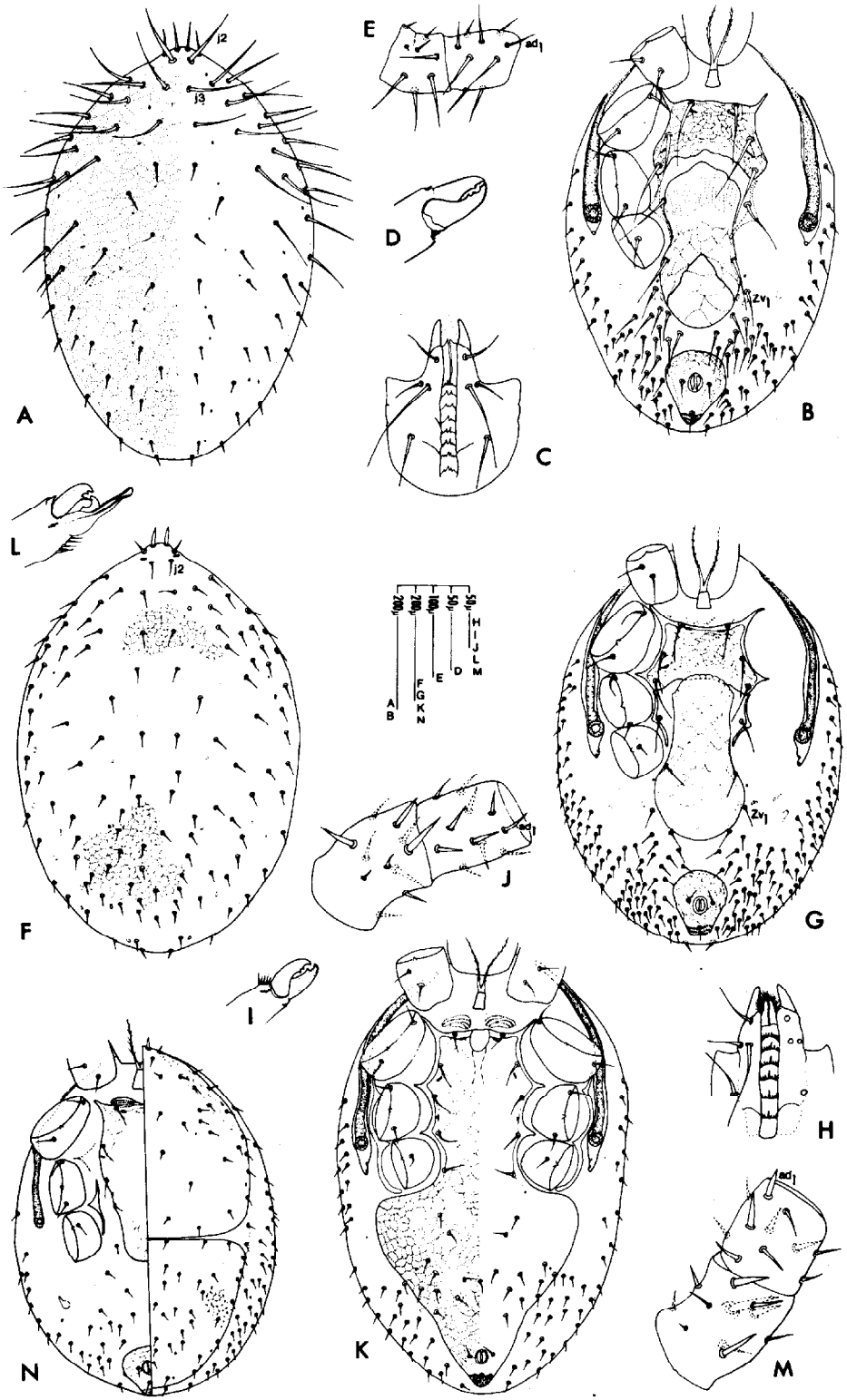

Fig. 1. *Pneumolaelaps groenlandica* (Trägardh). Female: A, dorsum; B, venter; C, gnathosoma; D, chelicera; E, dorsum of femur and genu of leg II. *Pneumolaelaps longanalis,* n. sp. Female: F, dorsum; G, venter; H, gnathosoma; I, chelicera; J, dorsum of femur and genu of leg II. Male: K, venter; L, chelicera; M, dorsum of femur and genu of leg II. Deutonymph: N, dorso-ventral view.

1D) chelate, fixed digit bidentate, movable digit with 3 teeth. *Legs.* Coxal setae well developed; relative lengths of dorsal setae of femur II and genu II as shown, Fig. 1E.

MALE. Unknown.

Our material (over 50 specimens) from Trägardh's collection did not include a specimen labelled as the type for the variety. The specimen we designated as holotype had the following data: No. 31, 8/8, 39; Tigsalŭk, Tlumle, Greenland; off *Bombus* species; coll. W. L. Lundbeck. Paratypes (all from Greenland) data included: off *Bombus hyperboreus* from following locations—Moshusokse-fiord Löppenshin, 10 August 1930; Equaluit-landet (Julianehaab), 21 July 1948; Kánissartut (Julianehaab), 22 June 1948; Grónnedal, T. Feddersen (no date); off *Bombus* species—Tigsalŭk, Tlumle, 8 August 1889. Holotype deposited in ZMCD, paratypes in UG, RWH, and FSCA.

Pneumolaelaps longanalis, n. sp.

FEMALE. *Dorsum.* Fig. 1F. Dorsal plate covering dorsum, small square-shaped reticulation pattern over entire surface of plate; over 50 pairs of simple setae, 28 pairs in podonotal area, relative lengths and distribution as shown; setae j1 much thicker than other dorsal setae; setae j2 to j5 extending no more than 1/2 the distance to the base of the next posterior seta of the j row. *Venter.* Fig. 1G. Sternal plate concave posteriorly; reticulation pattern and relative lengths of sternal setae as illustrated; metasternal setae arise from integument. Genital plate setae not reaching to base of seta Zv_1; surface of plate bearing strong reticulation pattern. Anal plate with distinct reticulation pattern; lateral margins of plate with knob-like structure posterior of or on level of para-anal setae. Two pairs of platelets between genital and metapodal plate. Many short, simple opisthogastric setae; setae arising from integument lateral of coxae III and IV; arrangement and numbers as shown. Presternal plates appearing bead-like along striation lines. Relative width of peritremes as illustrated. *Gnathosoma.* Fig. 1H. Deutosternal groove with 6 transverse rows of teeth, rows 2-5 each with 1 long tooth; relative length of hypostomal setae 3 as illustrated. Chelicera (Fig. I) chelate, movable digit bidentate, fixed digit with 2 small and 1 larger tooth, plus setiform pilus dentilis. *Legs.* Femur II and genu II chaetotaxy pattern, and relative setal size as illustrated (Fig. 1J); seta ad_1 on femur distinctly stouter than other setae.

MALE. *Dorsum.* Chaetotaxic pattern, setal length, and dorsal plate as in female. *Venter.* Fig. 1K. Holoventral plate bearing 16 pairs of simple setae plus 3 anal setae, posterior setae shorter than sternal setae; striation pattern distinct over entire plate. Narrow exopodal plates lateral of coxae III, IV, and posterior part of II. Opisthosomal setae short, simple. Presternal plates appearing beaded along striation lines as in female. *Gnathosoma.* Venter as in female. Cheliceae (Fig. 1L) with straight trough-like spermadactyl arising from lateral surface of fixed digit; both fixed and movable digits unidentate, movable digit bearing setiform pilus dentilis. *Legs.* All tarsi bearing paired claws. Femur II (Fig. 1M) with seta av_1 very stout and spine-like, pd_1 also stout; genu II with setae ad_1 and ad_2 thickened. Legs I, III, and IV not modified, as in female.

DEUTONYMPH. *Dorsum.* Fig. 1N. Plate covering podonotal region, striations distinct along anterolateral margin only, seta j1 thickened, other setae

short and simple; most of opisthonodal plate covered with weak striation pattern, plate slightly smaller than podonotal plate; all dorsal plate setae short, simple. Integument lateral of plates bearing simple, short setae as illustrated. *Venter.* Fig. 1N. Sternal plate bearing 4 pairs setae, relative lengths as illustrated; striation pattern indistinct or absent medially. Anal plate with weak striation pattern; knob-like structure at lateral margin near level of para-anal setae as in female. Metapodal plate drop-shaped. Endopodal plate well developed medial of coxae III and IV; weakly developed between coxae II and III. Peritremal plate not present. Presternal plate fused to sternal, bead-like appearance along striation lines. Gnathosoma and legs as in female.

Holotype (female) data as follows: Gull Lake Biological Station, Kalamazoo County, Michigan; 10 August 1964; on female *Bombus griseocollis*; coll. R. W. Husband. Paratypes have been taken from bumble bees collected in July, August and September in Michigan, in May and August in Alberta, Canada, and in March in Lawrence, Kansas. Bumble bee hosts are given in Table 1. Holotype deposited in UG. Paratypes deposited in UG, RWH, NMNH, and FSCA.

Comments. The junior author has collected this species routinely from bumble bees and bumble bee nests in Michigan. Only female mites have been taken on bumble bees, the other mite stages were collected from the bee nests.

Pneumolaelaps sinhai, n. sp.

FEMALE. *Dorsum.* Fig. 2A. Single plate covering entire dorsal area, surface of plate strongly reticulate. Podonotal area with 23 pairs of setae; setae j5, j6, z5, and z6 short, similar to opisthonotal setae, other podonotal setae longer and heavier, seta j4 approximately three times length of j5; seta j2 longer than j3 or j4. Opisthosomal region with 18-19 pairs of simple, short setae. *Venter.* Fig. 2B. Posterior margin of sternal plate strongly concave; reticulations distinct over surface of plate; relative length and thickness of sternal and metasternal setae as illustrated. Genital plate narrow, width approximately equal to distance between sternal setae 2; not overlapping sternal plate; surface of plate bearing heavy reticulations, pattern as illustrated; posterior margin of plate appearing granulated; genital setae extending well past base of seta Zv_1. Anal plate bearing weak reticulations. Chaetotaxy of opisthogastric area as illustrated; 2-3 platelets between genital plate and metopodal plate. Peritremes as wide or slightly wider than base of tritosternum; peritremal plate extending posterior to stigmata approximately equal to diameter of stigmata. Presternal plates not sclerotized (some specimens show striation of presternal integument). *Gnathosoma.* Fig. 2C. Deutosternal groove with 7 transverse rows of teeth; general type and relative sizes as illustrated; internal mali split, lateral parts bearing median fringe as illustrated. Chelicerae (Fig. 2D) typical for genus. *Legs.* Dorsal chaetotaxy of genu II and femur II (Fig. 2E) as illustrated; femur II setae ad_1, pd_1, and pd_2 long and heavy, of approximately equal size.

MALE. Unknown.

Holotype (female) data: Prairie Bluff Mountain, Alberta, Canada; 5200 ft elevation; 26 May 1971; on female *Psithyrus suckleyi*; coll. L. A. Richards. Paratypes collected in May and July in Canada, and during August in Michigan. Bumble bee hosts are given in Table 1. Holotype deposited in UG; paratypes deposited in UG and RWH.

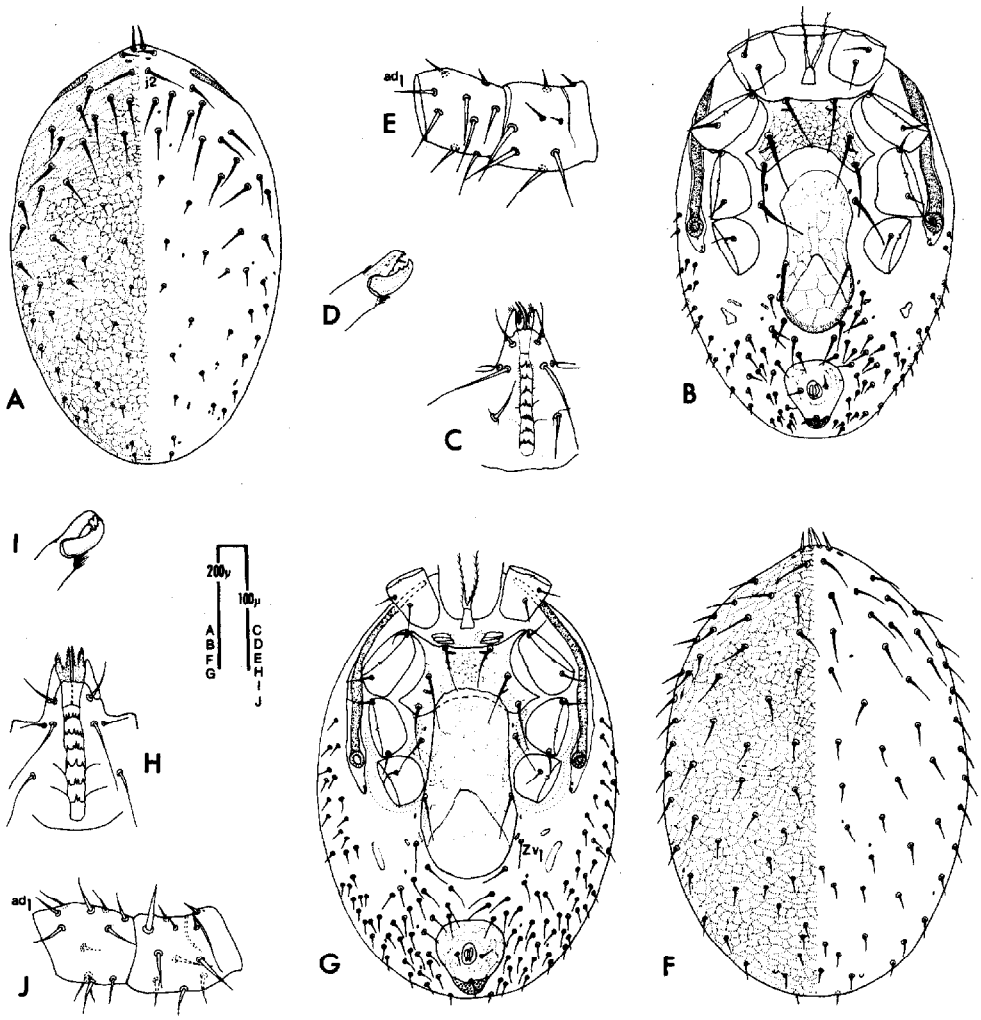

Fig. 2. *Pneumolaelaps sinhai,* n. sp. Female: A, dorsum; B, venter, C, gnathosoma; D, chelicera; E, dorsum of genu and femur of leg II. *Pneumolaelaps patae,* n. sp. Female: F, dorsum; G, venter; H, gnathosoma; I, chelicera; J, dorsum of genu and femur of leg II.

Comments. *Psithyrus suckleyi* and *P. insularis* are socially parasitic bumble bees which invade the established nests of other bumble bees. Of the 10 mite specimens in the type series, 3 were taken from bumble bee nests—1 mite from the nest of each of *Bombus flavifrons, B. frigidus* and *Bombus* species. Only 1 specimen was taken off a non-parasitic bee (*B. californicus*), and socially parasitic bumble bees may be important in the distribution of this mite.

Pneumolaelaps patae, n. sp.

FEMALE. *Dorsum.* Fig. 2F. Covered by single plate, surface of plate bearing distinct reticulation pattern as illustrated; 34 pairs of dorsal setae (27 arising from podonotal region) plus several unpaired setae between J rows; seta j4 slightly longer than j5; setae j2, j3, and j4 of approximately equal length,

relative lengths of other dorsal setae as illustrated. *Venter.* Fig. 2G. Sternal plate concave posteriorly; striation pattern distinct over surface of plate; sternal setae slender, relative lengths and widths as illustrated. Genital plate bearing distinct striation pattern over entire surface; posterior margin of plate appearing grandular; genital setae not extending beyond base of seta Zv_1. Anal plate with reticulation pattern. Opisthogastric area with many slender setae, setae arising from integument lateral of coxa III and IV; 2 platelets in integument between genital and metapodal plate. Exopodal and endopodal plates at level of coxae III and IV. Peritremal plate extending well posterior of stigmatal opening. Presternal plates distinct, joined medially by semi-sclerotized integument. *Gnathosoma.* Fig. 2H. Six transverse rows of deutosternal teeth, posterior 3 rows with 2-4 teeth/row, anterior 3 rows with 5-6 teeth/row. Internal mali fringed on both lateral and medial margins. Hypostomal setae 4 (capitular setae) approximately 3/4 length of setae 3. Cheliceae (Fig. 2I) typical for genus. *Legs.* Femur II seta ad_1 spine-like (Fig. 2J), relative length and size of other setae of femur and genu of leg II as shown.

MALE. Unknown.

Described from a series of 10 specimens. Holotype (female) data: Tigsalŭk, Tlumle, Greenland; on *Bombus* sp.; 8 August 1889; coll. W. L. Lundbeck. Paratypes data: Marshall Bugt—Inglefieldland, Greenland, 29 June 1941, on *Bombus hyperboreus*; Dansk Pesnyed Exp., 1036 N. Heilpoin, Greenland, 8 July 1949, on *B. polaris*; 5 specimens from Ellesmere Island, Canada, summer 1967, on *B. polaris,* coll. K. W. Richards.

Holotype deposited in ZMCD; paratypes deposited in UG and RWH.

Comments. The 2 specimens from Greenland were included in Trägardh's material as *Hypoaspis bombicolens* var. *groenlandica.* Host records and distribution data indicate this mite species occurs at the northern limits of the range of North American bumble bees.

Pneumolaelaps connieae, n. sp.

FEMALE. *Dorsum.* Fig. 3A. Covered by single plate bearing reticulations over entire surface. All dorsal setae simple, of approximately same size in podonotal and opisthonotal regions; j setae of equal lengths; setae j2 and j3 reaching only about 1/2 the distance to the base of the next posterior j seta; 22 pairs of podonotal setae, 18 pairs of opisthonotal setae. *Venter.* Fig. 3B. Sternal plate not concave on posterior margin, striations limited to anterior 2/3 of plate; sternal setae long, narrow; metasternal setae shorter than sternal setae, arising from integument. Genital plate with distinct striation pattern, median inverted V striation more distinct than other striations, pattern as shown; genital setae short, reaching 1/2 or less the distance to the base of setae Zv_1. Para-anal setae arising at anterior level of anal opening; anal plate bearing striations anterior to post-anal seta. Opisthogastric setae simple, all approximately subequal in length, those near genital and anal plates slightly longer than setae lateral of coxa III and IV; 3 platelets between the elongate metapodal plate and genital plate. Endopodal and exopodal plates weakly sclerotized. Peritreme narrower than base of tritosternum; peritremal plate present, relative width as shown, extending well posterior of stigmata. Presternal plates distinct from each other and from sternal plate. *Gnathosoma.* Fig. 3C. Deutosternal groove with 5 transverse rows with teeth, anterior row without teeth. Chelicera (Fig. 3D) with bidentate movable digit, fixed digit with 3-4 teeth (of approximate equal size)

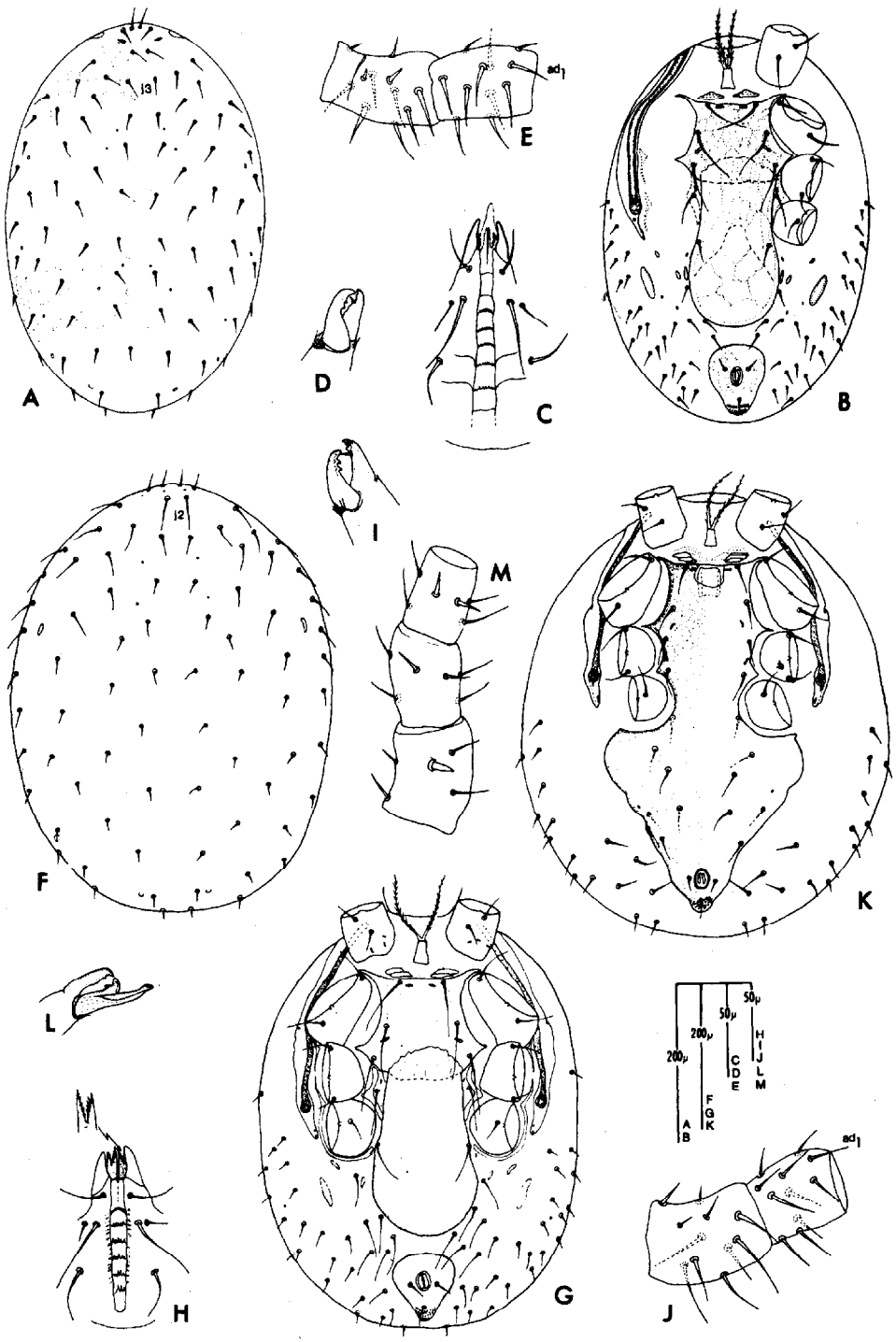

Fig. 3. *Pneumolaelaps connieae,* n. sp. Female: A, dorsum; B, venter; C, gnathosoma; D, chelicera; E, dorsum of femur and genu of leg II. *Pneumolaelaps richardsi,* n. sp. Female: F, dorsum; G, venter; H, gnathosoma; I, chelicera; J, dorsum of femur and genu of leg II. Male: K, venter; L, chelicera; M, venter of femur, genu and tibia of leg II.

plus setiform pilus dentilis. *Legs.* Coxal setae slender, of about equal thickness; femur II setae ad_1 and ad_2 thickened, ad_3 peg-like; relative lengths of setae on femur II and genu II as shown, Fig. 3E.

MALE. Unknown.

Described from a series of 6 specimens. Holotype (female) data: Grand Rapids (Kent County), Michigan; on *Bombus americanorum*; coll. R. W. Husband; no collection date given. Paratypes collected during July and August in the following Michigan counties: Kalamazoo, Alpena, Baraga, and Delta. One paratype collected from Clarke County, Georgia, 10 September 1971, on *B. impatiens,* by R. W. Husband. Bumble bee hosts are listed in Table 1. Holotype deposited in UG; paratypes deposited in UG, RWH, and NMNH.

Comments. The bumble bee hosts from Michigan—*B. americanorum, griseocollis,* and *terricola*—have overlapping ranges (unpublished data of R. W. H.). The collection from Georgia on *B. impatiens* would indicate that the mite should be found between Michigan and Georgia and probably is generally distributed over the eastern part of the United States.

Pneumolaelaps richardsi, n. sp.

FEMALE. *Dorsum.* Fig. 3F. Covered by a single plate; striations weakly developed, distinct pattern absent medially. Dorsal setae slender, 24 pairs on podonotal region, 15 pairs on opisthonotal region; seta j2 distinctly longer than any other seta in j row, reaching almost to base of j3; setae j4 and j5 of equal length, j3 slightly longer than j4; opisthonotal setae shorter than podonotal setae; relative lengths of setae as illustrated. *Venter.* Fig. 3G. Sternal plate slightly convex on posterior margin; striae weakly developed, distinct pattern absent; setae slender, needle-like. Genital setae reaching to base of setae Zv_1; genital and anal plates without striation pattern. Para-anal setae arising near posterior margin of anal opening. Opisthogastric setae needle-like, setae nearest genital and anal plates at least twice length of marginal setae; relative lengths of setae as shown. Metapodal and 2 platelets present on each side of genital plate. Endopodal and exopodal plates sclerotized; posterior exopodal plate partially encircling coxa IV. Peritreme approximately 1/2 width of base of tritosternum; peritremal plate extending anterior to level of coxa I, lateral margin scalloped between coxa II and III, pore in plate at this level; plate extending well posterior of stigmata. Presternal plates present, integument weakly sclerotized between plates. *Gnathosoma.* Fig. 3H. Six rows of deutosternal teeth, 1st row teeth small, equal in size, posterior row with 1 or more longer plus several shorter teeth/row. Chelicera (Fig. 3I) with typical dentation plus setiform pilus dentilis. *Legs.* Coxal setae II longer than other coxal setae; all setae on femur II slender (Fig. 3J), seta pd_1 longest; relative size of setae on genu II as shown, Fig. 3J.

MALE. *Dorsum.* General striation pattern, setae type, and chaetotaxy as in female. *Venter.* Fig. 3K. Holoventral plate present; weak striations in area of sternal setae 2 and 3; depending upon sclerotization anterior to anal area, 10-11 pairs of setae on holoventral plate (setae indicated by dash lines were broken off on specimen illustrated, type and relative lengths of these setae taken from paratype male). Fewer opisthogastric setae than in female. Peritreme about 1/2 width of base of tritosternum; peritremal plate extending to area of coxa I; lateral margin scalloped, pore in plate at level of coxa II. Exopodal plates not well sclerotized. Presternal plates present, integument striated medial and anterior of plates. *Gnathosoma.* Chelicera (Fig. 3L) with straight, trough-like

spermadactyl arising from movable digit and extending well beyond tip of digit; fixed and movable digits bidentate; remainder of gnathosoma as in female. *Legs.* Legs I, III, and IV as in female. Leg II (Fig. 3M) heavier than other legs, femur with seta av_1 stout and spine-like, ventral setae of tibia thickened, other setae of femur, tibia, trochanter, and genu similar to those in female; tarsus with terminal ventral setae somewhat heavier and more whip-like than in female.

Described from a series of 9 females and 2 males. Holotype (female) data: Prairie Bluff Mountain, Alberta, Canada; 5200 ft elevation; 8 August 1970; on *Bombus bifarius*; coll. L. Richards. Four female paratypes collected in August and/or May from Alberta, Canada; 1 female paratype collected in Delta County, Michigan, May 1964, on *B. ternarius*. Bumble bee hosts for female mites are listed in Table 1. Male paratypes collected from nest of *B. bifarius*, other data same as for female. Holotype deposited in UG; paratypes deposited in UG and RWH.

Pneumolaelaps costai, n. sp.

FEMALE. *Dorsum.* Fig. 4A. Covered by single plate bearing 40 pairs of simple, needle-like setae; j2 slightly longer than other j setae; setae j3, j4, and j5 approximately equal in length; weak striations along anterolateral margin of plate, remainder of plate without striations. *Venter.* Fig. 4B. Posterior margin of sternal plate straight or slightly convex; striations consist of few weakly developed lines on anterior 1/3 of plate. Genital plate without striations except for 2 lines forming an inverted V-shape; 2 half moon shaped muscle attachment lines in plate posterior to sternal plate margin; genital setae extending to base of setae Zv_1. Anal plate with a pair of lens-like structures on margin at anterior level of anal opening; striation pattern as shown. Opisthogastric setae needle-like, longest setae nearest genital and anal plates; metapodal plate and 2-3 platelets in integument lateral of genital plate. No opisthogastric setae arising anterior to stigmatal opening. Peritremal plate well developed, extending anterior to area of coxa I, extending posterior of stigmata approximately twice diameter of stigmata, pores as shown; margin of plate scalloped lateral to coxae II and III; peritreme extends to area of coxa I; peritreme narrower than base of tritosternum. Presternal plates present, integument between plates showing some striation lines. *Gnathosoma.* Fig. 4C. Six rows of deutosternal teeth, teeth of about equal length in anterior row, other rows with 1 or more longer teeth per row; relative length of hypostomal setae as shown; internal mali normal for genus. Chelicera (Fig. 4D) typical for genus, pilus dentilis setiform. *Legs.* Leg II femur and genu (Fig. 4E) with slender setae, seta pd_1 on genu longer than other seta on that segment, ad_3 shortest seta of segment.

MALE. *Dorsum.* General features and chaetotaxy as in female. *Venter.* Fig. 4F. Holoventral plate present, bearing 10 pairs of simple needle-like setae plus three anal setae; striation of plate limited to anal area and genital opening, remainder of plate without striation pattern; lens-like structures on lateral margin of anal plate as in female. Opisthogastric setae proportionally shorter than in female, extending anteriorly to level of coxa IV as in female. Narrow exopodal plate lateral of coxae IV, III, and posterior half of II. Peritreme extending only to level of coxa II; peritremal plate extending to anterior end of peritreme, width of plate and pores in plate lateral of coxa II and III as shown, 3 pores in plate posterior of stigmata. *Gnathosoma.* Chelicera (Fig. 4G)

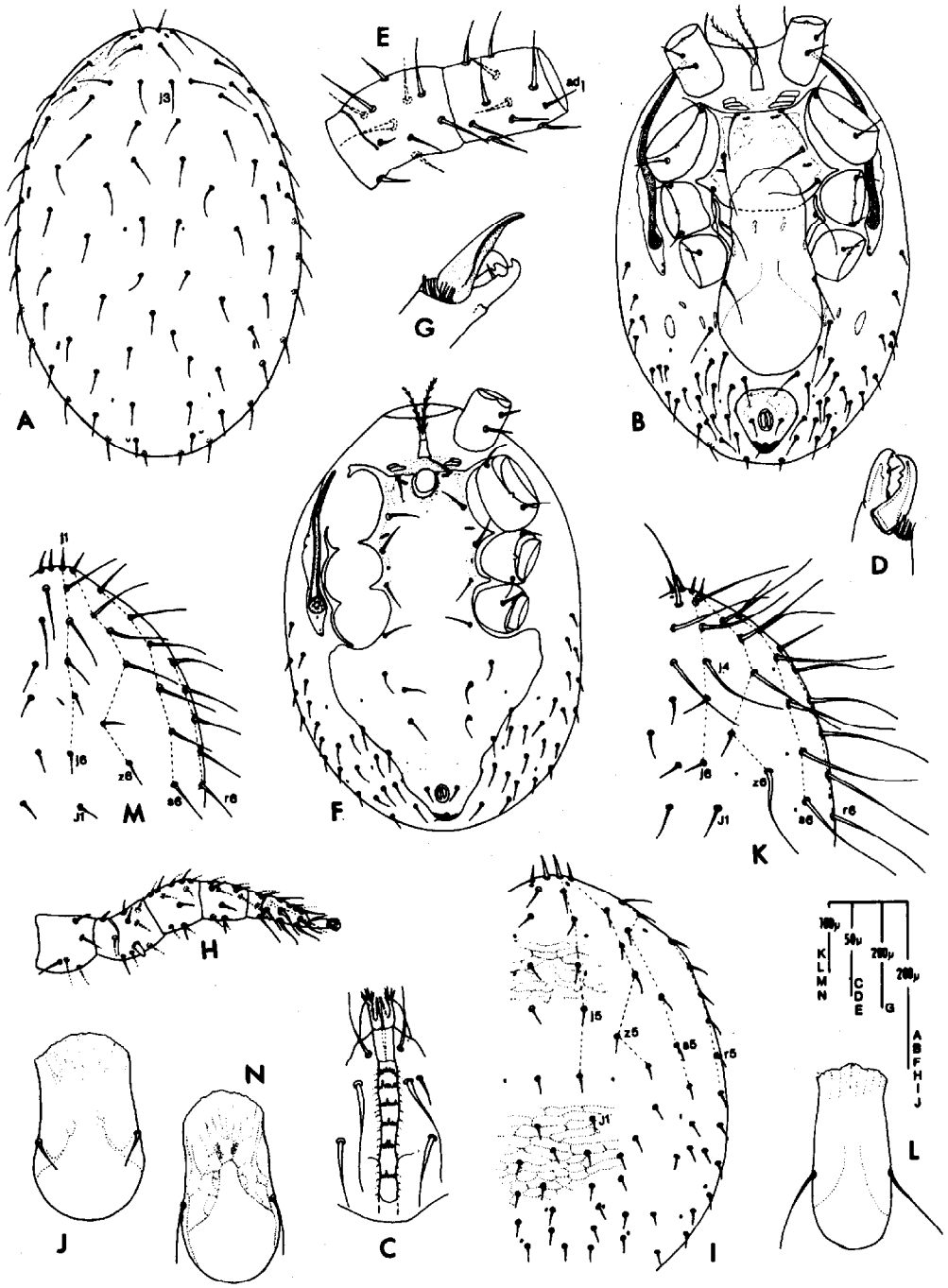

Fig. 4. *Pneumolaelaps costai,* n. sp. Female: A, dorsum; B, venter; C, gnathosoma; D, chelicera; E, dorsum of femur and genu of leg II. Male: F, venter; G, chelicera; H, ventrolateral view, leg II. *Pneumolaelaps aequalipilus* Hunter. Female: I, dorsum; J, genital plate. *Pneumolaelaps longipilus* Hunter. Female: K, dorsum; L, genital plate. *Pneumolaelaps mistipilus* Hunter. M, dorsum; N, genital plate.

chelate, movable digit unidentate; spermatodacyl process trough-like, terminally curving toward bidentate, fixed digit; pilus dentilis setiform. Remainder of gnathosoma of general features as in female. Leg II heavier than other legs, femur with seta av, spine-like (Fig. 4H), other setae as in female, except that ventral tarsal setae proportionally longer than in female.

Described from a series of 9 specimens. Holotype (female) data: Kalamazoo County, Michigan; from *Bombus americanorum* nest; 3 September 1963; coll. R. W. Husband. Paratype females collected in August and September, Kalamazoo County, Michigan. Host records given in Table 1. Male paratypes and one nymph collected from bumble bee nest, other collection data same as for holotype. Holotype deposited in UG; paratypes deposited in UG and RWH.

Biology and Host Associations

All of the biological observations reported below were made by the junior author in Michigan. In the nests, *Pneumolaelaps* mites are commonly found in pollen cylinders and on honey pots. Mites appear attracted to and moved onto bees coming into the nest; entering bees normally carry pollen which may be an attractant to the mites. The food of the mites is unknown, but very likely it is both pollen and honey. Other types of liquids may also serve as mite food, 2 examples are illustrated. When a bee was accidently decapitated in opening a nest, *P. longanalis* mites immediately swarmed over the cut surface and fed on the haemolymph. In another instance, a bumble bee's air sac had been opened and a *P. longanalis* mite came from between the thorax and abdomen, stuck its chelicerae through the air sac and fed on haemolymph until the mite's body became swollen.

In Michigan nearly all bumble bee nests collected during the summer months have *Pneumolaelaps* mites in the nest material and/or on bees taken from the nest. Nests left out-of-doors and collected in January did not have *Pneumolaelaps* mites. Since only the queen bumble bees overwinter, this suggests that only those mites—always females—which attach to the hibernating queens survive northern winters. In a study of incidence of mites found on bees taken from nests, *Pneumolaelaps* species were found to be much more common on queen and male bees than on worker bees, although all castes are equally exposed in the nest. Of 95 *Bombus bimaculatus* collected from nests, the following observations were made: 3 of 28 queens had mites; none of 11 males and 56 workers had mites. Of 94 *B. americanorum* taken from nests, 7 of 17 queens had mites, 7 of 29 males had mites, and 1 of 48 workers had mites. In collections of bumble bees at flowers in the summers of 1963-64, large numbers of worker bees were taken, but very few had *Pneumolaelaps* mites attached.

Based upon the host association information and field observations, data are available to speculate on the dispersal of *Pneumolaelaps* mites from nest to nest and from host species to host species. Queen bumble bees of different species often compete for nest sites in the spring, and at this time of the year it is not unusual to find dead queens of more than 1 species outside the entrance to a nest. In the struggle for the nest site, mites are likely to be brushed off into the nest. Bumble bees, especially males, will commonly enter nests of their own species as well as nests of other bumble bees species. This could afford an opportunity for the transfer of *Pneumolaelaps* mites. The parasitic bumble bees, *Psithyrus* species, would also provide an excellent source of mite dis-

tribution; however, the number of mite species recovered from *Psithyrus* species compared to other species of bumble bees (Table 1) indicates that the parasitic bees probably are not proportionally more important as a source of mite transportation.

TABLE 1. THE NUMBER OF *Pneumolaelaps* MITE SPECIES COLLECTED IN ASSOCIATION (ON THE BEE OR IN THE NEST) WITH VARIOUS SPECIES OF BUMBLE BEES.

Bumble bee species	*Pneumolaelaps* species											
	aequalipilus Hunter	*conniecae* n. sp.	*costai* n. sp.	*groenlandica* n. sp.	*longanalis* n. sp.	*longipilus* Hunter	*mistipilus* Hunter	*patae* n. sp.	*richardsi* n. sp.	*sinhai* n. sp.
Bombus (Bombus) affinis					15		7			
B. (B.) occidentalis					1					
B. (B.) terricola		3			1					
B. (Fraternobombus) fraternus	9		1		5		16			
B. (Separatobombus) griseocollis		1			13		4			
B. (Fervidobombus) americanorum	28	1	7		34	19	13			
B. (F.) californicus										1
B. (F.) fervidus					6	6	1			
B. (Bombias) nevadensis					2		11			
B. (Alpinobombus) hyperboreus				50				1		
B. (A.) polaris								6		
B. (Pyrobombus) bifarius					3				2	
B. (P.) bimaculatus					32		8			
B. (P.) flavifrons										1
B. (P.) frigidus					5				5	1
B. (P.) huntii					8				1	
B. (P.) impatiens	1	1					26			
B. (P.) mixtus					2				1	
B. (P.) perplexus							2			
B. (P.) ternarius					1				2	
B. (P.) vagans			1		2					
Bombus sp.	6		1		12	14	16	2		1
Psithyrus ashtoni							1			
P. insularis										2
P. laboriosus							2			
P. suckleyi					1				1	4
P. variabilis	1					1				

The North American *Pneumolaelaps* mites neither show close host-parasite associations (Table 1), nor distribution patterns correlated with the distribution of a given species of bumble bee. The most extensive distribution records we have at this time are for *P. aequalipilus* (Alabama, Florida, Georgia, Illinois, Kansas, Louisiana, South Carolina, and Texas), *P. longipilus* (Georgia, Indiana, Iowa, Kansas, Michigan, and Minnesota), and *P. mistipilus* (Arkansas, Georgia, Illinois, Kansas, Louisiana, Michigan, and Missouri). Records for other species show a disrupted distribution, such as *P. connieae* recorded from Michigan and Georgia, and very likely additional collections will show a generally continuous distribution pattern similar to that for the above 3 species. We have no evidence as to the factors that may limit the distribution of *Pneumolaelaps* mites—possibly temperature, soil moisture, or other soil conditions may be important.

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