Giselia arizonica, a new genus and species of mite (Acari: Tarsonemidae) associated with bark beetles of the genus *Pseudopityophthorus* (Coleoptera: Scolytidae) in North America

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Abstract—A new genus and species of the mite family Tarsonemidae, subfamily Tarsoneminae, is described and illustrated. Its systematic position among genera of Tarsoneminae and its host association with bark beetles of the genus *Pseudopityophthorus* Swaine, 1918 in North America are briefly discussed.

Résumé—Les auteurs décrivent et illustrent un nouveau genre et une nouvelle espèce d'acarien de la famille des Tarsonemidae, sous-famille des Tarsoneminae. Ils présentent brièvement la position systématique du genre parmi les Tarsoneminae et son association avec des coléoptères sous-corticoles du genre *Pseudopityophthorus* Swaine, 1918 de l'Amérique du Nord.

Introduction

Bark beetles (Coleoptera: Scolytidae) are among the insect groups having the most diversified and elaborate associations with tarsonemid mites. These associations range from simple coexistence, through phoresy, to hyperphoresy and obligate parasitoidism. At present, three genera of tarsonemids (*Pseudotarsonemus* Lindquist, 1986, *Iponemus* Lindquist, 1969, and *Heterotarsonemus* Smiley, 1969) are known to be exclusively associated with bark beetles (and colydiids), and another two (*Ununguitarsonemus* Beer and Nucifora, 1965 and *Pseudotarsonemoides* Vitzthum, 1921) with bark or other xylophagic or cambiophagic beetles (mostly cerambycids). There are also two species groups of *Tarsonemus* Canestrini and Fanzago, 1876 (*sensu* Lindquist, 1986) more or less bound to subcortical insects. The number of species is hard to estimate, and growing. This paper describes a new genus of tarsonemid mites associated with bark beetles in North America.

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Methods

The insect specimens (bark beetles) were collected from Lindgren traps and subsequently examined; mites were removed directly from beetles and mounted in Berlese's medium on microscope slides. The mites were studied with a phase-contrast microscope (Olympus BX 50) supplied with a drawing attachment and photographic camera (SC 35). All measurements are given in micrometres; terminology for the gnathosoma, idiosoma, and legs follows Lindquist (1986) and is abbreviated as follows: PrS, prodorsal shield; PrP, ventral propodosomal plate; ap. 1–1 and ap. 2–2, distances between anterolateral ends of apodemes 1–1 and 2–2, respectively; Ta, tarsus; Tb, tibia; Tbt, tibiotarsus; Fe, femur; Ge, genu; and Fege, femorogenu. Excluded from the setal counts are minute, often hardly discernible setae flanking

the pretarsi: *u'–u"* of leg I and *u"* of legs II and III; "–" indicates the separation of leg segments and "+", their fusion.

Giselia gen. nov.

(Figs. 1–10)

Type species: *Giselia arizonica* **sp. nov.** Monotypic.

Etymology

The name of the new generic taxon is dedicated to our esteemed colleague Dr. Gisela Rack (retired) from Hamburg University, who has greatly contributed to the knowledge of systematics and biology of many heterostigmatic taxa. The name is feminine in gender.

Diagnosis

(The synapomorphic character state within the *Suctarsonemus–Pseudotarsonemus* cluster is preceded by an asterisk.) Adult females of the new genus are similar to those of *Suctarsonemus* Mahunka, 1974 in having the idiosomal dorsum ornamented with clear, well-separated puncta and striae, the dorsal opisthosomal setae *d* and *f* elongate, slender, the pharynx with heavily sclerotized, horseshoe-shaped lateral walls, and the tarsal claw of leg I very strongly hooked yet remaining on a clearly developed pretarsus. They differ from the latter in having the gnathosoma conical and partly retractable into the idiosoma, the dorsal opisthosomal setae (other than *d* and *f*) shorter, slenderer, *apodemes 3 extended laterally of anterior extremities of trochanters III and fusing medially, and apodemes 4 uniting with poststernal apodeme. Females of *Suctarsonemus* have the other dorsal opisthosomal setae moderately long, the posterior edges of the tergites smooth, apodemes 3 not extended laterally of trochanters III and well separated from each other medially, and apodemes 4 separate, their anterior apices autapomorphically procurved, parallel to each other, and usually not uniting with poststernal apodeme anteriorly.

Adult females of *Giselia* are similar to those of *Pseudotarsonemus* in dorsal idiosomal ornamentation, form of the pharynx, the asymmetrical reduction of the posterolateral claw on tarsi II and III, and the absence of seta *pv"* on tarsus III, coupled with its presence on tarsus II. They differ in the enlarged, strongly hooked form of the claw on leg I (small in *Pseudotarsonemus*), the elongate and slender setae *d* and *f* (setae *e* differentiated as larger in *Pseudotarsonemus*), the serrated posterior edges of the tergites (smooth in *Pseudotarsonemus*), and the laterally and medially extended form of apodemes 3 (not extended in *Pseudotarsonemus*). Adult females of *Giselia* also resemble those of *Neotarsonemoides* Kaliszewski, 1984, group *N. denigratus* (*sensu* Magowski, 2002), in dorsal idiosomal ornamentation, similar form of metapodosomal apodemes, and asymmetrical reduction of tarsal claws II and III. They are, however, easily distinguishable by the much more strongly developed claw on leg I (small in *Neotarsonemoides*), the different form of the pharynx (muscular, thinly sclerotized lateral walls in *Neotarsonemoides*), elongate and slender setae *d* and *f* (short, undifferentiated in *Neotarsonemoides*), the broadly rounded form of the tegula (bluntly to sharply pointed in *Neotarsonemoides*), and the typical three-segmented form of leg IV, with four setae (two-segmented, with three setae in *Neotarsonemoides*).

The adult males and larvae are unknown.

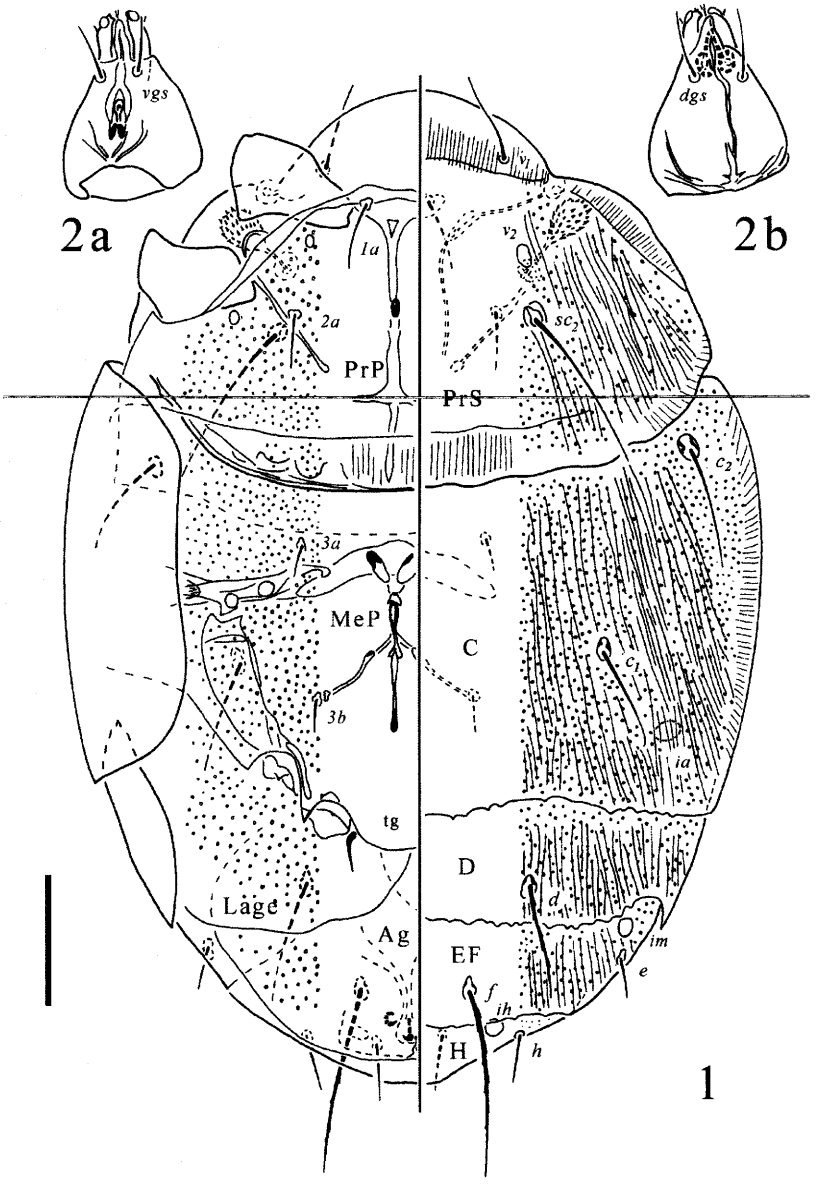
Description

With character states of tribe Tarsonemini *sensu* Lindquist, 1986.

Gnathosoma. Capsule partly retractable into idiosoma; when extended, half its length still covered by anterior margin of prodorsal shield; capsule round-conical rather than barrel-shaped, with elongate palpi protruding anteriorly, parallel, approximate, each with small process and minute seta distally. Pharynx with well-sclerotized, horseshoe-shaped lateral walls and ovoid, small but apparent pair of gland-like structures posteriorly. Cheliceral stylets short, based on small levers. Dorsal and ventral gnathosomal setae smooth, simple; postpalpal setae indiscernible.

Idiosoma. Dorsal shields covered by fine but well-separated puncta and striae. Dorsal setae generally slender, *d* and *f* more elongate, *e* and *h* short and stiffer, all those weakly barbed, though *c1–c2* smooth. Stigmata placed slightly posterolaterally of setae *v1*, tracheal tubes with weakly sclerotized atria followed by uniformly narrow tracheal tubes. Setae *sc2* spaced slightly farther apart than *v1* and inserted near mid-length of prodorsal shield. Bothridial pits and sensilli *sc1* entirely hidden under anterolateral margins of prodorsal shield. Posterior margin of tergite D deeply emarginate near insertions of setae *e* and cupules *im* of tergite EF. Setae *f*

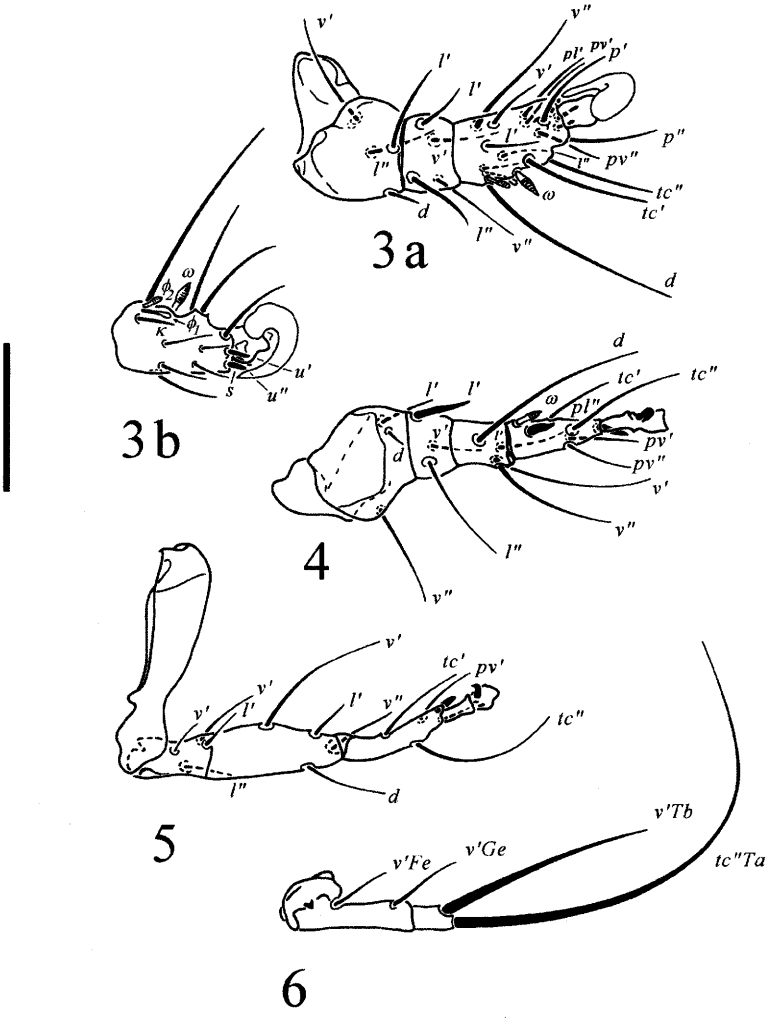
Figs. 1–2. *Giselia arizonica*, adult female. 1, idiosoma, ventral aspect on left side, dorsal aspect on right; 2, gnathosoma: *a*, venter, *b*, dorsum. Ag, aggenital plate; Lage, laterogenital plate(s); PrS, prodorsal shield; PrP, ventral propodosomal plate; MeP, ventral metapodosomal plate; and tg, tegula. Scale bar = 20 μm.



located slightly posterior to transverse line between setae *e*, and more narrowly spaced than setae *d*.

Ventral plating with apodemes 1 forming Y-shaped union with prosternal apodeme. Apodemes 2 separated from prosternal apodeme, which is weakened posteriorly, not apparently uniting with sejugal apodeme. Sejugal apodeme continuous, though diffused medially and more elaborate laterally, though not apparently angled or bent anteriorly. Apodemes 3 well developed laterally beyond apices of trochanters III. Area of medial diffused sclerotization fills interval between proximal condyles of apodemes 3, thus forming continuous subsurface band of transverse sclerotization. Apodemes 4 not extending

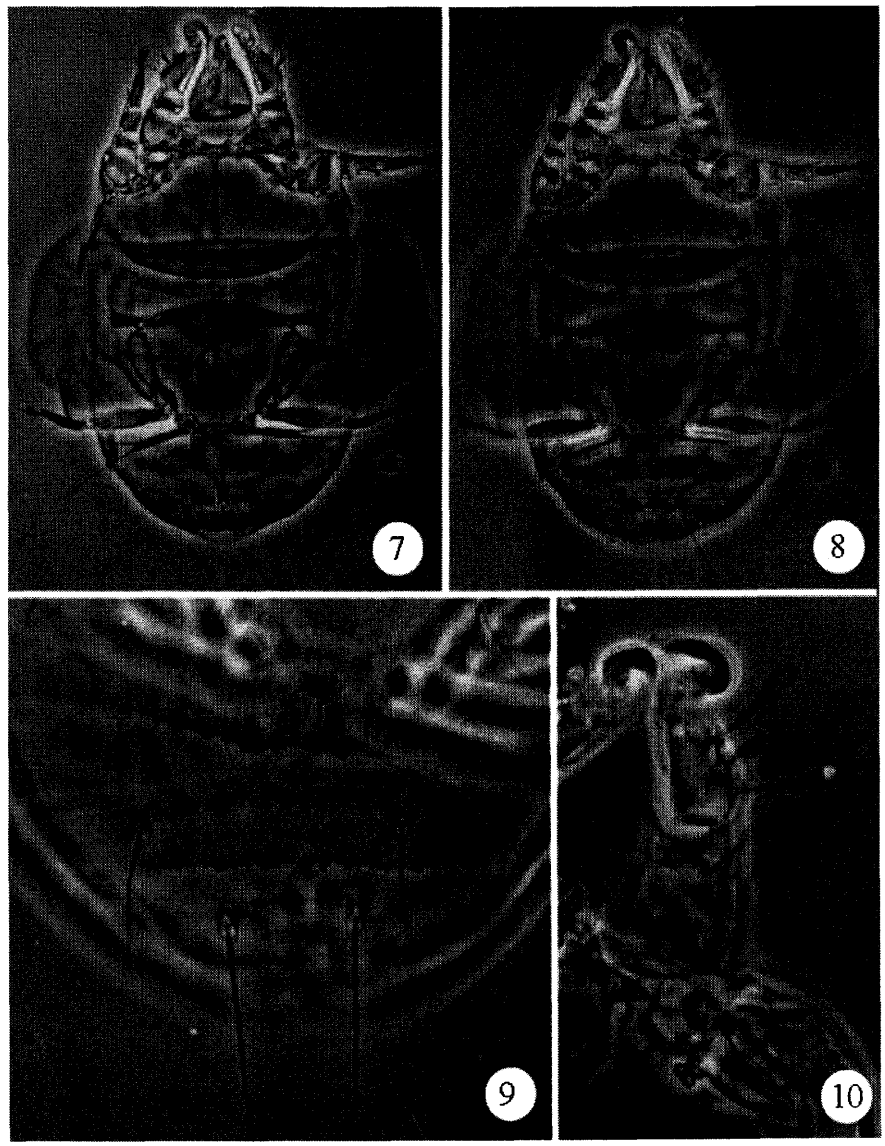
Figs. 3–6. *Giselia arizonica*, adult female legs. 3, leg I: *a*, dorsolateral aspect, *b*, ventrolateral aspect of tibiotarsus; 4, leg II, dorsal aspect; 5, leg III, dorsal aspect; 6, leg IV, ventral aspect. Scale bar = 20 μm.



posterolaterally beyond bases of setae *3b*, united with poststernal apodeme, the latter protruding anteriorly in form of usual bifurcation that blends with above-mentioned sclerotized band. Metapodosomal plate with two pairs of setae; setae *3c* and *4a* lacking. Trochanters of legs IV separated by interval approximately 2 times greater than their width. Posterolateral margin of metapodosomal plate with small acute process between trochanters III and IV. Posterolateral margins of coxisternal plates IV overlapping but not uniting with each other medially beneath tegula. Aggenital plate lacking setae. Pseudanal platelet with setae *ps* smooth, slender.

Legs. Ambulacrum of leg I with short but well-developed pretarsus bearing strong, tightly hooked, pointed claw. Pretarsi of legs II and III with typically developed, rather small empodia but both lacking posterior claw; anterior claw small, curved. Femora lacking lobate flanges. None of legs unusually slender or shortened, tibiotarsus I short, cylindrical, less than twice as long as wide. Trochanter III elongate, about as long as combined femorogenu and tibia III. Leg IV elongate, cylindrical, shorter than femorogenu and tibia III. Femorogenu IV over twice as long as tibiotarsus, each with two setae. Leg chaetotaxy (for Fe, Ge, Tb, and Ta): I, 4–4–6(2φ)+8(1ω); II, 3–3–4–6(1ω); III, 1+3–4–4.

Figs. 7–10. *Giselia arizonica*, adult female. 7, habitus venter; 8, habitus dorsum; 9, dorsal opisthosoma, detail of posterior edges of tergites C and D; 10, tibiotarsus I.



Tibia I sensory cluster developed typically for the tribe, tarsus I setation with three simple, slender setae, including *pl″*, ventrally; accompanying eupathidia, both unguinal setae (*u′* and *u″*), and slender, spinelike subunguinal seta *s* short with blunt apices. Tarsus II seta *pl″* present, spinelike, located slightly distally of solenidion. Minute unguinal seta *u″* flanking pretarsi II and III untapered, rodlike; seta *u′* typically spinelike, pointed but not prominent.

Giselia arizonica sp. nov.

(Figs. 1–10)

Type material

Holotype: female, phoretic on coxa I of female *Pseudopityophthorus opacicollis* Blackman (Coleoptera: Scolytidae) caught in Lindgren trap baited with *Dendroctonus frontalis* Zimmermann pheromone, within stand of *Pinus*

leiophylla Schiede & Deppe infested with *Dendroctonus mexicanus* Hopkins and *D. frontalis* (Moser *et al.*, unpublished data); Chiricahua Mountains, Turkey Creek, elevation 2000 m, 31°51.280′N, 109°19.883′W, Cochise Co., Arizona, United States of America, 1.ii.2003, coll. B. Fitzgibbon. **Paratypes:** 3 females with same collection data as the holotype. The holotype is deposited in the collection of the Department of Animal Taxonomy and Ecology, A. Mickiewicz University, Poznań, Poland; one of the paratypes is deposited in each of the following: Zoological Museum of Hamburg University, Hamburg, Germany; Canadian National Collection of Insects and Arachnids, Ottawa, Ontario, Canada; and National Museum of Natural History Entomological Collection, Beltsville, Maryland, United States of America.

Etymology

The specific name refers to the state in the United States of America from which the new taxon was collected.

Diagnosis

With character states of the genus.

Description

Adult female

Gnathosoma. Capsule approximately 1.4 times as long as wide, pharynx width 0.2 times the basal width of gnathosoma. Dorsal and ventral gnathosomal setae subequal in length.

Idiosoma 1.6 times longer than wide. **Dorsum.** Relative lengths of dorsal setae (*v1*:*sc2*:*c2*:*c1*:*d*:*e*:*f*:*h*): 1:1.9:1.3:1.2:1.4:0.5:2.0:0.6. Anterior projection of prodorsal shield broadly rounded, almost 3 times wider than long. Distance between setae *v1* nearly twice their length. Prodorsal shield about 1.5 times as wide as long, its posterior margin weakly undulate. Pits *v2* indiscernible. Setae *sc2* located slightly posterior to midline of prodorsal shield, their tips reaching slightly beyond posterior edge of prodorsal shield, distance between their bases about 1.5 times their length. Posterior margins of tergites C, D, and EF irregularly and finely serrated. Setae *c2* with their tips reaching half the distance to bases of *c1*, latter with tips reaching about two thirds the distance from their bases to posterior edge of tergite C. Setae *d* slender, attenuate, reaching well over one half their length beyond posterior edge of tergite D; distance between their bases about twice their length. Setae *f* slender, attenuate, distance between their bases slightly more than half their length. Distance between bases of setae *h* over 4 times their length. Cupules *im* nearly contiguous with bases of setae *e*, and cupules *ih* located medially at a distance of their diameter to bases of setae *h*.

Venter. Apodemes 1 well sclerotized, prosternal apodeme defined, diffused slightly posteriorly of proximal ends of apodemes 2. Sejugal apodeme well developed, slightly fainter in its medial part, with few apparent thickenings on each side. Setae *1a* inserted on apodemes 1, separated by a distance of their length. Setae *2a* inserted slightly anteriorly of apodemes 2, distance between their bases about 3.5 times their length. Alveolar vestiges of setae *1b* placed midway between bases of setae *1a* and anterolateral extremities of apodemes 2. Those of setae *2b* located on lateral edges of ventral propodosomal plate, transversely aligned with setae *2a*. Apodemes 4 ending distally at bases of setae *3b*. Setae *3a* subequal to *3b* and located approximately 4 times their length from the bases of the latter, and separated from each other by a distance greater than that between *3b*. Setae *3b* separated by a distance of approximately 5–6 times their length. Ventral metapodosomal plate weakly concave anteriorly, with strong, acute processes between trochanters III and IV. Tegula short, broadly convex. Distance between bases of setae *ps* slightly greater than their length.

Legs. Relative lengths of free segments of legs (I:II:III:IV, from proximal end of femur to distal end of tarsus/tibiotarsus): 1.0:1.1:1.2:0.6. **Leg I.** Claw large, tightly hooked, inserted on relatively short pretarsus. Spinelike seta *s* slender, blunt, slightly smaller than seta *u′* of legs II and III. Setae *u′* and *u″* similar in size to *s*. Tibiotarsus approximately 1.7 times as long as wide at base. Eupathidium *p′* inserted subapically, and *p″* apically on tibiotarsus I; *tc′* the longest of the eupathidia, and *tc″* located slightly distally of transverse midline of tibiotarsus; both adaxial eupathidia (*p″* and *tc″*) inserted on small cylindrical protuberances of wall of segment. Solenidion ω with spindle-shaped, striated head, as large as that on tarsus II. Tibial solenidion ϕ_2 shorter but slightly thicker than solenidion ϕ_1; famulus *k* approximately as long as ϕ_1 and inserted at same level. Tibial seta

d long, attenuated; genual seta *l'* tapered, blunt, not stouter than other genual setae. All femoral setae slender, attenuate, except *d* short, stiff, pointed. **Leg II.** Claw small, hooked; empodium small, pad-like. Tarsal spinelike seta *pl''* as long as solenidion ω and inserted slightly distally to it; tarsal seta *pv''* present, and *tc''* longer than other setae of segment. Tibial seta *d* attenuated, longer than other setae of segment. Genual seta *l'* pointed but thicker and stiffer than other setae of segment. Femoral seta *d* short, slender, pointed. **Leg III.** Claw similar to that on leg II. Tarsal seta *pv''* absent, and seta *tc''* clearly longer than other setae of segment. Genual seta *l''* placed closer to femoral seta *v'* than to remaining genual setae. **Leg IV.** Free segments (femorogenu and tibiotarsus) clearly shorter than femorogenu and tibia III. Femorogenu less than 3 times as long as tibiotarsus. Femoral seta *v'* shorter than genual seta *v'*, the latter inserted at a distance of 0.5 times the distal width of femorogenu from the end of segment. Tibial seta *v'* 1.4 times as long as combined length of femorogenu and tibiotarsus. Tarsal seta *tc''* 3 times as long as free segments of leg IV.

Measurements (ranges among holotype and three paratypes). Body and tagmata: length of body, 157–183; length of idiosoma, 141–157; width of idiosoma, 95–102; length of gnathosoma, 30–32; width of gnathosoma, 21–23; length of pharynx, 10–11; width of pharynx, 5; *dgs*, 9–11; *vgs*, 9–10. Dorsum: length of PrS, 60–63; width of PrS, 88–105. Lengths of setae: *v1*, 13–15; *sc1*, 12–14; *sc2*, 25–27; *c2*, 18–20; *c1*, 16–17; *d*, 18–21; *e*, 6–7; *f*, 25–30; *h*, 7–9. Distances between setae (and stigmata): *v1–v1*, 26–29; *sti–sti*, 45–47; *sc1–sc1*, 37–41; *sc2–sc2*, 37–39; *c2–c2*, 79–85; *c1–c2*, 31–34; *c1–c1*, 58–61; *d–d*, 35–37; *e–e*, 63–66; *e–f*, 23–25; *f–f*, 17–19; *h–h*, 33–36. Venter, lengths of setae: *1a*, 9–10; *2a*, 8–10; *3a*, 3–5; *3b*, 4–5; *ps*, 8–9. Venter, distances between setae: *1a–1a*, 9; *2a–2a*, 31; *3a–3a*, 29–30; *3b–3b*, 25; *ps–ps*, 8–10. Length of tegula, 6–8; width of tegula, 16; length of PrP, 45–50; width of PrP, 85–95; ap. 1–1, 10–12; ap. 2–2, 45–49. Leg segments and leg setae (lengths): Tbt I, 16–18; Ta I ω, 5; ϕ_2, 3; ϕ_1, 4–5; *k*, 5–6; Ta II ω, 5; Ta II *pl''*, 5; Fege IV, 15–16; Tbt IV, 6–7; Fe *v'*, 7–8; Ge *v'*, 9–11; Tb *v'*, 30–31; Ta *tc''*, 63–66.

Remarks

Although *Giselia* is clearly a member of the tribe Tarsonemini *sensu* Lindquist, 1986, its systematic position within the tribe is problematical. While its adult females share some external similarities with those of *Suctarsonemus*, they also differ considerably in a suite of other attributes, as noted in part in the Diagnosis. Moreover, some of those similarities may represent homoplasies. For example, an enlarged, hooked tarsal claw on leg I has been derived apparently independently in clusters of genera in the tribes Pseudotarsonemoidini (*e.g.*, *Ununguitarsonemus*, *Pseudotarsonemoides*) and Tarsonemellini (*e.g.*, *Tarsonemella*, *Paratarsonemella*, and, to a less enlarged degree, *Ficotarsonemus* and *Alkithoenemus*), as well as in the tarsonemine genus *Suctarsonemus*. This homoplasy is further apparent among multiple genera of other heterostigmatic families such as Athyreacaridae, Pyemotidae, Pygmephoridae, Scutacaridae, and Acarophenacidae. Even so, it may be argued that the tightly hooked condition of the claw, without its being sessile, is synapomorphic between *Giselia* and *Suctarsonemus*. However, *Giselia* lacks the anteriorly procurved form of apodemes 4 that is autapomorphic to *Suctarsonemus*. A well-sclerotized, horseshoe-shaped pharynx appears to be a derived attribute shared among the tarsonemine genera *Giselia*, *Suctarsonemus*, and *Pseudotarsonemus*. However, this attribute may be homoplastic, as it is also found in the pseudotarsonemoidine genus *Pseudotarsonemoides*, and a somewhat similar form of pharynx is also found among some species in other genera of Tarsonemini. An idiosomal ornamentation consisting of puncta and striae is also not unique for *Giselia* and *Suctarsonemus*, as similar ornamention has been derived apparently independently at least four other times, *e.g.*, among some species of *Iponemus*, *Pseudotarsonemus*, and *Neotarsonemoides*, and some as yet undescribed species of *Tarsonemus*. The presence of seta *pv''* on tarsus II, coupled with its absence on tarsus III, is shared between *Giselia*, *Pseudotarsonemus*, and some species of *Neotarsonemoides*; again, however, this attribute occurs elsewhere among a few taxa of Tarsonemini, including a few species of *Tarsonemus* and its subgenus *Floridotarsonemus* (Lindquist 1986). The apomorphic asymmetrical reduction of the posterolateral claw on tarsi II and III in *Giselia* is shared with *Pseudotarsonemus* and some species of *Neotarsonemoides*, but this

attribute also is found in the tarsonemine genus *Heterotarsonemus* and in several pseudotarsonemoidine genera (Lindquist 1986). The finely serrated posterior edges of the dorsal tergites are also not unique to the new genus, as they occur in some species of *Neotarsonemoides* and in two undescribed species of *Tarsonemus*. Thus, although the systematic position of the new genus is uncertain, it seems to share more putatively derivative attributes with *Suctarsonemus*, *Pseudotarsonemus*, and *Neotarsonemoides* than with other genera of Tarsonemini. As in *Giselia*, adult females of the monobasic genus *Pseudotarsonemus* are phoretic on bark beetles, though from unspecified hardwood hosts in South America. In contrast, species of *Suctarsonemus* are known only from tropical regions of Africa, where their adult females are phoretic on undetermined insects collected from light traps (a record of this genus from the skin of cattle in Mexico by Otero and Bassols (1980) is exceedingly doubtful and in need of confirmation). Species of *Neotarsonemoides* are known only from plant litter habitats in Eurasia, and a phoretic association with insects has not been confirmed (Lin and Zhang 2002).

Little can be said about the biology and ecology of *G. arizonica*. It is probably not a parasitoid, since the pharyngeal pump is reduced in size and not conspicuously muscular. A badly damaged specimen (legs I were lost during remounting, though notes were taken of them prior to that) of apparently the same species was recovered earlier by one of us (E.E.L.), phoretic on *Pseudopityophthorus minutissimus* (Zimmermann), 13 February 1965, from Salem, Missouri (S. Thewke coll.). The geographic range of this mite, then, may extend at least from Missouri to Arizona, a distance overlapping the ranges of its two phoretic host species, *P. minutissimus* (eastern United States) and *P. opacicollis* (southwestern United States). Both of these scolytids attack cut, broken, or stressed branches, limbs, or boles of *Quercus* spp. (Fagaceae) (Wood 1983). Only two males and two females of *P. opacicollis* flew into the traps during the 2-year period of collection, but the mites were seen on only one of these four beetles. This small number of beetles was probably trapped accidentally, and the trapping had little to do with the pheromone bait attraction, which lured thousands of *D. frontalis* and *D. mexicanus*. The possible distribution of this mite may be extensive, since there are 21 species of *Pseudopityophthorus* infesting *Quercus* spp. ranging from Oregon and Quebec south through Central America to Colombia (Wood 1983).

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