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### NEW CAVERNICOLOUS RHAGIDIIDAE FROM IDAHO, WASHINGTON, AND UTAH (PROSTIGMATA: ACARI: ARACHNIDA)

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The cavernicole fauna of western North America has not received much attention until recent years. Lava caves, surprisingly, have yielded a wealth of cave-adapted species, which have been reported by Causey (1972), Peck (1973), Holsinger (1974), and Briggs (1974). Rhagidiid mites have been reported previously from eastern North American limestone caves, but a number of species still await description (Holsinger, 1965*a*, 1965*b*; Elliott and Strandtmann, 1971). No rhagidiids have been reported yet from western North America, except for Alaska and western Canada (Strandtmann, 1971). This report concerns a remarkable new genus discovered in lava caves of Idaho by Stewart B. Peck, and in Washington by Francis G. Howarth. A new species of *Rhagidia*, collected by Richard E. Graham, is reported also from a limestone cave in Utah. All measurements are in microns.

#### **Flabellorhagidia**, new genus

*Diagnosis.*—The following is based on the adults of both sexes. Medium to large (650-1100), soft-bodied mites with long legs; leg I, 1.4 to 2.3 times body length; all femora divided; apparently eyeless; chelicerae large, with three or four-cusped fixed digit; setae, especially those on the legs, long and finely ciliated; suture between propodasoma and metapodasoma faint; tibia II bears a large, unusual dorsoapical structure, here termed the flabellum, probably a large, highly modified rhagidial organ (r.o.); stellate seta large, placed between first and second r.o. of tarsus I; stellate seta with large,

central bulb on stalk and four to eight radial branches (each branch with six to eight lateral spines), which occasionally are ramifying and also bear spines; tarsi I and II each with three to four long, oblique or tandem r.o.; trichobothria long, filiform, and finely ciliated; legs I and II, longer, relative to body length, in females than in males; chelicerae larger with relatively longer shears in males than in females. *Flabellorhagidia* differs from *Rhagidia* and *Coccorhagidia*, the other rhagidiid genera, in the unusual flabellum, a structure reported in no other mite. *Flabellorhagidia* is more similar to *Rhagidia* in that the trichobothria are filiform.

*Etymology*.—The generic name is derived from the Latin *flabellum*, meaning flap (describing the structure on tibia II), and *rhagidia*, from the genus *Rhagidia*.

*Type species*.—*Flabellorhagidia pecki*, new species.

***Flabellorhagidia pecki*, new species**

Figs. 1-9

1973. *Rhagidia* sp. Peck, Bull. Nat. Speleol. Soc., 35:101.

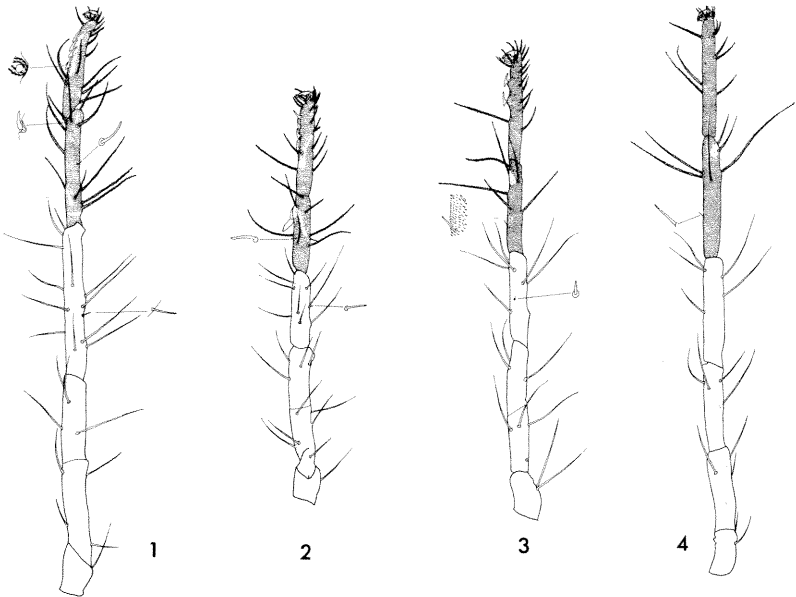
1974. *Rhagidia* Briggs, J. Arachnol., 1:206.

*Holotype*.—Adult male, collected in Boy Scout Cave (lava, 4°C air temperature), Craters of the Moon National Monument, Butte Co., Idaho, 1 October 1969, by Stewart and James Peck. Deposited in the United States National Museum of Natural History, no. 3725.

*Venter*. Coxal formula 3-1-5-3; genital setae, six pairs, clavate; paragenital setae, five pairs, narrowly clavate; medial coxal setae narrowly clavate; longer setae either cylindrical or slightly tapered; all setae finely ciliated; internal genital setae, twenty.

*Dorsum*. Apparently eyeless; suture between pro and metapodasoma faint; epivertex divided from propodasoma by a suture; all setae long and finely ciliated; trichobothria ciliated and longer than scapulars, which are subequal to humerals; internal humeral (i.h.), dorsal 1 (d1), and dorsal 2 (d2) not quite as long as distances from one to another; internal sacral (i.s.) and external sacral (e.s.) long, extending past posterior; anus terminal, four pairs of anal setae.

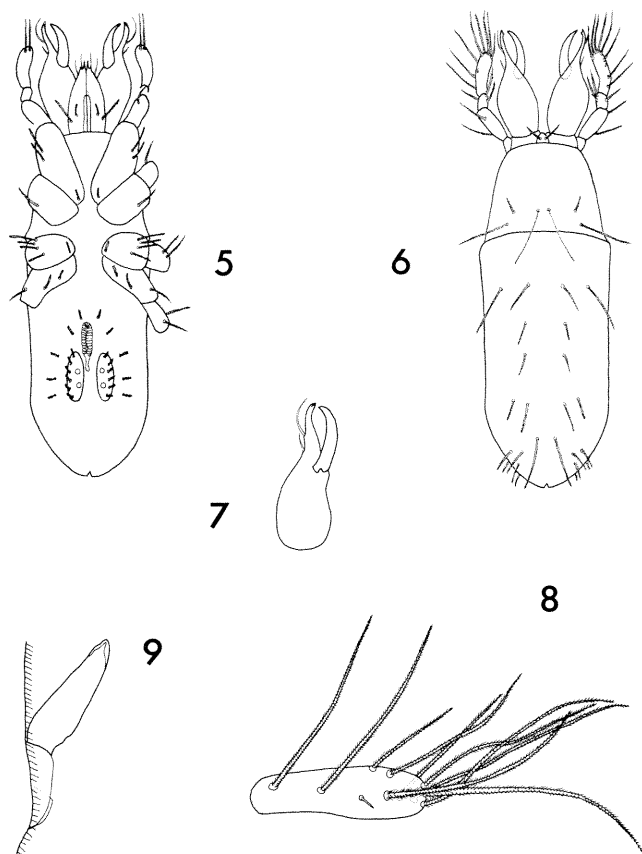
*Gnathosoma*. Hypostome about 1.5 times as long as broad, with the typical eight setae: four ciliated posteriors, four nude anteriors; chelicerae large, the shears 46 per cent of total length, fixed digit tricusped, the middle cusp small, no denticles; cheliceral setae about one third and one half distance from base of fixed digit to tip, the posterior reaching the anterior, and the anterior about two-thirds the length of the fixed digit; fourth segment of palp with a dorsal solenidion, one-third distance from tip, and 10 setae: one dorsobasal, one



FIGS. 1-4.—*Flabellorhagidia pecki*, male holotype: 1, left leg I; 2, left leg II; 3, left leg III; 4, left leg IV.

dorsal subbasal, three dorsal subapical, two ventral subapical, and three apical.

Legs. Long and slender, covered with fine pubescence (illustrated on tibiae and tarsi only); all femora divided; trochanter formula 1-1-2-2; leg I, 1.9 times body length (excluding coxa); tarsus I with four long, curved, oblique r.o.; large stellate seta placed between first and second r.o.; stellate seta with large central bulb on stalk and four radial branches, each branch with six to eight lateral spines; tibia I with a small, dorsoapical r.o. projecting from a pit and a midventral solenidion; genu I with a midventral solenidion; tarsus II with four long, curved, oblique r.o. and a small spiniform seta just basal to the first r.o.; tibia II with large dorsodistal flabellum; flabellum folded back as a flap and the naked membrane, which lines the depression under the flabellum, everted; dorsolateral solenidion one-third distance from base of tibia II; genu II with a midventral solenidion; tarsus III with two long, tandem, subapical r.o., elevated on left leg, in two oval depressions on right leg; tibia III with a dorsal subbasal solenidion and a dorsolateral subbasal solenidion; dorsolateral solenidion about midway on genu III; tibia IV with dorsal subbasal solenidion; all setae long and tapered.



FIGS. 5-9.—*Flabellorhagidia pecki*, male holotype: 5, venter; 6, dorsum; 7, ventral view of right chelicera; 8, dorsal view of apical segment of right pedipalp; 9, lateral view of flabellum on tibia II.

Measurements. Body length, 945; leg I, 1776; leg II, 1240; leg III, 1408; leg IV, 1696; flabellum, 45; chelicera, 363; shears, 167; sperm sac, 147.

*Allotype*.—Adult female, taken at the same locality and by the same collectors as the holotype, 1 October 1969, and deposited in the United States National Museum of Natural History.

Venter. Same as male holotype except there are only five pairs of genital setae.

Dorsum. Same as male.

Gnathosoma. Hypostome about 1.8 times as long as broad, with the typical eight setae; chelicerae smaller than in male, the shears only 33 per cent of total length.

Legs. Leg I, 2.0 times body length; relative to body length, legs I and II longer, leg III shorter, and leg IV about the same as in male; tarsus III without the two r.o. of male; other characters same as in male.

Measurements. Body length, 1103; leg I, 2194; leg II, 1548; leg III, 1543; leg IV, 1940; flabellum, 41; chelicera, 314; shears, 103.

*Sexual dimorphism.*—The female is larger and has relatively longer legs I and II than the male; the male, despite being smaller, has much larger chelicerae and the shears are relatively longer (46 versus 33 per cent); the male has six pairs of genital setae, the female only five pairs; only the male has rhagidial organs on tarsus III.

*Comparisons.*—*Flabellorhagidia pecki* is related closely to a species from Washington (described below), with which it shares the large stellate seta, flabellum, long legs and setae, tricusped fixed digit, and large chelicerae. Differences are discussed below.

*Distribution.*—Known only from the type locality.

*Remarks.*—*Flabellorhagidia pecki* exhibits cave adaptation in the great attenuation of the legs and setae, eyelessness, and the high degree of sensory development. It should be considered troglobitic. The most extremely cave-adapted rhagidiids of Europe, *Rhagidia longipes* and *R. strouhali*, attain a leg I length twice that of the body (Strandtmann, 1971).

*Etymology.*—This species is named for Dr. Stewart B. Peck, Department of Biology, Carleton University, Ottawa, Ontario, Canada.

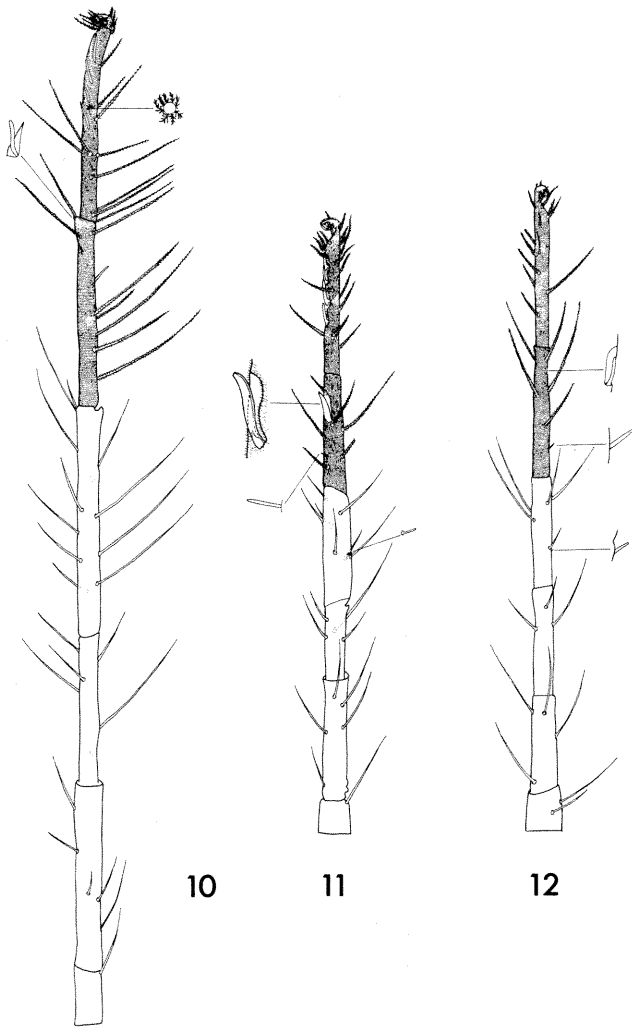
### ***Flabellorhagidia howarthi*, new species**

Figs. 10-17

*Holotype.*—Adult female, collected in Cheese Cave (lava), 620 m., 2 km. SW Trout Lake, Klickitat Co., Washington, 25 August 1972, by Francis G. Howarth and Luurt G. Nieuwenhuis, in twilight on breakdown. Deposited in the Bernice P. Bishop Museum, no. 10667, Honolulu, Hawaii (Figs. 10-15).

Venter. Coxal formula 3-1-4-3; genital setae, five pairs, clavate; paragenital setae, five pairs, clavate; genitalia everted, about 20 internal genital setae visible; medial coxal setae narrowly clavate; other setae narrowly clavate, cylindrical, or tapered; all setae finely ciliated.

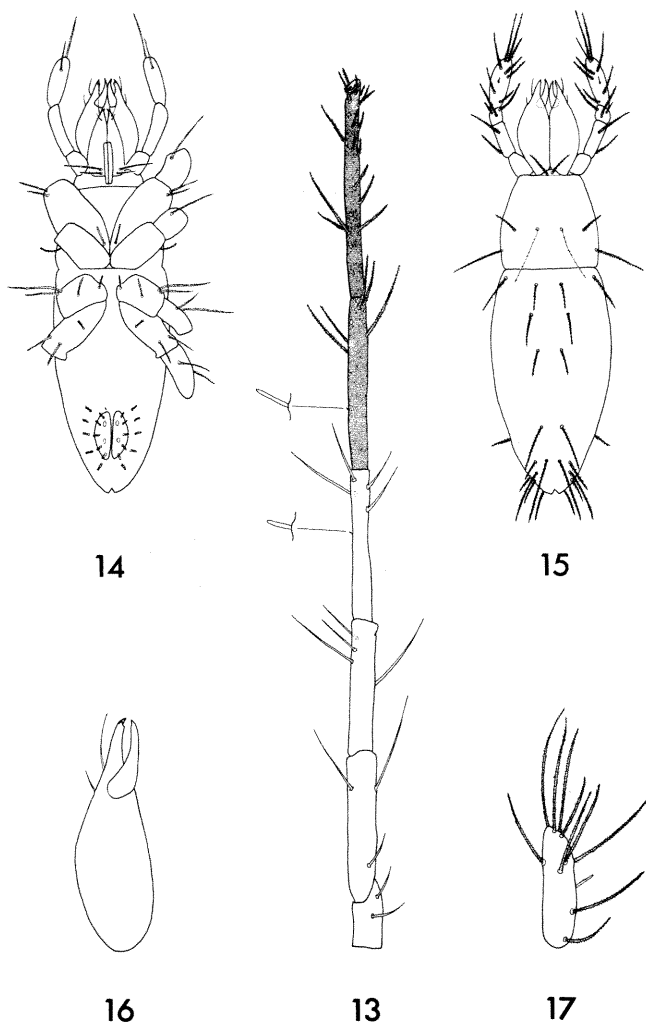
Dorsum. Apparently eyeless; suture between pro and metapodasoma faint; suture between epivertex and propodasoma pronounced; all setae long and finely ciliated; trichobothria ciliated and about twice as long as scapulars, which are longer than external humerals; i.h., d1, and d2 about as long as distances between one and another; i.1. long and extending past base of i.s.; i.s. longer than i.1. and extending



FIGS. 10-12.—*Flagellorhagidia howarthi*, female holotype: 10, right leg I; 11, right leg II; 12, right leg III.

for one-half their length past posterior; anus terminal; four pairs of anal setae.

Gnathosoma. Hypostome about twice as long as broad, with the typical four anterior nude setae and four posterior ciliated setae; chelicerae large, the shears about 25 per cent of total length; fixed digit tricusped, cusps about equal in size; posterior seta of fixed digit just anterior to base of movable digit and reaching about one-third



FIGS. 13-17.—*Flabellorhagidia howarthi*, female holotype (Figs. 13-15), male allotype (Figs. 16-17): 13, right leg IV; 14, venter; 15, dorsum; 16, ventral view of right chelicera; 17, dorsal view of apical segment of right pedipalp.

distance to tip of digit, to the base of the anterior seta; anterior seta extends past the tip; fourth segment of palp with a long solenidion about middorsal, and bearing ten setae: one dorsobasal, one dorsal subbasal, three dorsal subapical, one ventral subapical, and four apical.

Legs. Long and slender, covered with fine pubescence; all femora divided; trochanter formula 1-1-2-2; leg I (excluding coxa), 2.3 times body length; tarsus I with four long, curved, oblique r.o.; stellate seta placed between the two basal r.o.; stellate seta with large central bulb on stalk and seven radial branches, each branch with several lateral spines; tibia I with a small dorsoapical r.o. projecting from a pit and a long, ventral, subapical solenidion; tarsus II with four long, curved, oblique r.o. and a short spiniform seta just basal to the first r.o.; tibia II with a partially "open" flabellum (about the same size and shape as in *F. pecki*) and a dorsal subbasal solenidion; genu II with a midventral solenidion; tibia III with a recumbent dorsoapical solenidion and a dorsal subbasal solenidion; genu III with a short solenidion about middorsal; tibia IV with a dorsal subbasal solenidion; genu IV with a middorsal solenidion; setae long and tapered.

Measurements. Body length, 656; leg I, 1533; leg II, 975; leg III, 940; leg IV, 1367; flabellum, 47; chelicera, 191; shears, 49.

*Allotype*.—Adult male found floating on the surface of a small pool of water in the dark zone of Cheese Cave on the same date and by the same collectors as the holotype, and deposited in the Bernice P. Bishop Museum, no. 10667-A, Honolulu, Hawaii (Figs. 16, 17).

Venter. About twenty internal genital setae, as in the female holotype; other characters same as in female.

Dorsum. Same as in female.

Gnathosoma. Hypostome as in female; chelicerae large, the shears about 30 per cent of total length; other characters same as in female.

Legs. Leg I, 1.9 times body length, relatively shorter than in female; leg II also relatively shorter than in female; legs III and IV about the same as in female; leg IV, longest; other characters same as in female.

Measurements. Body length, 749; leg I, 1455; leg II, 1004; leg III, 1092; leg IV, 1494; flabellum, 56; chelicera, 206; shears, 64; sperm sac, 127.

*Sexual dimorphism*.—The female is smaller than the male but has longer legs I and II, relative to body length; the male has chelicerae that are slightly longer, the shears of which, relative to the chelicerall length, are slightly longer than in the female (30 versus 25 per cent); other characters appear to be equivalent in the two sexes.

*Paratypes*.—Adult male (three legs missing; body length, 926) and a damaged individual of unknown sex (three legs missing) both found floating on small pools of water in the dark zone in the upper and lower sections of Cheese Cave, on the same date and by the same collectors as the holotype, and deposited in the Bernice P. Bishop Museum, Honolulu, Hawaii.



*Description of tritonymph.*—Taken in Upper Falls Creek Cave System, 950 m., about 20 km. W Trout Lake, Skamania Co., Washington, 24 August 1972, near stream, air temperature 7°C, by Francis G. Howarth and Luurt G. Nieuwenhuis.

Venter. Same as in adult except there are three pairs of genital setae and four pairs of paragenital setae; no internal genital setae.

Dorsum. Setae on propodasoma about the same as in adult; setae on opisthosoma generally shorter than in adult; i.h. extending about three-fourths distance to d1, d1 extending about one-half distance to i.1., i.1. extending almost as far as i.s., and i.s. nearly terminal; four pairs of anal setae.

Gnathosoma. Hypostome as in adult; chelicerae four-cusped, with three transverse cusps at tip and one medial and basal to them; cusps subequal; setation same as in adult; palps same as in adult.

Legs. Leg I, 2 times body length; other legs relatively shorter than in adult; tarsus I with three long, oblique r.o., a fully formed stellate seta between the basal two; other setation on leg I as in adult; tarsus II with three long, curved, oblique r.o. and a short spiniform seta just basal to the first r.o.; fully formed, open flabellum on tibia II; other setation on legs II, III, and IV as in adult.

Measurements. Body length, 651; leg I, 1278; leg II, 804; leg III, 837; leg IV, 1152; flabellum, 49; chelicera, 191; shears, 49.

Additional specimens collected by Francis G. Howarth and Luurt G. Nieuwenhuis from the Upper Falls Creek Cave System (body length given in parentheses) include: a second tritonymph (?) in poor condition (603); a nymph (?) with all but two legs missing (343); three females (593, 720, 833); and a damaged adult of unknown sex. These are deposited in the Bernice P. Bishop Museum.

*Comparisons.*—*Flabellorhagidia howarthi*, although closely related to *F. pecki*, differs from that species by possessing the following: smaller body, greater relative leg length, fewer setae on third coxa (four versus five), fewer genital setae, fewer leg setae, shorter shears, more branches on the stellate seta, lack of r.o. on tarsus III, and presence of two solenidia on tibia III. Sexual dimorphism is less pronounced in *F. howarthi*.

*Variation.*—The mean body length of the two males (749 and 926) is 838; the mean body length of the four females (ranging from 593 to 833) is 701; the two tritonymphs (603 and 651) average 627. The tritonymph has one less r.o. on tarsi I and II than the adult. The tritonymph described above has four-cusped chelicerae; the adults have tricusped chelicerae.

*Remarks.*—*Flabellorhagidia howarthi* exhibits the most extreme leg attenuation of any rhagidiid and should be considered troglobitic. Conceivably, this species could migrate through the lava interstices among caves within adjoining and overlaying lava flows. However, Howarth's investigation of four other caves in the Mt. Adams basaltic lava flows did not yield this species, nor were any rhagidiids taken in three caves studied in the Mt. St. Helens lava flows to the west (F. G. Howarth, personal communication). This species is sympatric with *Flabellorhagidia* sp. in Upper Falls Creek Cave System (see below).

*Etymology.*—This species is named for Dr. Francis G. Howarth, Bernice P. Bishop Museum, Honolulu, Hawaii.

### ***Flabellorhagidia* sp.**

Yet a third species of *Flabellorhagidia* is represented by a tritonymph and two adults from three caves in the Mt. Adams lava flows, Skamania County, Washington. The two adults were damaged badly when the author remounted them from Hoyer's Medium to polyvinyl alcohol. Rather than describe a new species from damaged or immature specimens, I present here some of the more obvious characters of the species. It is hoped that good specimens can be obtained from these caves in the future. The author recommends that any who attempt to mount rhagidiids take extreme care in clearing and handling the specimens. The extreme fragility of the body and leg length make it difficult to obtain a good mount.

*Description.*—Each specimen is described below. All were collected by Francis G. Howarth and Luurt G. Nieuwenhuis and are deposited in the Bernice P. Bishop Museum, Honolulu, Hawaii.

Adult from Upper Falls Creek Cave System. Body length, 808; coxal formula 3-1-5-3; genital setae, five pairs; paragenital setae, five pairs; large chelicerae with tricusped fixed digit; robust legs with conical knobs on femur II; tarsus II with three tandem r.o. and a spiniform seta just basal to the first r.o.; tibia II with short, round flabellum; body damaged on remounting; legs I missing. Collected 24 August 1972 near stream, air temperature 7°C. The cave location is given above.

Adult from Lower Falls Creek Cave System. Body length, 1033; paragenital setae, four pairs; leg IV with low, blunt, conical knobs on trochanter, femur, and genu; leg IV about same length as body; trochanter formula 1-1-2-2; opisthosoma damaged on remounting; other characters as in first adult. Collected 23 August 1972, either on slime on wall or garbage on floor, air temperature 8°C. The cave is located at 880 m., about 20 km. W Trout Lake, Skamania Co., Washington.

Tritonymph from Dry Creek Cave. Body length, 700; genital setae, three pairs; paragenital setae, five pairs; no knobs on legs; leg I about 1.4 times body length; other characters as in adults. Collected 22 August 1972 on or near rodent dung. The cave is located at 1040 m., 10.5 km. W Trout Lake, Skamania Co., Washington.

This species, though eyeless, should probably be considered troglomorphic until more data are available.

### Origin of *Flabellorhagidia*

At present, little can be said about the origin of *Flabellorhagidia*. Further studies of the Rhagidiidae of North America will be necessary to discover its affinities.

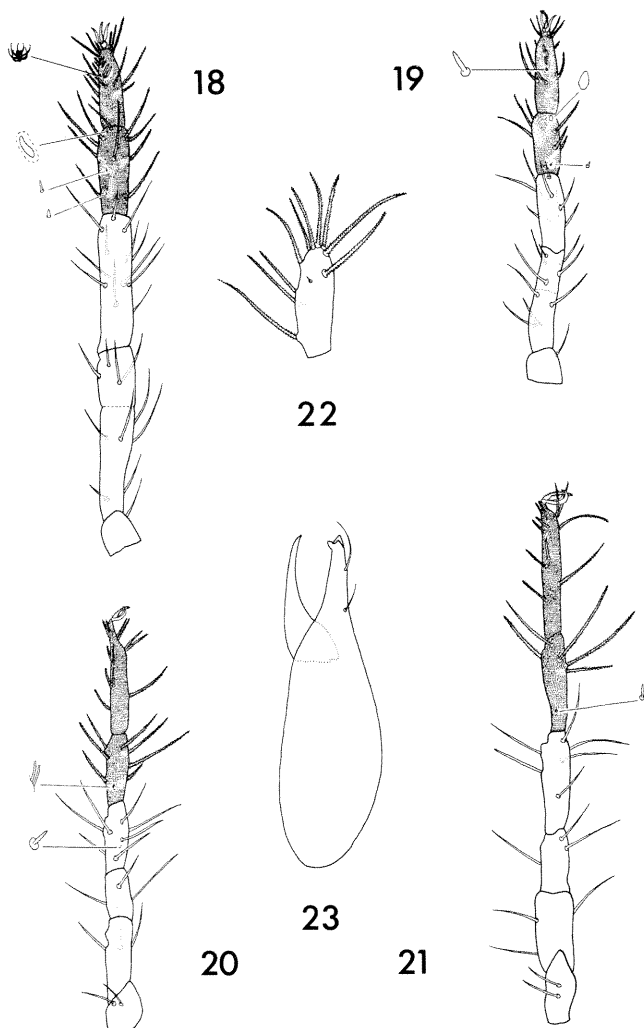
Rhagidiid mites generally are found in cool, moist habitats. It is possible that a widespread, ancestral *Flabellorhagidia* colonized lava caves in a cooler, wetter time, such as during the Wisconsinan glacial period or even earlier. Subsequent climatic changes may have isolated the present populations. The undescribed species of *Flabellorhagidia* seems to exhibit less modification for cave life than either *F. howarthi* or *F. pecki*. It is perhaps a more recent cavernicole, or may still be found in the epigeum. It seems unlikely that *F. howarthi* and *F. pecki* could have originated in the present caves, inasmuch as these caves were formed in postglacial (possibly glacial) flows in Washington (9000 to 15,000 years BP) and Recent flows (about 2000 years BP) in Idaho (Halliday, 1972; Peck, 1974). Howarth (1972, 1973), Peck (1973, 1974), and Briggs (1974) have discussed the possible colonization, by various arthropods, of new lava caves via interstices in old and new lava. Thus, *F. howarthi* and *F. pecki* may have longer histories than the caves in which they are found. This may also explain the apparent sympatry of *F. howarthi* and the undescribed species of *Flabellorhagidia* in Upper Falls Creek Cave System.

### *Rhagidia grahami*, new species

Figs. 18-25

*Holotype*.—Adult female, collected in Little Brush Creek Cave (limestone), Ashley National Forest, Uinta Mountains, Uintah Co., Utah, June 1970, by Richard E. Graham. Deposited in the United States National Museum of Natural History, no. 3726. The species is known by a single specimen.

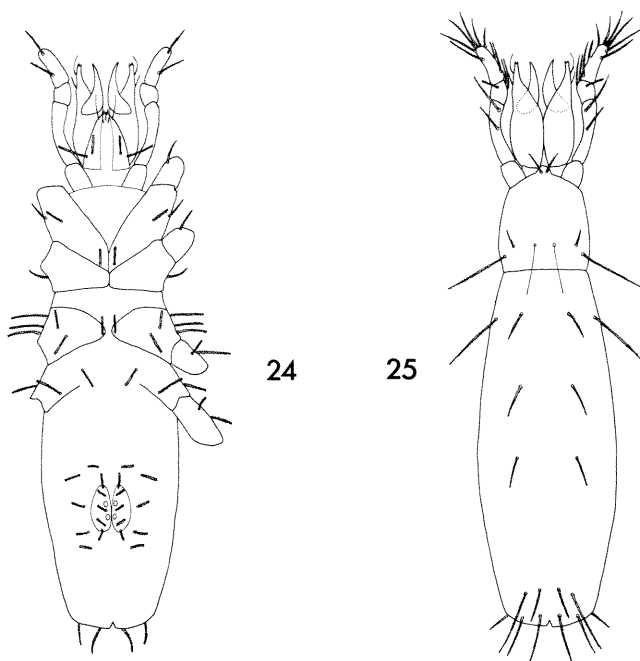
Venter. Rear coxae poorly defined; coxal formula 3-1-6-3; genital setae, five pairs, clavate; paragenital setae, five pairs, clavate; internal genital setae, about 20; medial coxal setae clavate, longer setae cylin-



FIGS. 18-23.—*Rhagidia grahami*, female holotype: 18, left leg I; 19, left leg II; 20, left leg III; 21, left leg IV; 22, dorsolateral view of apical segment of right pedipalp; 23, dorsal view of right chelicera.

drical or tapered; all setae finely ciliated; only three pairs of anal setae visible, all terminal (four pairs are the normal number); anus terminal.

Dorsum. All setae finely ciliated; trichobothria very finely ciliated and shorter than scapulars; scapulars subequal to external humerals; i.h., d1, and d2 about same length, the distance between each about



FIGS. 24-25.—*Rhagidia grahami*, female holotype: 24, venter; 25, dorsum.

three times their lengths; lumbar and sacral nearly terminal; e.1. and i.s. long, and extending about the same distance past posterior as the shorter e.s.; i.1. extends to posterior.

Gnathosoma. Hypostome 1.8 times as long as broad, with the typical four naked anterior and four ciliated posterior setae; chelicerae large, the shears about 38 per cent of total length; fixed digit with three large cusps, the medial one slightly apical to the others, no denticles; posterior cheliceral seta one-half distance from base of fixed digit to tip, and extending two-thirds distance to the anterior seta; anterior seta two-thirds distance from the base and extends for one-third of its length past the tip; fourth segment of palp with a short, dorsal, subapical solenidion and ten setae: one dorsobasal, one dorsal subbasal, one midventral, three ventral subapical, and four apical.

Legs. Conical hairs on legs tending to become conical knobs on ventral sides of trochanters, femora, and genua; femora I and II faintly divided, femora III and IV strongly divided; leg I, 1.4 times body length; tarsus I with four oblique r.o. in separate fields; stellate seta placed between the two basal r.o.; stellate seta with eight bare branches and a small bulb; tibia I with a small, recumbent, dorsoapical

r.o., a small dorsolateral solenidion placed medially, and a dorsal sub-basal solenidion; tarsus II with three short r.o. placed longitudinally, the middle one lateral to the other two and in a single field with the basal one; a short spiniform seta just basal to the first r.o.; tibia II with a dorsoapical r.o. in a pit and a dorsobasal solenidion; tibia III with two dorsal subbasal solenidia close together; genu III with a short, dorsal subbasal solenidion; tibia IV with a short, dorsal sub-basal solenidion.

Measurements. Body length, 715; leg I, 998; leg II, 688; leg III, 784; leg IV, 992; chelicera, 287; shears, 108.

*Comparisons.*—*Rhagidia grahami* seems to be most similar to *R. hilli* Strandtmann, 1971, which is known from moss and lichens under rocks and logs in Alaska and the Northwest Territories of Canada. It differs chiefly from *R. hilli* in having a smaller body, longer legs, longer chelicerae, the lack of serrations on the movable digit, the presence of two rather than one solenidia on tibia I, the presence of only the two basal r.o. of tarsus III in a common field instead of all in a common field, the lack of solenidia on genua I and II, the presence of a solenidion on genu III and on tibia IV, and the presence of conical knobs on the legs.

*Distribution.*—Known only from the type locality.

*Remarks.*—*Rhagidia grahami*, though eyeless, shows no obvious adaptation to cave-dwelling, such as great attenuation of legs or setae. It should probably be considered a troglophile until more ecological data are available.

*Etymology.*—This species is named for Dr. Richard E. Graham, Department of Biology, Upsala College, East Orange, New Jersey.

### ***Rhagidia trisetata***

*Rhagidia trisetatus* Elliott and Strandtmann, 1971, is here emended to *R. trisetata* in order that the specific epithet agree in gender with *Rhagidia*. Another oversight of Elliott and Strandtmann (1971) was in not designating a depository for the type of this species. The type and only specimen is deposited in the United States National Museum of Natural History.

### ACKNOWLEDGMENTS

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