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Edward L. Mockford
Illinois State University

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**DIAGNOSES, DISTRIBUTION, AND COMPARATIVE
LIFE HISTORY NOTES ON *AARONIELLA MACULOSA* (AARON) AND
A. EERTMOEDI N.SP. (PSOCOPTERA: PHILOTARSIDAE)**

Edward L. Mockford¹

ABSTRACT

Two species formerly confused under the name *Aaroniella maculosa* (Aaron) are separated in all life history stages. Application of the name *maculosa* was determined by examination of the type. The other species is new and is named (*A. eertmoedi*) and described. It is parthenogenetic, apparently with no males. The ranges of the two species are largely distinct but show some overlap.

Elipsocus maculosus Aaron was described from a single specimen collected in the Philadelphia region (Aaron, 1883). The species was transferred to *Philotarsus* by Chapman and Nadler (1928) and was made the type of *Aaroniella* by Mockford (1951). An augmented description of the species based on material from Winona Lake, Indiana, accompanied the diagnosis of *Aaroniella*. In accumulating and examining material from midwestern and eastern United States, I came to realize that the name *Aaroniella maculosa* was being applied to two forms, one of these represented only by females.

The purposes of this paper are the following: (1) to present data indicating that the two forms are species, (2) to show which species is the true *maculosa*, (3) to re-diagnose *maculosa* for differentiation from the new species (here named *A. eertmoedi* n.sp.), (4) to name and describe the new species, (5) to present comparative descriptions of eggs and nymphs of the two species, (6) to present data indicating that *eertmoedi* is an obligate parthenogen, and (7) to discuss the geographic distributions of the two species with speculation about their evolution.

MATERIALS AND METHODS

Comparative observations were based on 1033 adult specimens, 250 nymphs, and 20 clusters of eggs. Of these, 870 adults, 140 nymphs, and 12 egg clusters represent *eertmoedi*, while the remainder represent *maculosa*. The type of *maculosa* was examined.

Morphological observations of adults were made both on whole specimens under the dissecting microscope and on slide preparations in euparal and Hoyer's medium under a compound microscope. Morphological observations of nymphs and eggs were made on whole specimens with a dissecting microscope. Measurements were made with a filar micrometer. The micrometer unit for adult structures was 0.987 μ , that for eggs was 1.890 μ .

Abbreviations used in the measurements (Table 1) are: FW = forewing; HW = hindwing; F = hind femur; T = hind tibia; t_1 , t_2 , t_3 = first, second, and third hind tarsomere; cten = ctenidia (comb-based setae) on first hind tarsomere; f_1 , f_2 , f_3 = first, second, and third flagellomeres; IO/D = least distance between compound eyes divided by greatest antero-posterior eye diameter in dorsal view; PO = transverse diameter of eye divided by greatest antero-posterior diameter of eye in dorsal view.

Short-term laboratory rearing of *eertmoedi* was carried out to ascertain the type of reproduction. Specimens were kept on bark from the trees on which they had been collected, in shell vials over saturated KCl solution in a closed dessicator at 23.3°C daytime, 18.0°C night-time temperature and 15 hours light phase.

¹Department of Biological Sciences, Illinois State University, Normal, IL 61761.

Table 1. Greatest lengths in μ , head ratios, and ctenidial counts for females of *Aaroniella maculosa* (Aaron) and *A. eertmoedi* n.sp. Figures in parentheses are condyle to condyle lengths.

FW	HW	F	T	t ₁	t ₂	t ₃	cten	f ₁	f ₂	f ₃	IO/D	PO
<i>Aaroniella maculosa</i> (Rocky Fork State Park, Highland Co., Ohio), 2 females												
2716	2126	649	1130	362(323)	92(74)	88	13	374	214	197	2.55	0.78
2606	2051	570	1030	308(281)	73(58)	82	13	335	197	188	2.31	0.68
<i>Aaroniella eertmoedi</i> (Bell Smith Springs, Pope Co., Illinois), 2 females												
2479	1898	532	959	311(280)	82(69)	84	15	289	178	156	2.19	0.69
2438	—	543	1015	327(296)	77(59)	89	14	296	174	162	2.08	0.70

SPECIFIC STATUS OF THE TWO FORMS

In 1971 I observed that adults (121 specimens) of supposed *maculosa* from southern Illinois were all females, while both sexes were present in material then on hand from Winona Lake, Indiana, and Santeetla Dam, North Carolina. After comparing females from populations having males with females from populations where no males were collected, I found several morphological characters that differed between the two sets and remained constant within each set of specimens examined (see diagnoses, below). Thus, two forms were distinguishable by female morphology as well as by presence or absence of the male. The possibility remained that clines existed between the character states of the two forms. From 1972 to 1978 I made extensive collections of these insects, concentrating on the areas where the two forms were likely to be parapatric or sympatric. I found three localities of sympatry (McCormick's Creek State Park, Indiana; Indianapolis, Indiana; Rocky Fork Lake, Ohio) and a region of parapatry (separation by about 6 miles in Coles and Cumberland counties, Illinois). At all of these localities, as well as all other localities, each of the observed character differences held true. These observations, plus the ascertainment of parthenogenesis, apparently obligate, in *eertmoedi*, confirm that the two forms are species. *A. eertmoedi* is an agamospecies.

APPLICATION OF THE NAME AARONIELLA MACULOSA

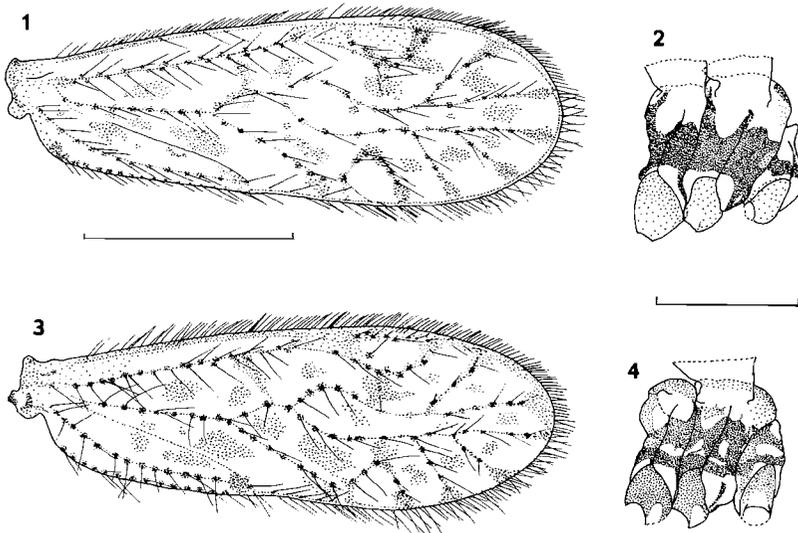
I have examined the type of *maculosa* (No. 108, Academy of Natural Sciences of Philadelphia; specimen mounted on a point) and, without dissecting it, find the following characters which show clearly that it is a male of the species which I described under that name (Mockford, 1951): (1) thoracic pleura uniformly dark brown (variegated in *eertmoedi*); (2) Rs-M fusion in forewing elongate, longer than first segment of Rs (equal to or shorter than first segment of Rs in female; shorter still, or Rs and M joined at a point or by a crossvein in *eertmoedi*); (3) areola postica longer at base than high (higher than basal length in females of both species); (4) minute spur vein from pterostigma present (usually absent in females of both species); (5) epiproct emarginate distally (rounded distally in females of both species); (6) paraproctal sense cushion large and rounded, in diameter nearly half basal width of epiproct (decidedly smaller and somewhat elongate in females of both species). The distal margin of the hypandrium, with numerous setae in place, is also discernible. This structure, even on a dried specimen, cannot be mistaken for the subgenital plate and flanking gonapophyses of the female of either species.

Aaroniella maculosa (Aaron)*Elipsocus maculosus* Aaron (1883:40)*Philotarsus maculosus* (Aaron) Chapman and Nadler (1928:62).*Aaroniella maculosa* (Aaron) Mockford (1951:103).

DIAGNOSIS. With radial pattern of spots distally in forewing; no setae on distal lobe of subgenital plate; transverse region of forewing from Rs origin to nodus marked only with spot bordering and including veins Rs and M and a spot in cell Cu_1b ; forewing 2.8-3.3 mm in length; pterostigma only lightly pigmented basally. Differing from *eertmoedi* n.sp. as follows: (1) in general, somewhat larger (Table 1); (2) lacking a spot in distal end of cell R of forewing; (3) with spot absent or very poorly developed in base of cell M_3 of forewing; (4) thoracic pleura uniformly dark brown except immediately below wing bases (Fig. 2); (5) subgenital plate deeper, the flattened plate about 1.9X as broad as long (vs. about 2.3X in *eertmoedi*); (6) spermapore sclerite more extensively pigmented (Fig. 9 vs. Fig. 11); (7) second valvula bluntly rounded at tip (vs. acuminate in *eertmoedi*, Fig. 5 vs. Fig. 6).

This species was adequately described by Mockford (1951). I am adding some measurements (Table 1), and, for convenient comparison, figures of female forewing and genital parts (Figs. 1, 5, 7, 9).

MATERIAL EXAMINED (collected by the author unless otherwise stated). ILLINOIS: Coles Co.: Fox Ridge State Park, 9 September, 1973, on tree trunk, 1 female; 1 and 15 September, 1974, on tree trunks, 7 males, 16 females, E. L. Mockford and D. Brooks; Lake Charleston, 1 September, 1974, on tree trunks, 2 females; 12 August, 1976, on trunk of silver maple, 3 females; Dewitt Co.: Weldon Springs State Park, 8 August, 1976, on trunk of silver maple, 5 males, 24 nymphs, E. L. Mockford and H. A. V. Evans; McLean Co.: Funks Grove, 4 September, 1974, on tree trunk, 1 female; Parklands South, 5 miles west of Lexington on Mackinaw River, 10 August, 1975, on trunks of large trees, river bottomland forest, 2 males, 2 females, 3 nymphs. INDIANA: Huntington Co.: eastern end of Huntington Reservoir, 31 July, 1977, tree trunks in grove, 15 nymphs; Kosciusko Co.: Winona Lake, 5 August, 1948, on elm trunk, 6 males, 5 females, 2 nymphs; 26 July, 1949, on trunks of sycamore and cottonwood, 1 male, 1 female, 4 nymphs; 20 July, 1950, on tree stump, 3 males, 2 females, 4 nymphs; Madison Co.: Mounds State Park, 31 July, 1977, on tree trunks along White River, 21 nymphs; Marion



Figs. 1-4. Forewings and thoracic pleura. 1, *Aaroniella maculosa* female, forewing. 2, *A. maculosa* female, thoracic pleura, anterior end on right. 3, *A. eertmoedi* female, forewing. 4, *A. eertmoedi* female, thoracic pleura. Scales = 1 mm.

Co.: Buck Creek at south county line, 11 August, 1974, 2 nymphs; Eagle Crest Forest Preserve north of Indianapolis, 31 August, 1952, trunks of oak and elm, 1 male, 16 females; Parke Co.: Turkey Run State Park, 10 September, 1967, on stones along Sugar Creek, 4 males, 1 female; U.S. Highway 31 and Sugar Creek 4 September, 1976, trunks of hackberry, 7 males, 6 females, 2 nymphs; U.S. Highway 41, 4 miles south of State Highway 234, trunk of musclewood (*Carpinus caroliniana* Walter), 4 males, 7 females, 2 nymphs; Spencer Co.: McCormick's Creek State Park, 9 September, 1973, on tree trunks, 1 male, 1 female; Warren Co.: County road, 2.2 miles east of Independence, 9 September, 1978, trunks of silver maple, 1 male, 4 females, B. W. Betz; Old State Highway 63, 7.3 miles south of New Palatine, 9 September, 1978, trunks of cottonwood, 4 egg batches. NORTH CAROLINA: Graham Co.: Santeetla Dam, 2 September, 1951, on oak trunks, 2 males, 1 female. OHIO: Ashland Co.: Vermilion River at Highway 224 and 250, 11 August, 1977, on sycamore trunk, 1 male, 1 nymph; Crawford Co.: Sandusky River at U.S. Highway 30, 11 August, 1977, on tree trunks, 2 males, 1 nymph; Highland Co.: Rocky Fork State Park, 11-12 September, 1973, on tree trunks, 2 males, 22 females; Licking Co.: Gratiot, 8 August, 1978, on honey locust trunks along creek, 1 male, 5 females, 8 nymphs; Logan Co.: Indian Lake, 11 August, 1977, on tree trunks, 2 males, 7 females, 3 nymphs; Mercer Co.: Grand Lake St. Mary, Sportsman's Association Park, 11 August, 1977, on tree trunks, 3 females, 2 nymphs. Washington Co.: Little Muskingum River, 1.5 miles north of Wingett Run, 5 August, 1978, on tree trunks, 3 males, 26 nymphs. PENNSYLVANIA: Philadelphia region, 1 male (holotype), S. F. Aaron. TENNESSEE: Unicoi Co.: Limestone Cove Recreation area, 16 September, 1973, beating hemlocks (*Tsuga canadensis* Carriere), 2 females.

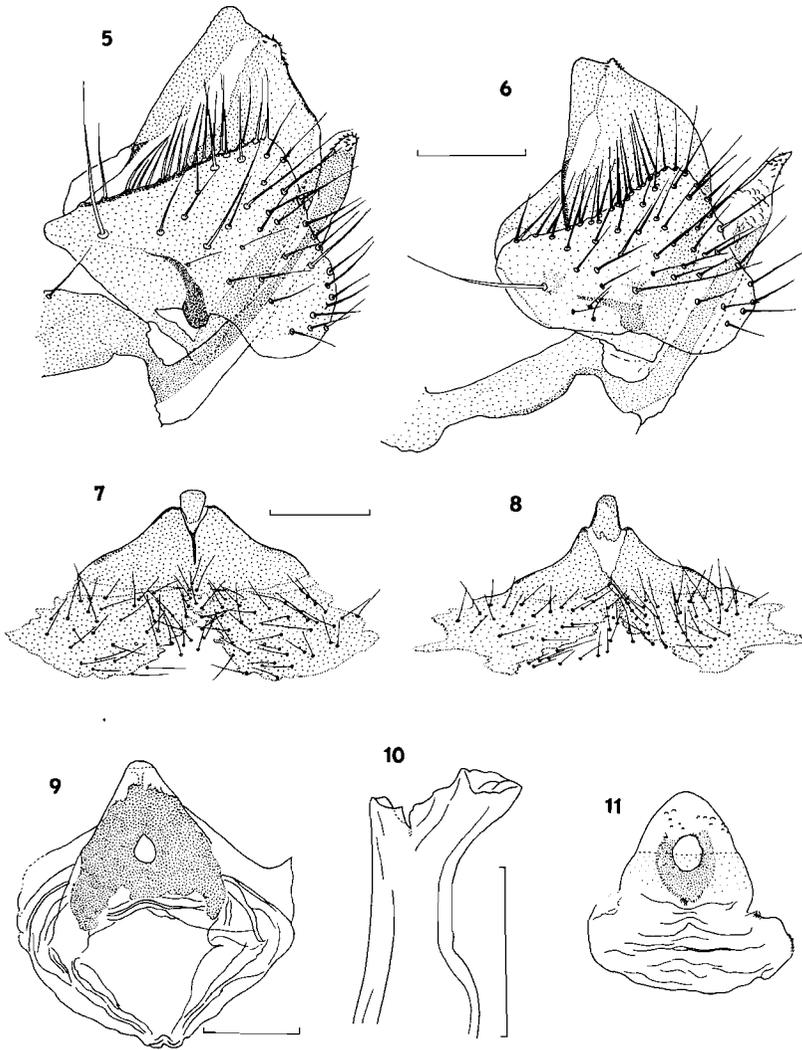
Aroniella eertmoedi new species

DIAGNOSIS. With radial pattern of spots distally in forewing; no setae on distal lobe of subgenital plate; transverse region of forewing from Rs origin to nodus marked with spot bordering and including vein Rs before its junction with M, spot near distal end of cell R, spot near basal end of cell M₃, and spot in cell Cu_{1b}; pterostigma relatively well pigmented basally (Fig. 3). Differing from *maculosa* in latter two characters and in following: (1) in general somewhat smaller (Table 1); (2) thoracic pleura (Fig. 4) marked by two parallel longitudinal dark brown bands separated by white; ventral band narrow, straight, above leg bases; dorsal band broader, less regular, below wing bases and along upper edge of propleuron; the two bands joined by dark brown band along mesopleural suture; (3) other characters differing as noted in diagnosis of *maculosa*.

FEMALE. Measurements (Table 1).

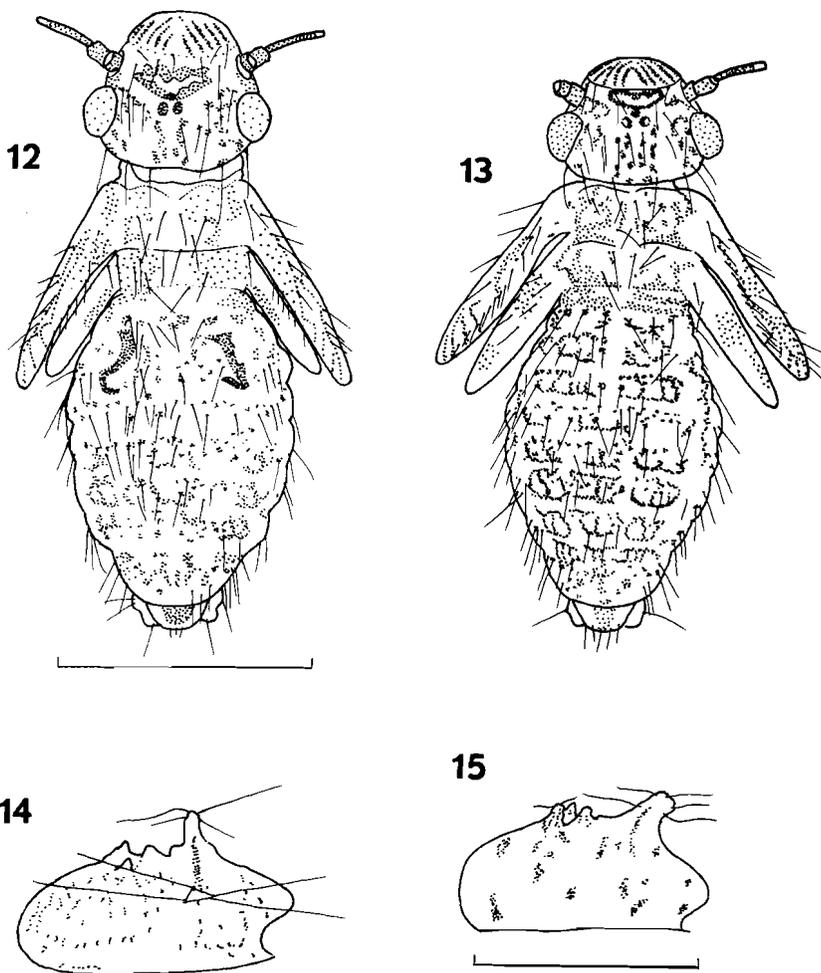
MORPHOLOGY. Epicranial eclydysal line distinct to ocellar interval; frontal eclydysal lines present but vague. Vertex and postclypeus with moderately dense, mostly backward-directed setae of varying lengths, the longest ones located anteriorly on postclypeus (two laterals directed forward, others directed downward) and posteriorly on vertex; setal length about a third the width of vertex between eyes. Terminal segment of maxillary palpus with three thin-walled setae before apex. Terminal seta of distal flagellomere slightly longer than flagellomere. Lacinial tip (Fig. 10) with median cusp small, bearing rounded denticles; lateral cusp large, bearing a few low, rounded denticles. A trace of pterostigmal spur vein present. In hindwing: vein R₁ setose except in basal fourth, vein M setose in distal 3/5, radial fork stem setose only in distal third. Subgenital plate (Fig. 8) with two laterally directed pigmented arms narrowly separated in middle by unpigmented area; the plate setose in basal half; distal piece somewhat tapering toward its free end, the latter end beset with microtriches. Ovipositor valvulae (Fig. 6) with first valvula acuminate-tipped, the tip bearing minute, backward-directed spines; second valvula with two-lobed apex, the median lobe bearing backward-directed spines; third valvula triangular. Epiproct broad, semicircular, bearing numerous setae in distal half. Paraprocts rounded distally, sense cushion broad-elliptical, bearing 16-18 trichobothria.

COLOR (in alcohol). Compound eyes black (in life pale green, dark brown along ventral margin). Ground color creamy white becoming yellow on sides of abdomen. Vertex of head marked with band of medium brown spots along median eclydysal line and



Figs. 5-11. Genital and mouthpart structures. 5, *Aaroniella maculosa* female, left ovipositor valvulae. 6, *A. eertmoedi* female, left ovipositor valvulae. 7, *A. maculosa* female, subgenital plate. 8, *A. eertmoedi* female, subgenital plate. 9, *A. maculosa* female, spermapore sclerite. 10, *A. eertmoedi* female, lacinial tip. 11, *A. eertmoedi* female, spermapore sclerite. Scales of gonapophyses and spermapore sclerites = 0.1 mm; scale of subgenital plates = 0.2 mm; scale of lacinial tip = 0.05 mm.

double row of such spots bordering each compound eye; a narrow dark brown band from compound eye to dorso-lateral margin of postclypeus touching dorsal edge of antennal base. Chevrons of postclypeus dark brown. Labrum dark brown except for two spots of ground color, one on each side of midline at its base. Maxillary palpus pale brown basally



Figs. 12-15. Nymphs (dorsal view not showing legs or antennae except bases) and eggs (lateral view). 12, *Aaroniella maculosa*, nymph. 13, *A. eertmoedi*, nymph. 14, *A. maculosa*, egg. 15, *A. eertmoedi* egg. Nymph scale = 1 mm; egg scale = 0.5 mm.

becoming darker distally. Antenna with scape and pedicel medium brown, first and most of second flagellomere pale brown, the second becoming darker distally; other flagellomeres dark brown except region bordering distal end of each white. Thorax variegated dark brown and white; notal lobes dark brown, mostly bordered in white; pleura (Fig. 4) as described in diagnosis. Coxae dark brown basally, dull white distally; femora dull white, each with a diffuse brown ring around distal end; fore tibiae medium brown, paler in middle; middle and hind tibiae dull white, with conspicuous dark brown spots at hair bases and at base and near distal end; tarsi dark brown. Forewings marked as in Figure 3. Hindwings unmarked. Abdomen marked dorsally with diffuse medium brown reticulate

pattern (as in nymph, Fig. 13); laterally an elongate dark brown spot enclosing each spiracle, each of these spots continuing ventrally as a transverse band usually interrupted medially but sometimes complete on sternum 7. Pigmented area of subgenital plate dark brown. Other terminal abdominal structures variegated dark brown and white.

HOLOTYPE. Female, Illinois: Pope Co.: Bell Smith Springs Recreation Area, 19 September, 1959, on rocks, E. L. Mockford and J. Mathieu. **PARATYPES:** 31 females, same data as for holotype. The types are in my collection.

OTHER MATERIAL EXAMINED. The data are too extensive to be published in full. I will provide these to any interested reader. They are summarized in the following three paragraphs.

GEOGRAPHIC DISTRIBUTION (Fig. 16). The species is known from the states of Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Mississippi, Missouri, New Hampshire, New Jersey, North Carolina, Ohio, South Carolina, Tennessee, Texas, Virginia, and West Virginia. Its known northern limit of distribution is as follows (east to west): Scarborough, Maine; Penwell, New Jersey; Baltimore County, Maryland; Kent, Ohio; Englewood, Ohio; Richmond, Indiana; Indianapolis, Indiana; Hurricane Creek, Cumberland County, Illinois; Pere Marquette State Park, Illinois. Its known southern limit of distribution is as follows: Goldhead Branch State Park, Florida; Oleno State Park, Florida; several Gulf Coast localities in West Florida; 2.6 miles south of Tickfaw, Tangipahoa Parish, Louisiana; 4.5 miles north of Appleby, Nacogdoches County, Texas. The latter locality and other Texas localities in approximately a straight line north of it constitute the known western limit of its range.

SEASONAL OCCURRENCE. In Illinois, nymphs appear in early June and the first generation is complete by the end of July. In early August egg clusters produced by the first generation, a few persistent females, and a few second-generation nymphs are found. In late August, nymphs and adults of the second generation are present. Adults of this generation persist until mid-October. The number of generations per year at the southern end of the range is not known. Adults were collected at Blackwater River State Forest, Okaloosa County, Florida, on 28 October, 1973. Collecting at the known Texas localities was done on 28-29 November, 1975. Numerous egg clusters were found at all of these localities, and only one adult was taken. Two adults were taken at Seashore State Park, Virginia, in early December, 1956.

HABITAT DISTRIBUTION. These insects are most frequent in river bottomland woods, where they spin their dwelling webs on trunks and branches of various trees. They also occur in upland woods where the trees are relatively sparse. They also inhabit shaded rock outcrops and shaded stone bridges. The species has been taken on the following trees and shrubs: eastern red cedar (*Juniperus virginiana* Linnaeus), spruce (*Picea* sp.), loblolly pine (*Pinus taeda* Linnaeus), sand pine (*Pinus clausa* Sargent), short-leaf yellow pine (*Pinus echinata* Miller), slash pine (*Pinus caribaea* Morelet), Virginia pine (*Pinus virginiana* Miller), honey locust (*Gleditsia triacanthos* Linnaeus), water locust (*Gleditsia aquatica* Marshall), cottonwood (*Populus deltoides* Marshall), hazel alder [*Alnus rugosus* (Du Roi) Sprengel], black oak group (*Quercus* spp.), turkey oak (*Quercus laevis* Walter), live oak (*Quercus virginiana* Miller), hackberry (*Celtis occidentalis* Linnaeus), silver maple (*Acer saccharinum* Linnaeus), sugar maple (*Acer saccharum* Marshall), sweet-gum (*Liquidambar styraciflua* Linnaeus), rhododendron (*Rhododendron catawbiense* Michaux), mountain laurel (*Kalmia latifolia* Linnaeus).

This species is named for Dr. Gary Eertmoed of Chicago State University, who has published several important works on Psocoptera and who aided with the collecting of this species.

COMPARATIVE DESCRIPTIONS OF IMMATURE STAGES. Eggs of both species are laid on bark under the dwelling web in clusters of three to seven. Each egg is overplastered with a coating of gray to grayish-brown particulate material. The coating narrows to a vertical keel anteriorly and is broad and rounded posteriorly. Dorsally it bears four processes: a relatively long anterior median process above the keel and three shorter processes, all of about the same length, set in about the middle of the dorsal surface of the egg, one more forward on the midline, the other two side by side and

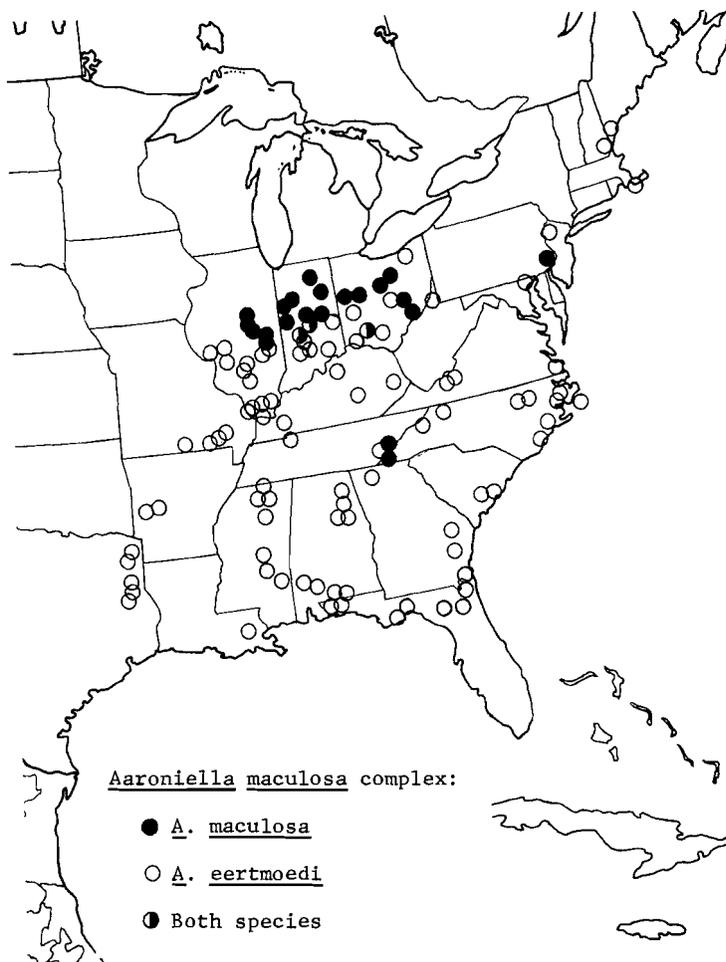


Fig. 16. Map of distribution of *Aaroniella maculosa* and *A. eertmoedi*.

slightly to the sides of the midline (Figs. 14, 15). The processes serve as props for strands of webbing spun over the egg cluster, but some strands may be attached to the body coating of the egg. The egg under the coating is drop-shaped with the narrow end lying in the keel of the coating. The surface of the egg proper appears to be smooth. Some eggs have a vertical slit in the keel, which is presumably where eclosion has occurred. The two species differ in two egg characters: (1) the amount of webbing spun over the egg cluster and (2) orientation of the long dorsal processes. *A. maculosa* spins only a few strands over the eggs, while *eertmoedi* spins a dense mat of webbing over each egg cluster. This mat appears as a small white spot to the unaided eye. Thus, eggs of this species may be collected readily in the field when other life history stages are absent. The long dorsal process of the egg in *maculosa* projects straight upward, while that of *eertmoedi* projects

antero-dorsally. Egg dimensions are as follows (each figure a mean of five measurements): *A. maculosa*, length = 566 μ , greatest width = 332 μ ; *A. eertmoedi*, length = 532 μ , greatest width = 296 μ .

Nymphs of both species are about 3 mm in length when mature, with the body relatively robust, slightly depressed, and the head semi-prognathous. Compound eyes are well developed with numerous facets. Antennae are about two-thirds the body length. Wing pads extend postero-laterally at an angle of about 20° from the body and reach not quite to half-way along the length of the abdomen. The body in general is beset with conspicuous setae as in Figures 12, 13. Nymphs of *maculosa* are creamy white with medium to dark brown marks as in Figure 12. Especially conspicuous is a pair of elongate brown marks dorso-laterally on the abdomen near its base. Nymphs of *eertmoedi* are pale greenish-white with medium to dark brown marks as in Figure 13. They have no marks on the abdomen near its base comparable to those of *maculosa*.

PARTHENOGENESIS IN *AARONIELLA EERTMOEDI*. Parthenogenesis is strongly suggested by the fact that of 870 adults observed to date, all are females. There remains, however, the possibility that males may exist in some part of the range not yet investigated. Geographic parthenogenesis is known for several species of North American psocids (Mockford, 1971). Parthenogenesis in this species was demonstrated by rearing. Two females were reared from an egg mass collected at Range Creek and State Highway 130, Cumberland County, Illinois, on 12 August, 1976. Both females oviposited on or about 30 October, 1976. Their eggs eclosed successfully beginning on or about 27 October, 1976. No attempt was made to rear the offspring to adulthood.

DISTRIBUTION PATTERNS AND SPECIATION. The known distribution of *maculosa* and *eertmoedi* are plotted in Figure 16. In general, except along the Atlantic coast, *maculosa* occurs immediately north of *eertmoedi*. There is a zone of overlap which appears to include most of Ohio (except its northwestern quarter) and a band through central Indiana. In Illinois no overlap has been found but the two species occur within about 6 miles of each other in Coles and Cumberland Counties. *A. maculosa* has a seemingly disjunct population in southeastern Tennessee and the adjacent part of North Carolina.

The most intensive collecting has been done with the view of establishing the zone of overlap and parapatry of the two species. The northern limit of distribution of *maculosa* east of Illinois and the western limit of distribution of *eertmoedi* have not yet been established. Their distribution in most of the Appalachians remains unknown. In Illinois, the limits of the two species taken together seem to follow approximately the 80% precipitation/evaporation line of Transeau (1905).

Aaroniella is a primarily tropical genus. It seems likely that the ancestor from which *maculosa* and *eertmoedi* were ultimately derived reached the eastern United States by the early Tertiary via Mexico along with several other largely tropical psocid genera. Several species of *Aaroniella* occur at present in Mexico (personal observation). In view of the morphological proximity of *maculosa* and *eertmoedi*, a single invading ancestral species is postulated, but they are probably too distinct morphologically to be thought of as the products of a single speciational event. *A. eertmoedi* was doubtless derived from a sexual ancestor. There may have been a speciational event, involving geographic isolation, which established that ancestor and *maculosa*. The present distributions of *maculosa* and *eertmoedi* may not reflect that event. More likely, they reflect differences in climatic tolerance and interspecific competition. The change to parthenogenesis, which subsequently established *eertmoedi*, may have involved slight additional morphological change.

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the loan of the type of *Aaroniella maculosa*. The manuscript was critically read by Mr. Bradford Betz and Dr. Boyce Drummond III of the Department of Biological Sciences, Illinois State University. To the above-mentioned individuals and institutions I express my sincere thanks.

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