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NEW AND REDEFINED SPECIES BELONGING TO THE *PARUROCTONUS BAERGI* GROUP (SCORPIONES, VAEJOVIDAE)

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ABSTRACT

The baergi group of the nominate subgenus *Paruroctonus* Werner, 1934, of North America, is differentiated by the combination of: basitarsus II without a mid-retrosuperior seta, pectinal teeth usually exceed 22 in males and 18 in females, pedipalp palm with well developed and granular carinae in both sexes, pedipalp primary denticles in rows 1-5 usually exceed 36 on movable finger and 28 on fixed finger. Four mutually allopatric, arenicolous species consitituting the baergi group are defined or redefined, and keyed: *P. baergi* (Williams and Hadley, 1967), southern Mojave Desert and lower Colorado River drainage region; *P. utahensis* (Williams, 1968), upper Colorado River and Rio Grande drainage regions; *P. arenicola*, n. sp., Amargosa Desert, Nevada; *P. arenicola nudipes*, n. ssp., eastern Mojave Desert; *P. marksi*, n. sp., central and western Mojave Desert.

INTRODUCTION

New diagnostic characters involving the macrosetae on the legs and pedipalps have permitted the delimitation of species groups and the redefinition of many species within the North American genus *Paruroctonus* Werner, 1934. The reliability of similar characters in other scorpion taxa also appears promising. Defined herein is a group of four mutually allopatric arenicolous species, belonging to the subgenus *Paruroctonus* (see Haradon, 1983). *Paruroctonus baergi* (Williams and Hadley 1967) and *Paruroctonus utahensis* (Williams, 1968) are redefined, and two new species and one new subspecies are described.

METHODS

The number of macrosetae on the superior surface of each basitarsus is reported either as two counts (distal row + proximal row), or as a single count when the setae are irregularly distributed or if they form an essentially single file. Metasomal seta counts are given for segments I-IV for the dorsals, dorsolaterals and ventrals, and for segments I-V for the laterals and ventrolaterals. Primary denticles on the pedipalp fingers are either counted for all six rows (distal to proximal), or reported as a sum of rows 1-5. Primary denticle counts and tarsal seta counts of holotypes and allotypes are given for each side (left-right), or as one number when both sides are the same.

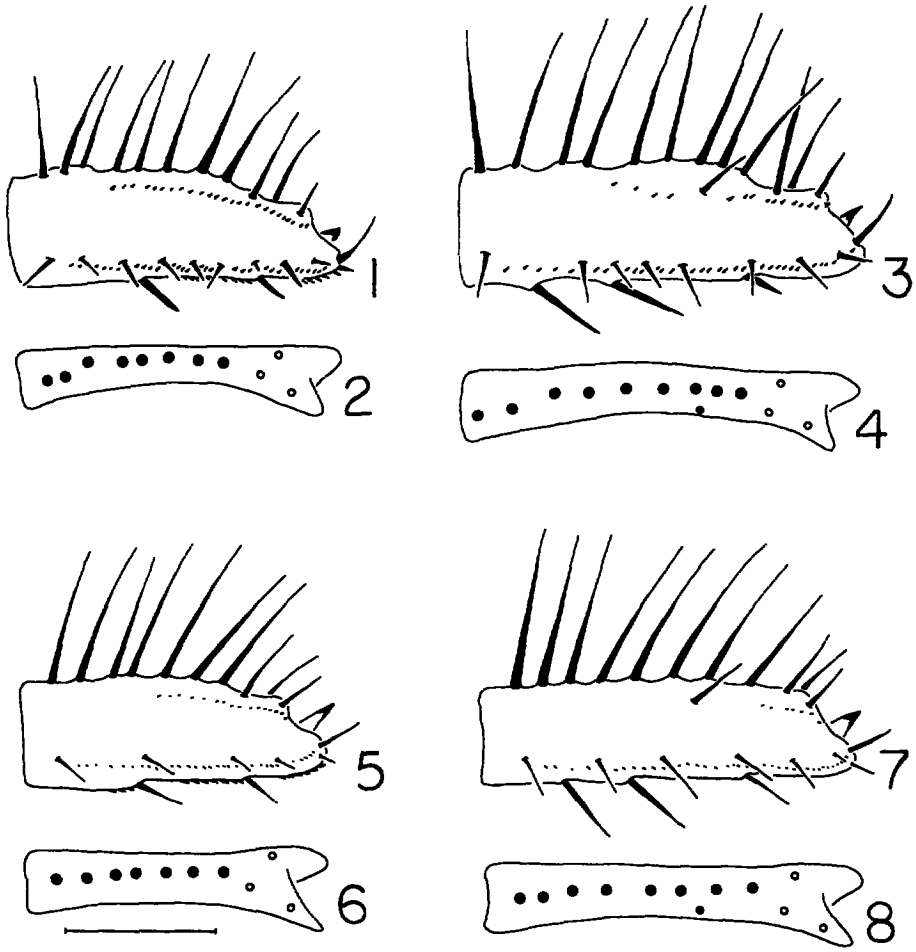
Definitions of most of the measurements used in this study are provided by Stahnke (1970). The cheliceral fixed digit length, used in a diagnostic ratio below, is the distance from the proximal base of the bicusp to the digit's tip. Additional cheliceral measurements have been defined by Francke (1975:109). Statistical data in the text include the observed range (sample mean ± one standard deviation, n = sample size).

Acronyms of specimen depositories are explained below in the acknowledgments.

DIAGNOSTIC CHARACTERS

Besides various conventional characters, the following new characters have been found useful for defining and diagnosing *Paruroctonus* species and subspecies.

Tarsal setae.—In this report, and in others in preparation, I have adopted the general tarsal terminology proposed by Couzijn (1976), except that instead of "anterior" and

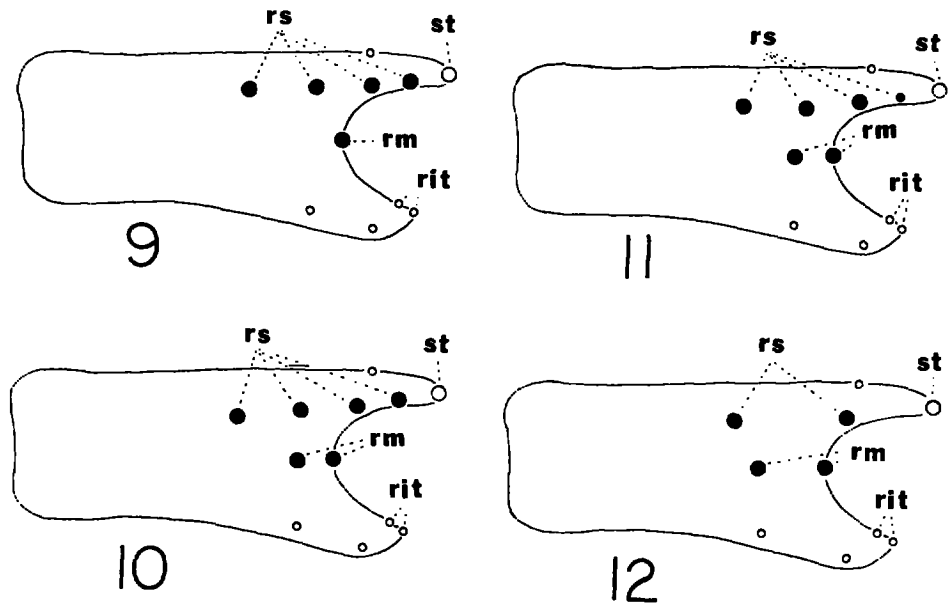


Figs. 1-8.—Right basitarsi II and III. 1-4, *P. baergi:* 1, II, retrolateral view; 2, II, superior view; 3, III, retrolateral view; 4, III, superior view. 5-8, *P. utahensis:* 5, II, retrolateral view; 6, II, superior view; 7, III, retrolateral view; 8, III, superior view. Key: large circles = diagnostic superior setae; small closed circle = mid-retrosuperior (mrs) seta; small open circles = prosuperior and retrosuperior landmark setae. Scale = 1.0 mm.

"posterior" I use the terms prolateral and retrolateral respectively. The superior surface of the basitarsus is indicated in *Paruroctonus* by the most prominent series of long setae; as a landmark, the distal condyle lies along the prosuperior margin. Because of torsion, the superior surface of the basitarsus in a live *Paruroctonus* scorpion is generally 45° to 90° retrolateral from the perpendicular axis. Thus, viewed from above, the long superior setae, particularly in arenicolous species having laterally compressed tarsi, appear (and have been described) as "retrolateral", "exterior" or "posterior" setae.

Telotarsus (Figs. 9-12): Two characters of diagnostic importance in the baergi group include the number and development of the setae in the (1) retrosuperior series, and (2) retromedial series. The normal telotarsal complement of setae is apparently present by at least the third instar. Exceptions to the normal numbers of setae on telotarsus III in either series are rare.

Basitarsus (Figs. 1-8, 25-34): Two characters are diagnostically important. (1) The number and distribution of the major superior setae: The normal basitarsal superior series appears to develop gradually. In some immatures the full complement was not present, or the series included some setae in the normal position but somewhat less developed than the others. Immatures generally lack extraneous setae. Extraneous setae in juveniles and adults are conspicuously shorter and finer than the setae constituting the diagnostic series. The superior setae are distributed irregularly, or in two unaligned rows (one distal, one proximal), or in an essentially single file. (2) Mid-retrosuperior (mrs) seta: In most arenicolous species there is no distinctly differentiated mrs seta on basitarsi I or II. In such species the mrs seta appears to have become incorporated into the superior series of basitarsi I and II, coincident with the lateral compression of the segment, and the "absence" of the mrs seta would only refer to its change in position. In one subspecies (see below) the absence of the mrs seta on basitarsus III appears to be an actual loss.



Figs. 9-12.–Right telotarsus III, retrolateral views: 9, *P. baergi;* 10, *P. utahensis;* 11, *P. arenicola;* 12, *P. marksi.* Key: closed circles = diagnostic setae; large open circle = large landmark seta; small open circles = small landmark setae; rit = retroinferior terminal; rm = retromedial; rs = retrosuperior; st = superoterminal.

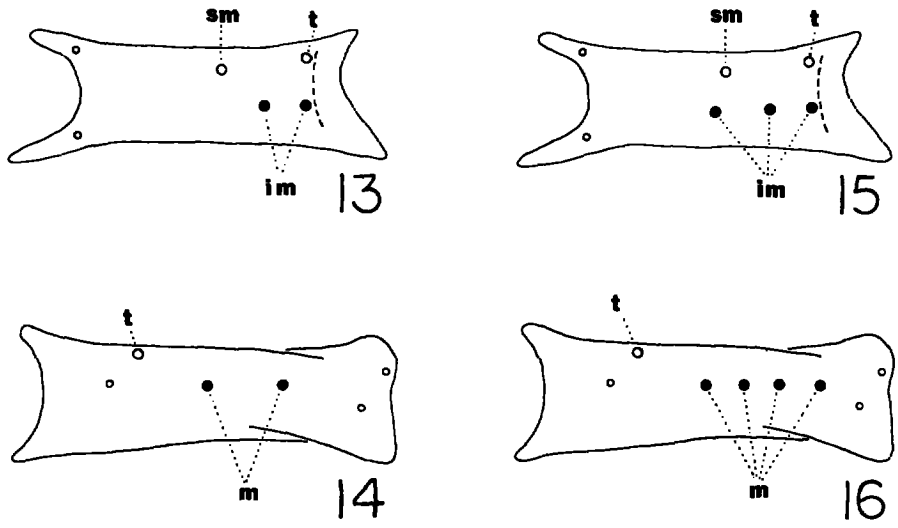
Pedipalpal macrosetae.—Among certain species, differences exist in the number and development of the macrosetae other than the trichobothria. Such setae are much stouter than the trichobothria, and typically originate at a distinct "granule", or small cuticular protuberance. Although numerous setae of many sizes are detectable, the macrosetae referred to herein as "diagnostic", whether very long or relatively short, are those that are dark reddish-brown and the only distinctly pigmented setae on a particular surface or surface region.

Humerus: In the baergi group the number of macrosetae in two setal groups are diagnostically important. (1) On the proximal 3/5 of the internal surface there are normally either two (Fig. 13) or three (Fig. 15) inframedial macrosetae. Occasionally the distal seta in the series of three is smaller than the other two. (2) On the distal 3/5 of the external surface there are normally either two (Fig. 14) or four (Fig. 16) medial macrosetae; species outside the baergi group may have three. An occasional exception to the two-setal pattern involves a much smaller seta between the normal two. In the normal four-setal pattern, typically the first (distal) and third setae are slightly smaller than the other two; exceptions to this pattern involve the absence of the first or third seta.

Chela: In the baergi group the macrosetae on the internal surface appear to be the most reliable diagnostically (Figs. 35-38). On the fixed finger there may be no, one, or two macrosetae. On the movable finger (excluding one or two setae along the ventrointernal margin) there may be one, two, or three macrosetae. And on the palm there may be two, three, or four (or more in other species) macrosetae. The diagnostic setae on the palm are positioned along the ventrointernal and internal carinae.

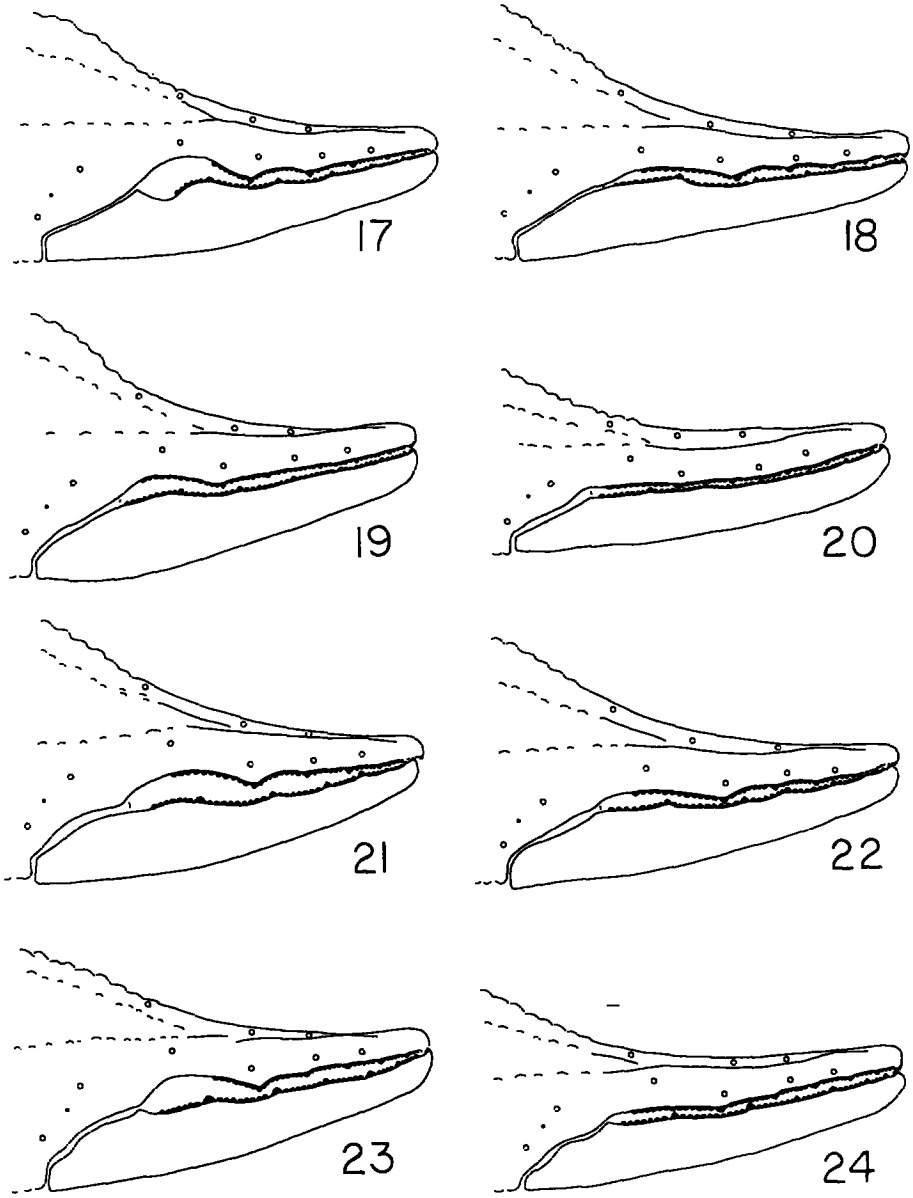
BAERGI GROUP

Diagnosis.—A species group of nominate subgenus *Paruroctonus* (subgenus diagnosed by absence of short intercarinal setae ventrally on metasomal segments I-IV) differenti-



Figs. 13-16.—Right humerus. 13-14, *P. baergi:* 13, internal view; 14, external view. 15-16, *P. arenicola:* 15, internal view; 16, external view. Key: large closed circles = diagnostic macrosetae; open circles = landmark setae and trichobothrium; im = inframedial; m = medial; sm = supramedial; t = trichobothrium.

ated by the combination of: carapace length/cheliceral fixed digit length ratio greater than 7.0; basitarsus II without mrs seta (Figs. 1, 5, 25, 31); pedipalpal primary denticles on fixed and movable fingers in six rows, denticles in rows 1-5 total 25-44 on fixed finger, 35-57 on movable finger; pectinal teeth in males 23-29 (except one population of *P. baergi* with low of 20), females 17-22 (except several populations of *P. baergi* with lows of 13-15); pedipalp palm carinae well developed and granular in both sexes, most intercarinal surfaces conspicuously concave (similar to *Paruroctonus mesaensis* Stahnke, shown in Soleglad 1973:fig. 7); pedipalp movable finger length/palm length ratio between 1.0 and 1.3 in both sexes.



Figs. 17-24.–Right pedipalp fingers, adult state, external views. 17-18, *P. baergi:* 17, male; 18, female. 19-20, *P. utahensis:* 19, male; 20, female. 21-22, *P. arenicola:* 21, male; 22, female. 23-24, *P. marksi:* 23, male; 24, female.

Comparisons: Species belonging to the partly sympatric (Mojave and Colorado Deserts) species group surrounding *Paruroctonus borregoensis* Williams, 1972, have the pedipalpal primary denticles in rows 1-5 totalling 28 or fewer (rarely more) on fixed finger, 36 or fewer on movable finger; pectinal teeth in males 22 or fewer (except in two undescribed species), in females 16 or fewer (except in one undescribed species); pedipalp palm in adult females with weakly developed and essentially smooth carinae, intercarinal surfaces in both sexes flat or weakly concave to convex (similar to that shown for *Paruroctonus luteolus* (Gertsch and Soleglad, 1966) in Soleglad 1973:fig. 8); pedipalp movable finger length/palm length ratio in adult males less than 1.0 (except in about 15 per cent of *P. luteolus*).

Paruroctonus xanthus (Gertsch and Soleglad, 1966), which occurs within the southern range of *P. baergi,* has seven rows of pedipalpal primary denticles on the movable finger, denticles in rows 1-5 totalling on fixed finger more than 80, in rows 1-6 on movable finger more than 90; pedipalp movable finger length/palm length ratio greater than 1.3 in both sexes; pedipalp fingers multiscalloped in both sexes (see Gertsch and Soleglad 1966:fig. 32); six to seven retrosuperior setae on telotarsus III.

All other species in the subgenus *Paruroctonus* have a distinctly differentiated mrs seta on basitarsus II.

Group description.—Total adult length 35-50 mm; adult carapace length 4.0-6.3 mm in males, 5.0-6.5 mm in females; uniformly pale yellow, fuscous markings absent except very rarely in immatures; anterior margin of carapace straight to convex; pedipalpal macrosetae include four on dorsal surface of humerus, four on internal surface of brachium; trichobothria typical of genus in number, general distribution as in *P. utahensis* (see Sissom and Francke 1981:figs. 1-6); mrs seta present on basitarsi III-IV (except absent on III in one subspecies), absent on I-II; telotarsus III with two to four retrosuperior setae; telotarsi I-IV with 1,1,2-3,2-4 retroinferior setae, and 2,2,2,2 retroinferior terminal setae.

Subordinate taxa.—*Paruroctonus baergi* (Williams and Hadley, 1967); *Paruroctonus utahensis* (Williams, 1968); *Paruroctonus arenicola,* new species; *Paruroctonus arenicola nudipes,* new subspecies; *Paruroctonus marksi,* new species.

Distribution.—Amargosa Desert of Nevada and Mojave Desert of California, southward along the Colorado River drainage in California and Arizona, into northwestern Sonora; upper Colorado River drainage in Utah and Arizona; upper Rio Grande drainage in New Mexico, western Texas and northern Chihuahua.

Paruroctonus baergi (Williams and Hadley)
Figs. 1-4, 9, 13-14, 17-18, 35, 39

Vejovis (Paruroctonus) baergi Williams and Hadley 1967:104, 106, 108-112, 114, figs. 2-4, tbl. 1; Hadley and Williams 1968:727.
Paruroctonus baergi: Williams 1972:3, 1976:2; Soleglad 1972:74, 1973:355, tbl. 2.
Vaejovis baergi: Diaz-Nájera 1975:6, 31.

Type.—*Vejovis baergi:* Holotype male (adult) from Mexico, Sonora, Cholla Bay, near Puerto Peñasco, 15 October 1966 (S. C. Williams). Depository: CAS, Type No. 9479.

Diagnosis.—A species in the baergi group of nominate subgenus *Paruroctonus* differentiated by: telotarsus III with four long retrosuperior setae, and one retromedial seta (subdistal seta, if present, inconspicuous) (Fig. 9); basitarsus III with eight to 11 (usually nine or 10) superior setae in essentially single file, mrs seta fine and less than 1/2 as long

as superior setae (Figs. 5-6); humeral macrosetae include two inframedials on proximal 3/5 of internal surface (Fig. 13), and two medials on distal 3/5 of external surface (Fig. 14); pedipalpal internal macrosetae include two (rarely three) on palm, one on movable finger, and none on fixed finger (Fig. 35).

Intragroup comparisons are presented in Table 4.

Distribution.–Fig. 39. Extreme southern Mojave Desert, southward along the Colorado River and Gila River drainages to Cholla Bay, Sonora, Mexico.

Remarks.–The pectinal tooth count range, which is relatively narrow among most other congeneric species, exhibits in *P. baergi* a striking clinal increase from the type locality in northwestern Sonora northward to near Cadiz Dry Lake (San Bernardino County) in California. The original concept of this species, therefore, is enlarged to include pectinal tooth counts up to 22 (not just 13-16) in females, and up to 29 (not just 20-24) in males. The above diagnosis is based upon a paratopotypic sample (CAS), as well as specimens from the localities listed below.

New records.–U.S.A.: CALIFORNIA; *San Bernardino County,* Twentynine Palms, 3 September 1972 (R. M. Haradon, J. L. Marks), 13 males, 1 female (CAS), 20 mi. E Twentynine Palms, 6 May 1972 (R. M. Haradon, J. L. Marks), 1 female (CAS), 25 mi. E Twentynine Palms, 6 May 1972 (R. M. Haradon, J. L. Marks), 1 male, 1 female (CAS), 27 mi. E Twentynine Palms, 2 September 1972 (R. M. Haradon, J. L. Marks), 2 males, 4 females (CAS); *Riverside County,* 26 mi. N Desert Center, 6 May 1972 (R. M. Haradon, J. L. Marks), 5 males, 3 females (CAS), 25 mi. N Desert Center, April 1973 (R. M. Haradon, J. L. Marks), 11 males, 8 females (CAS), 8.2 mi. N. Desert Center, 19 May 1973 (R. M. Haradon, J. L. Marks), 5 males, 1 female (CAS); *Imperial County,* Paloverde, 16 March 1976 (M. A. Cazier, O. F. Francke), 2 females (OFF), 1 mi. W Paloverde, 28 October 1967 (M. A. Cazier et al.), 8 males, 4 females (CAS): ARIZONA; *Yuma County,* 6 mi. E Parker, 5 April 1969 (M. A. Cazier), 10 males, 20 females (OFF), 6 mi. E Parker, 14 March 1976 (M. A. Cazier, O. F. Francke), 11 males, 29 females (OFF), 3 mi. N Dateland, 26 April 1968 (M. A. Cazier et al.), 2 males, 4 females (OFF), 6 mi. E Tacna, Mohawk Sand Dunes, 24 September 1970 (W. Fox, J. Bigelow), 30 males (OFF), 3 mi. W Wellton, 27 April 1968 (M. A. Cazier et al.), 1 male, 1 female (OFF).

Paruroctonus utahensis (Williams)
Figs. 5-8, 10, 19-20, 36

Vejovis boreus: Bugbee 1942:320 (see Sissom and Francke 1981:94).

Vejovis (Paruroctonus) aquilonalis: Gertsch and Allred 1965:9 (in part?); Gertsch and Soleglad 1966: 7, 42-44, 45, figs. 20, 23 (in part, see Sissom and Francke 1981:94).

Vejovis (Paruroctonus) utahensis Williams 1968: 313-315, figs. 1-2. tbl. 1.

Paruroctonus aquilonalis: Williams 1972:3 (in part?); Soleglad 1972:74 (in part?), 1973:355, tbl. 2 (in part?); Muma 1975:55; Rowland and Reddell 1976:1; Riddle et al. 1976:295; Riddle and Pugach 1976:248; Riddle 1978:243; Stahnke 1974:138 (in part?).

Paruroctonus utahensis: Williams 1972:3; Soleglad 1972:74, 1973:355, tbl. 2; Johnson and Allred 1972:157, 169-170, fig. 24, tbl. 9; Stahnke 1974:138; Allred and Gertsch 1976:95, 99, tbl. 7; Riddle 1979:125, 1981:233; Sissom and Francke 1981:94, 95, 107, figs. 1-6, 29, 30, 35; Francke and Soleglad 1981:251, figs. 50-52; Polis et al. 1981:11, 16.

Vaejovis aquilonalis: Diaz-Nájera 1975:6, 19.

Type.–*Vejovis utahensis:* Holotype male (adult) from U.S.A., Utah, San Juan County, 2 miles NE Bluff, 14 July 1967 (S. C. Williams, M. A. Cazier, J. Davidson). Depository: CAS, Type No. 10175.

Diagnosis.–A species in the baergi group of nominate subgenus *Paruroctonus* differentiated by: telotarsus III with four long retrosuperior setae, and two retromedial setae (subdistal seta may be smaller than distal) (Fig. 10); basitarsus III with seven to nine (usually eight) superior setae in essentially single file, mrs seta slightly finer than and

about 1/2 as long as superior setae (Figs. 7-8); humeral macrosetae include three inframedials on proximal 3/5 of internal surface (distal may be smaller than others) (similar to (Fig. 15), and two or three (usually two) medials on distal 3/5 of external surface (similar to Fig. 14); pedipalp internal macrosetae include four on palm, two on movable finger, none on fixed finger (Fig. 36); pedipalp fingers in adult male weakly scalloped, closed fingers form narrow proximal gap (Fig. 19); pectines in adult female barely extend to trochanter IV, carapace length/pectinal anterior margin length ratio greater than 1.5.

Intragroup comparisons are presented in Table 4.

Distribution.—Colorado River and Rio Grande drainages in southern Utah, northern Arizona, New Mexico, western Texas, and northern Chihuahua.

Remarks.—The above diagnosis is based upon specimens (CAS, AMNH) from Utah (paratopotypes), New Mexico, Texas and Chihuahua, representing previously reported localities.

Paruroctonus arenicola, new species
Figs. 11, 15-16, 21-22, 25-30, 37, 39

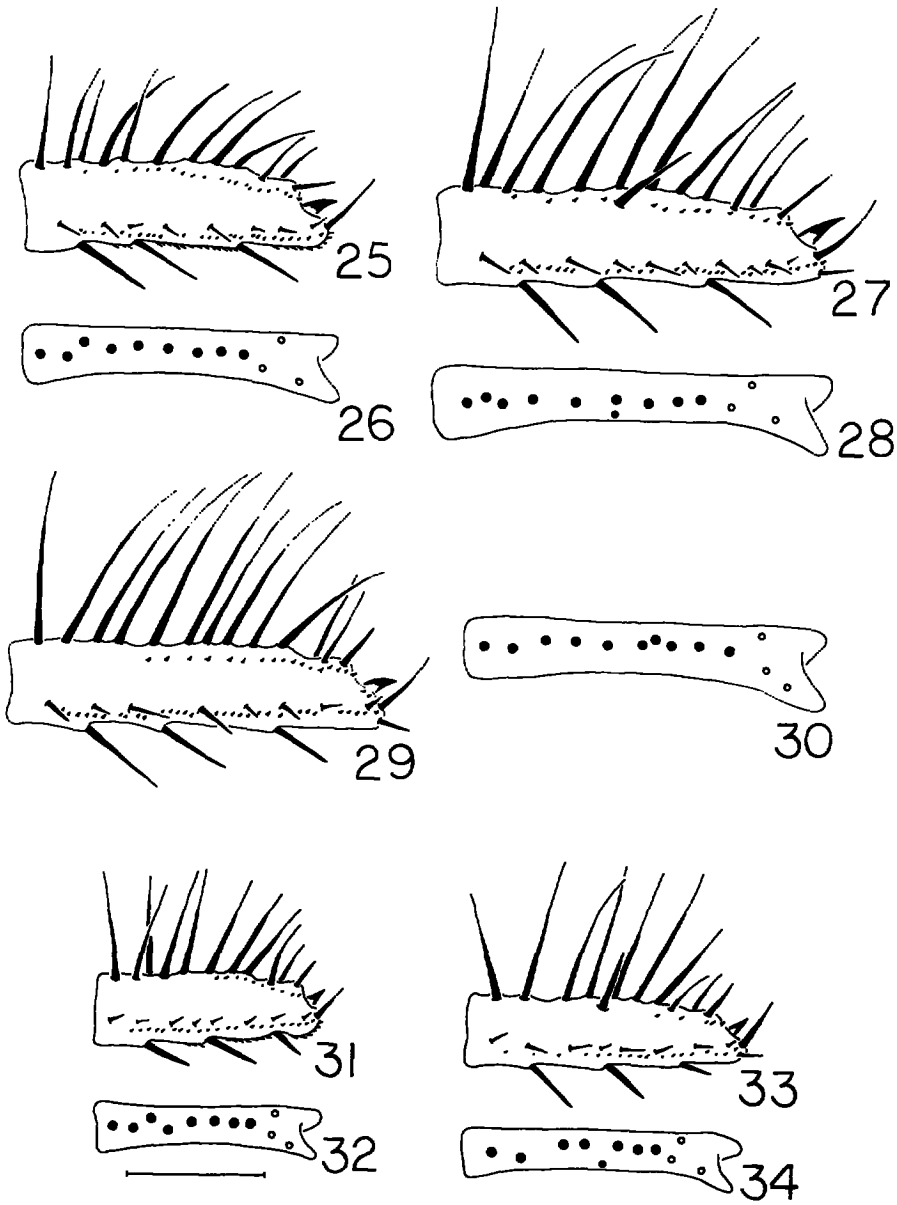
Type.—*Paruroctonus arenicola:* Holotype male (adult) from U.S.A., Nevada, Nye County, Amargosa Desert, 0.8 miles N California and Nevada border, along State Rt. 29, 12 August 1974 (R. M. Haradon, W. E. Savary). Depository: CAS, Type No. 15055.

Diagnosis.—A species in the baergi group of nominate subgenus *Paruroctonus* differentiated by: telotarsus III with three or four retrosuperior setae (if four, most distal one is shorter than others), and two long retromedial setae (Fig. 11); basitarsus III with eight to 11 (usually nine to 10) superior setae in essentially single file, mrs seta stout and about 2/3 as long as superior setae (Figs. 27-28) or may be absent (Figs. 29-30); humeral macrosetae include three inframedials on proximal 3/5 of internal surface (Fig. 15), four medials on distal 3/5 of external surface (Fig. 16); pedipalpal internal macrosetae include four on palm, three on movable finger, and two on fixed finger (Fig. 37).

Intragroup comparisons are presented in Table 4.

Description of male holotype (allotype).—Measurements: Table 3. Coloration: uniformly pale yellow, except pedipalp fingers pale orange. Carapace: anterior margin slightly convex; surface coarsely (moderately) granular. Tergites: granular, especially posteriorly (lightly granular, somewhat glossy); weak median carina on II-VI; five granular carinae on VII. Sternites: III-VI finely granular (essentially smooth); VII finely granular, with two weak carinae. Metasomal carinae: dorsals and dorsolaterals I-IV well developed, serrate, dorsolaterals V granular; ventrolaterals I-III smooth with one to three posterior crenulations, IV crenulate to weakly serrate posterior 1/3, V dentate; ventrals I-III weakly developed, smooth, IV crenulate posterior 1/3, V dentate. Metasomal setae: well developed, long; dorsals 1,3,3,3-4; dorsolaterals 0-1,2,3,3-4; laterals 1-2,0,0-1,0,3; ventrolaterals 2,3,3-4,5,10-11; ventrals 3,3-4,4,5. Telson: essentially smooth; 12 pairs of long setae on lateral and ventral surfaces. Pectines: extend to near distal margin of trochanter IV (to about 1/3 length of trochanter IV). Chelicerae: three to four weakly to moderately developed denticles, mainly unpigmented, on inferior border of fixed digit; four to five denticles or crenulations on inferior border of movable digit. Humerus: all carinae well developed, granular; intercarinal surfaces finely granular. Brachium: all carinae well developed, granular; intercarinal surfaces finely granular. Chela: eight major carinae moderately to coarsely (lightly to moderately) granular; intercarinal surfaces very finely granular; primary denticles on fixed fingers 3,4-5,5-4,7,8-9,16-14, movable fingers 4-3,6,

7,7-8,11,9-8; right movable finger anomalous with one primary denticle preceding first enlarged denticle. Basitarsi I-III: weakly (moderately) compressed laterally; superior setae 6,9-8,8, with one to three extraneous setae. Telotarsal setae I-IV: proinferiors 1,2,2,2; premedials 2,2,2,1; prosuperiors 2,3,2-3,3; retrosuperiors 3,4,4,3, with distal in series reduced on II-III; retromedials 2,2,2,2; retroinferiors 1,1-2,2,3; retroinferior terminals 2,2,2,2. Ungues I-IV: about 3/5 as long as telotarsus.



Figs. 25-34.–Right basitarsi II and III. 25-28, *P. arenicola arenicola:* 25, II, retrolateral view; 26, II, superior view; 27, III, retrolateral view; 28, III, superior view. 29-30, *P. arenicola nudipes:* 29, III, retrolateral view; 30, III, superior view. 31-34, *P. marksi:* 31, II, retrolateral view; 32, II, superior view; 33, III, retrolateral view; 34, III, superior view. Key: large circles = diagnostic superior setae; small closed circle = mid-retrosuperior (mrs) seta; small open circles = prosuperior and retrosuperior landmark setae. Scale = 1.0 mm.

Variation.—Light orange coloration in the pedipalp fingers was lacking in juveniles and immatures. Carapace anterior margin varied from essentially straight to moderately convex, but was usually slightly convex. Pectinal tooth counts are presented in Table 1. Metasomal seta counts for the ventrolaterals were usually 2,3,3,5,10-12, ventrals usually 3,4,4,5.

Two subspecies are distinguished by the presence or absence of the mrs seta on basitarsus III, and by differences in the numbers of dorsal metasomal setae.

Etymology.—The name "arenicola" refers to the sandy habitat in which this species lives.

Distribution.—Fig. 39. Sand dunes, Amargosa Desert in Nevada, and eastern Mojave Desert in California.

Specimens examined.—See material listed under subspecies.

Paruroctonus arenicola arenicola Haradon
Figs. 11, 15-16, 21-22, 25-28, 37, 39

Diagnosis.—A subspecies of *P. arenicola* differentiated by: basitarsus III with mrs seta present (Figs. 27-28); dorsal metasomal setae usually 1,2,2-3,3-4; pedipalp fingers in adult slightly darker than palm.

Comparison: *P. arenicola nudipes* differs in all three characters (see diagnosis below).

Variation.—Of 37 intact specimens, 35 (94.6%) had the diagnostic mrs seta present on both basitarsi III, and two (5.4%) had the mrs seta on one basitarsus only. Distribution of the dorsal metasomal seta counts is given in Table 2. Distribution of the pectinal tooth counts is given in Table 1. Pedipalpal primary denticles in rows 1-5 total on fixed finger 25-33 (30.00 ± 1.90, n = 30), movable finger 35-46 (39.87 ± 2.08, n = 31). Adult carapace lengths, male 4.8-6.1 mm, females 5.5-6.4 mm.

Distribution.—Fig. 39. Amargosa Desert in Nevada.

Specimens examined.—Paratypes. U.S.A.: NEVADA; *Nye County*, Amargosa Desert, 0.8 mi. N California-Nevada border, along State Rt. 29, 12 August 1974 (R. M. Haradon, W. E. Savary), 28 males, 10 females (includes allotype) (CAS).

Paruroctonus arenicola nudipes, new subspecies
Figs. 29-30, 39

Type.—*Paruroctonus arenicola nudipes:* Holotype male (adult) from U.S.A., California, San Bernardino County, 1.6 miles S Kelso, along Kelbaker Road, 27 May 1973 (R. M. Haradon, J. L. Marks). Depository: CAS, Type No. 15056.

Diagnosis.—A subspecies of *P. arenicola* differentiated by: basitarsus III without mrs seta (Figs. 29-30); dorsal metasomal setae usually 0,1,1,2; pedipalp fingers in adult pale yellow, similar to palm.

Comparison: *P. arenicola arenicola* differs in all three characters (see diagnosis above).

Description of male holotype (allotype).—Measurements: Table 3. Carapace anterior margin essentially straight. Metasomal setae: dorsals 0,1,1,2; dorsolaterals 1,3,3,4; laterals 2-3,0-1,0,0,3; ventrolaterals 2,3,4,5,11; ventrals 3,4,4-5,5-6. Pedipalpal primary denticles on fixed fingers 2-3,5,7-6,8-7,10,12-13, movable fingers 5-4, 7, 8, 11-10, 13-12, 7. Basitarsal setae I-III: superior setae 6,9,11. Telotarsal setae I-IV: proinferiors 1,2,2,2; promedials 3,3,2,1; prosuperiors 2,3,3,3; retrosuperiors 3,4,4,4, distal fourth in each series II-IV smaller than others; retromedials 2,2,2,2; retroinferiors 1,1-2,2-3,4; retroinferior terminals 2,2,2,2.

Variation.–Of 127 intact specimens, 116 (91.3%) lacked the mrs seta on both basitarsi III, seven (5.5%) lacked the seta on one leg only, and four (3.2%) had the seta on both legs. Distribution of the dorsal metasomal seta counts is given in Table 2. Distribution of the pectinal tooth counts is given in Table 1. Pedipalpal primary denticles in rows 1-5 total on fixed finger 29-39 (32.82 ± 1.79, n = 85), movable finger 38-48 (43.07 ± 2.53, n = 85). Adult carapace lengths, males 4.3-5.6 mm, females 4.9-6.2 mm.

Etymology.–The name "nudipes" refers to the absence of the mrs seta on basitarsus III, which is a unique condition within the genus *Paruroctonus*.

Specimens examined.–Paratypes. U.S.A.: CALIFORNIA; *San Bernardino County*, 1.6 mi. S Kelso, along Kelbaker Rd., 27 May 1973 (R. M. Haradon, J. L. Marks), 21 males, 30 females (includes allotype) (CAS), 1.6 mi. S Kelso, along Kelbaker Rd., 26 May 1973 (R. M. Haradon, J. L. Marks), 30 males, 35 females (CAS), Kelso Sand Dunes, 9 April 1977 (no other data), 3 males, 1 female (CAS), Kelso Dunes, 6mi. S Kelso on Cima Rd., 5 April 1977 (M. Swoveland, W. Savary), 1 male, 5 females (CAS).

Paruroctonus marksi, new species
Figs. 12, 23-24, 31-34, 38, 39

Vejovis (Paruroctonus) auratus Gertsch and Soleglad 1966:47 (in part, male from Pisgah Crater, San Bernardino Co., California).

Type.–*Paruroctonus marksi:* Holotype male (adult) from U.S.A., California, Los Angeles County, approximately 7 miles N Littlerock, 0.5 miles N jct. Avenue O, along 90th Street E, 1 September 1972 (R. M. Haradon, J. L. Marks). Depository: CAS, Type No. 15061.

Diagnosis.–A species in the baergi group of nominate subgenus *Paruroctonus* differentiated by: telotarsus III with two long retrosuperior setae, and two long retromedial setae (Fig. 12); basitarsus III with seven superior setae in two rows (five distal, two proximal), mrs seta stout and about 2/3 as long as and set relatively close to superior setae (Figs. 33-34); humeral macrosetae include three inframedials on proximal 3/5 of internal surface (similar to Fig. 15), and two medials on distal 3/5 of external surface (similar to Fig. 14); pedipalpal internal macrosetae include three on palm, two on movable finger, and one on fixed finger (Fig. 38); telson of adult male tubercular.

Intragroup comparisons are presented in Table 4.

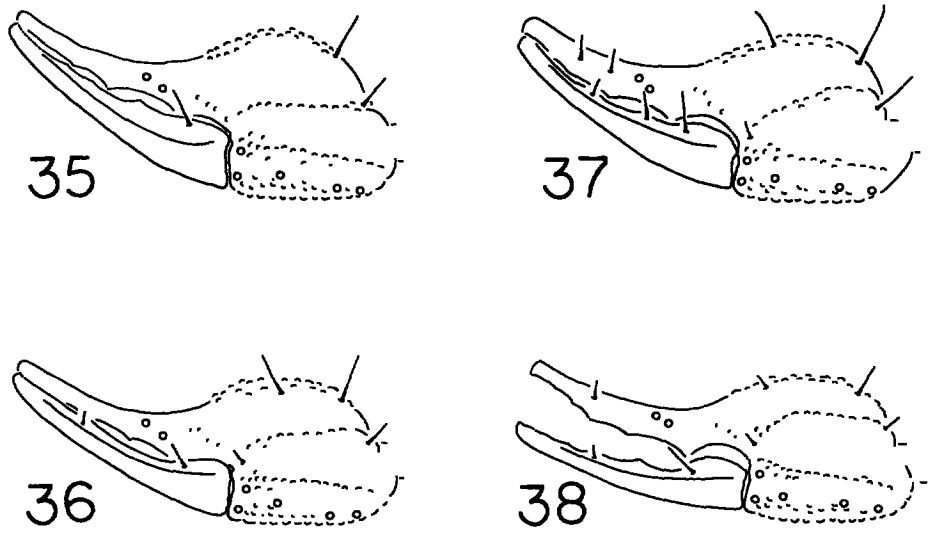
Table 1.–Frequencies of pectinal tooth counts in the subspecies of *P. arenicola*, and two populations of *P. marksi*.

	FEMALES						MALES						
	17	18	19	20	21	22	23	24	25	26	27	28	29
P. arenicola													
arenicola		10	9	3			7	13	14	9	4	1	
nudipes	4	27	49	33	15	2		10	23	36	17	11	1
P. marksi													
Mojave Desert													
I. Western	3	18	49	24	2		1	26	40	38	9	4	
II. Central	1	16	35	23	1		1	6	21	21	6	1	

Table 2.–Frequences of paired dorsal seta counts on metasomal segments I-IV in subspecies of *P. arenicola.*

	P. a. arenicola				*P. a. nudipes*			
	I	II	III	IV	I	II	III	IV
0/0	10				108			
0/1	3				11			
1/1	24	10	1		5	120	103	
1/2	1	5	5			2	17	
2/2		15	10	4		2	4	82
2/3		3	7	5				30
3/3		5	15	20				12
3/4				3				
4/4				6				

Description of male holotype (allotype).–Measurements: Table 3. Coloration: uniformly pale yellow. Carapace: anterior margin essentially straight; surface coarsely granular (lightly granular, somewhat glossy). Tergites: coarsely (lightly) granular posteriorly, essentially smooth (and somewhat glossy) anteriorly; weak medial carina on II-VI; five granular carinae on VII. Sternites: III-VII finely granular (glossy smooth), VII with pair of granular (weak) carinae. Metasomal carinae: dorsals and dorsolaterals I-IV well developed, serrate, dorsolaterals V granular; ventrolaterals I-III lightly to moderately granular (smooth with few posterior crenulations), IV crenulate to serrate (posteriorly serrate), V dentate; ventrals I-III weakly granular and mainly posteriorly (essentially smooth), IV granular (granular posterior 1/3), V dentate. Metasomal setae: long, well developed; dorsals 0,1,1,2; dorsolaterals 0,1,1,2; laterals 1,0,0,0,2; ventrolaterals 2,3,3,4-5,7-8; ventrals 3,4-5,4,4-5. Telson: lightly tubercular (smooth); eight pairs of long setae on lateral and ventral surfaces. Pectines: extend to femur IV (to 1/3-1/2 length of trochanter



Figs. 35-38.–Right pedipalp chela, adult male, internal views: 35, *P. baergi;* 36, *P. utahensis;* 37, *P. arenicola;* 38, *P. marksi.*

IV). Chelicerae: one pigmented denticle, and several smaller unpigmented denticles, on inferior border of fixed digit; four to five denticles or crenulations on inferior border of movable digit. Humerus: all carinae well developed, granular; intercarinal surfaces lightly granular. Brachium: all carinae well developed, granular; intercarinal surfaces finely granular. Chela: eight major carinae well developed, moderately (weakly to moderately) granular; intercarinal surfaces very finely granular; primary denticles on fixed fingers 3,5,6,6,9-10,10-8, movable fingers 5-4,6,8,9,13-14,8-9. Basitarsi I-III: not compressed (lightly compressed) laterally; mrs seta on III set relatively close to superior setae; superior setae 5,5+2,5+2, with one or two extraneous setae. Telotarsal setae I-IV: proinferiors 1,2,2,2; promedials 2,2,2,2; prosuperiors 2,2,2,2; retrosuperiors 2,2,2,2; retromedials 2,2,2,2; retroinferiors 1,1,2,2; retroinferior terminals 2,2,2,2. Ungues I-IV: about 3/5 as long as telotarsus.

Variation.–Two major populations of *P. marksi* have been identified as follows. Pectinal tooth counts for both populations are given in Table 1.

Population I. Distribution: Los Angeles County, west of the Shadow Mountains of extreme western San Bernardino County, in the Little Rock Wash and Big Rock Wash drainage region. Description: six to eight ventrolateral setae on metasomal segment V (mode 7/7, 80% with 7/7 or fewer); primary denticles in rows 1-5 total on pedipalp fixed finger 28-34 (30.48 ± 1.33, n = 67), movable finger 37-45 (40.61 ± 1.87, n = 66); adult carapace length in males 3.8-4.9 mm, females 4.3-5.0 mm.

Table 3.–Measurements (in millimeters) of the holotypes and allotypes of new species and subspecies of *Paruroctonus*. L = length, W = width, D = depth.

	P. arenicola		*P. a. nudipes*		*P. marksi*	
	Holotype Male	Allotype Female	Holotype Male	Allotype Female	Holotype Male	Allotype Female
Total L	47.6	48.0	46.1	49.3	40.7	35.4
Carapace L	5.8	6.2	5.0	6.1	4.5	4.4
Mid-length W	4.6	5.0	4.0	4.6	3.7	3.6
Posterior W	5.4	5.9	4.8	5.6	4.4	4.3
Median eyes W	1.1	1.2	1.0	1.2	1.0	1.0
Mesosoma L	10.1	11.9	12.0	14.8	11.0	10.6
Metasoma I L/W	3.4/2.9	3.1/3.0	3.0/2.4	3.0/3.0	2.7/2.5	2.0/2.1
II L/W	4.1/2.6	3.7/2.8	3.8/2.4	3.6/2.8	3.2/2.4	2.5/2.0
III L/W	4.3/2.6	4.0/2.6	4.0/2.2	3.7/2.6	3.4/2.2	2.7/1.8
IV L/W	5.4/2.4	4.9/2.4	5.0/2.1	4.7/2.4	4.2/2.1	3.2/1.7
V L/W	7.7/2.5	7.3/2.5	7.0/2.1	6.8/2.4	6.1/2.0	5.0/1.6
Telson L/W	6.8/2.4	6.9/2.5	6.2/2.3	6.6/2.4	5.5/2.0	5.0/1.7
Ampulla L/D	3.8/2.1	4.0/2.2	3.6/1.8	3.6/2.2	3.2/1.6	2.8/1.4
Chelicera palm L/W	1.8/1.2	1.8/1.4	1.5/1.2	1.9/1.4	1.3/1.0	1.4/1.0
Fixed digit L.	0.8	0.8	0.6	0.8	0.6	0.5
Movable digit L	1.4	1.6	1.1	1.5	1.0	1.1
Humerus L/W	5.0/1.6	4.4/1.6	4.5/1.4	4.6/1.6	3.8/1.2	3.4/1.1
Brachium L/W	5.0/2.0	5.2/2.2	4.6/1.8	5.0/2.0	4.0/1.7	3.7/1.5
Pedipalp palm L/W	5.3/4.3	5.1/3.8	4.7/3.8	4.3/3.5	4.4/3.4	3.4/2.2
Fixed finger L	4.2	4.2	4.0	3.8	3.2	3.0
Movable finger L	5.7	5.7	5.4	5.2	4.3	4.0
Pectine dentate L	5.4	3.0	5.8	3.6	4.8	2.8
Anterior L	6.1	4.2	6.2	4.8	5.0	3.4
Pectinal teeth	24/25	19/20	26/27	21/20	25/25	19/19

Table 4.—Diagnostic character states of the species in the *Paruroctonus baergi* group. Sexually dimorphic characters are indicated in the manner, male/female. Meristic data reported as a range of values may be followed by modal or bimodal counts in parentheses.

Characters		*baergi*	*utahensis*	*arenicola*	*marksi*
Chelicerae					
Fixed digit, inferior denticles: (A) inconspicuous or absent; (B) weak, unpigmented; (C) distinct, pigmented		B	A	B-C	C
Pedipalps					
Finger scalloping, adult male: (A) weak, form narrow proximal gap; (B) deep, form wide proximal gap		B	A	B	B
Humeral macrosetae: External medial, count		2	2-3(2)	4	2
Internal inframedial, count		2	3	3	3
Chelal macrosetae, internal: Palm, count		2	4	4	3
Fixed finger, count		0	0	2	1
Movable finger		1	2	3	2
Pectines					
Carapace length/pectine length, female: (A) less than 1.5; (B) greater than 1.5		A	B	A	A
Legs					
Telotarsal retrosuperior setae III: (A) distal shorter than others; (B) all long		B	B	A	B
Telotarsal retrosuperior setae III, count		4	4	3-4	2
Telotarsal retromedial setae II-III: (A) two long; (B) subdistal often shorter than distal; (C) one long distal only		C	B	A	A
Basitarsal superior setae I-III:(A)	I	B,C	B,C	B	B
in distal + proximal rows; (B)	II	C	C	C	A
irregularly set; (C) single file	III	C	C	C	A
Basitarsal superior setae I-III	I	5-6(5)	5	6-7(7)	5
count	II	6-8(7)	6-7(6)	8-9	4+3,5+2
	III	8-11(9-10)	7-9(8)	8-11(9-10)	5+2
Basitarsal mid-retrosuperior seta III: (A) stout, 2/3 length of superior setae; (B) intermediate to A and C; (C) fine, less than 1/2 length of superior setae		C	B	A	A
Metasoma					
Ventrolateral carinae I-IV: (A)	I	C	A	C	A/C
entirely granular; (B) granular	II	C	A	C	A/C
posterior 1/3 to 1/2; (C) smooth,	III	C	A	C	A/C
few posterior granules	IV	B	A	B	A/B-C
Ventrolateral setae IV, count		4	4	5	4-5
Ventrolateral setae V, count		8-12	9-12	10-12(9-12)	6-9(7-8)
Ventral carinae I-IV: (A) entirely	I	C	B-C	C	A-B/C
granular; (B) granular posterior	II	C	B-C	C	A-B/C
1/3 to 1/2; (C) weak, smooth	III	C	B	C	A/C
	IV	B	A	B	A/B
Telson					
Adult male: (A) smooth; (B) tubercular		A	A	A	B

Population II. Distribution: San Bernardino County, east of the Shadow Mountains of extreme western San Bernardino County, in the Mojave River drainage area and associated dry lake dunes from Barstow eastward to Ludlow. Description: seven to nine ventrolateral setae on metasomal segment V (mode 8/8, 89% with 7/8 or more); primary denticles in rows 1-5 total on pedipalp fixed finger 31-40 (34.91 ± 2.27, n = 34), movable finger 40-54 (45.56 ± 2.88, n = 32); adult carapace length in males 4.8-5.2 mm, females 4.9-6.0 mm.

Etymology.–*Paruroctonus marksi* is named for a friend of mine, Joseph L. Marks, who has contributed much time and effort collecting scorpions, including many of the specimens upon which the description of this species is based.

Distribution.–Fig. 39. Sand dunes, western and central Mojave Desert in California.

Specimens examined.–Paratypes. Population I. U.S.A.: CALIFORNIA; *Los Angeles County*, approx. 7 mi. N Littlerock, 1 September 1972 (R. M. Haradon, J. L. Marks), 15 males, 10 females (includes allotype) (CAS), 8.5 mi N Littlerock, 1 May 1972 (R. M. Haradon, J. L. Marks), 5 females (CAS), Alpine Butte, approx. 7 mi. N Pearblossom, 2 May 1972 (R. M. Haradon, J. L. Marks), 5 males, 11 females (CAS), Alpine Butte, 31 May 1972 (R. M. Haradon), 1 male, 2 females (CAS), Alpine Butte, 1 September 1972 (R. M. Haradon, J. L. Marks), 6 males, 4 females (CAS), approx. 5 mi. N Pearblossom, 5 September 1972 (R. M. Haradon, J. L. Marks), 10 males (CAS), Piute Butte, approx. 12 mi. NNW Pearblossom, 1 June 1972 (R. M. Haradon), 3 males, 3 females (CAS), Piute Butte, 3 May 1972 (R. M. Haradon, J. L. Marks), 5 males, 6 females (CAS), Piute Butte, 1 September 1972 (R. M. Haradon, J. L. Marks), 13 males, 3 females (CAS).

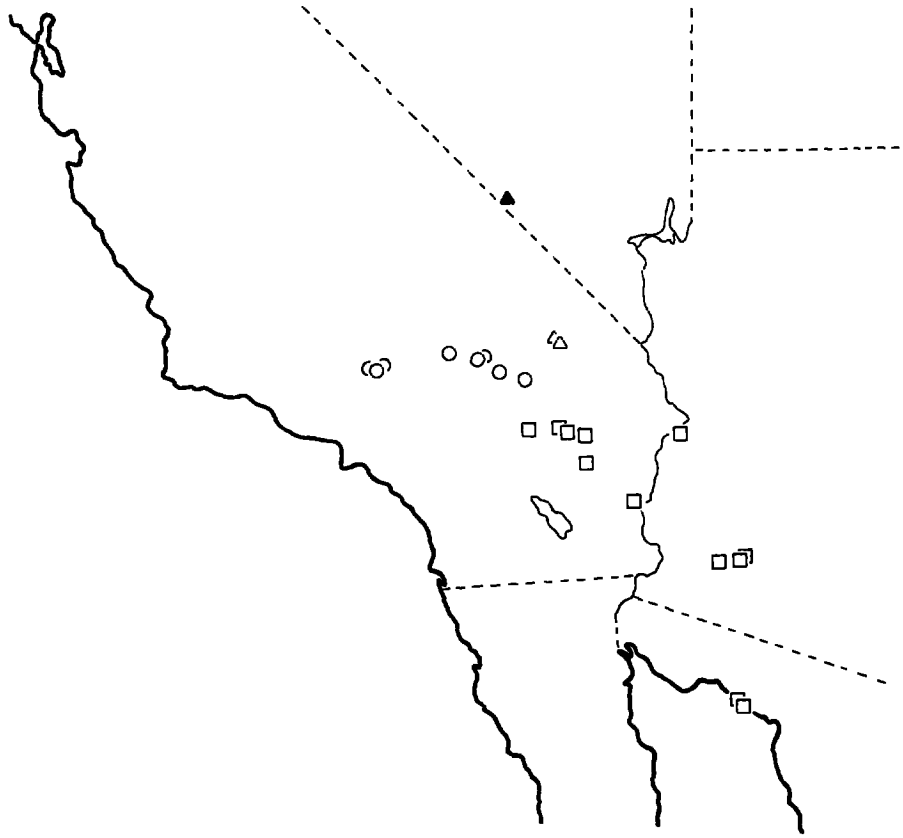


Fig. 39.–Southern California and adjacent areas. Key: *P. baergi* (squares); *P. arenicola arenicola* (closed triangle); *P. arenicola nudipes* (open triangles); *P. marksi* (circles).

Population II. U.S.A.: CALIFORNIA; *San Bernardino County,* 3.5 mi. NE Barstow, along road to Fort Irwin, 30 June 1977 (R. M. Haradon, J. L. Marks), 3 males, 8 females (CAS), 7 mi. ENE Newberry, 18 May 1968 (M. A. Cazier et al.), 19 males, 30 females (CAS), 9 mi. ENE Newberry, 18 May 1968 (M. A. Cazier et al.), 1 female (CAS), 2 mi. N Newberry, 18 May 1968 (M. A. Cazier et al.), 4 males, 1 female (CAS), 0.8 mi. N Daggett, 16 April 1965 (V. Lee), 6 males, 1 female (CAS), Pisgah Crater, 12 April 1961 (Norris and Heath), 1 female (AMNH), Pisgah Crater, 19 November 1962 (Norris and Heath), 2 males (AMNH), 7.6 mi. W Ludlow, 16 October 1977 (J. Hjelle, W. E. Savary), 6 males, 5 females (CAS).

KEY TO THE SPECIES AND SUBSPECIES OF THE *PARUROCTONUS BAERGI* GROUP

1. Telotarsus III with two retrosuperior setae (Fig. 12). . . . . *P. marksi*
   Telotarsus III with three or four retrosuperior setae (Figs. 9-11). 2

2. Telotarsus III with three long, and possibly one shorter subdistal, retrosuperior setae (Fig. 11); metasomal segment IV with five pairs of ventrolateral setae; humerus with four medial macrosetae on distal 3/5 of external surface (Fig. 16). . . . . .*P. arenicola* 3
   Telotarsus III with four long retrosuperior setae; metasomal segment IV with four pairs of ventrolateral setae; humerus with two or three medial macrosetae on distal 3/5 of external surface (Fig. 14) 4

3. Basitarsus III with mrs seta present (Figs. 27-28); paired dorsal metasomal setae 1,2,2-3,3-4 . . . . . *P. arenicola arenicola*
   Basitarsus III without mrs seta (Figs. 29-30); paired dorsal metasomal setae 0,1,1,2 . . . . . *P. arenicola nudipes*

4. Telotarsus III with one retromedial seta (Fig. 9); ventrolateral metasomal carinae I-III smooth; closed pedipalp fingers in adult male form wide proximal gap (Fig. 17) . . . . . .*P. baergi*
   Telotarsus III with two retromedial setae (Fig. 10); ventrolateral metasomal carinae I-III granular; closed pedipalp fingers in adult male form narrow proximal gap (Fig. 19). . . . . .*P. utahensis*

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LITERATURE CITED

Allred, D. M. and W. J. Gertsch. 1976. Spiders and scorpions from northern Arizona and southern Utah. J. Arachnol., 3:87-99.

Bugbee, R. E. 1942. Notes on animal occurrence and activity in the White Sands National Monument, New Mexico. Trans. Kansas Acad. Sci., 45:315-321.

Couzijn, H. W. C. 1976. Functional anatomy of the walking-legs of Scorpionida with remarks on terminology and homologization of leg segments. Netherlands J. Zool., 26:453-501.

Diaz-Nájera, A. 1975. Listas y datos de distribución geográfica de los alacranes de México (Scorpionida). Rev. Inv. Salud Pub., México, 35:1-36.

Francke, O. F. 1975. A new species of *Diplocentrus* from New Mexico and Arizona (Scorpionida, Diplocentridae). J. Arachnol., 2:107-118.

Francke, O. F. and M. E. Soleglad. 1981. The family Iuridae Thorell (Arachnida, Scorpiones). J. Arachnol., 9:233-258.

Gertsch, W. J. and D. M Allred. 1965. Scorpions of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser., 6:1-15.

Gertsch, W. J. and M. Soleglad. 1966. The scorpions of the *Vejovis boreus* group (subgenus *Paruroctonus*) in North America (Scorpionida, Vejovidae). Amer. Mus. Nov., No. 2278, 54 pp.

Hadley, N. F. and S. C. Williams. 1968. Surface activities of some North American scorpions in relation to feeding. Ecology, 49:727-734.

Haradon, R. M. 1983. A new subgenus of *Paruroctonus* Werner (Scorpiones, Vaejovidae). J. Arachnol., 11:251-270.

Johnson, J. D. and D. M. Allred. 1972. Scorpions of Utah. Great Basin Nat., 32:154-170.

Muma, M. H. 1975. The vernal ground-surface arachnid populations in Tularosa Basin, New Mexico. Southwest. Nat., 20:55-67.

Polis, G. A., W. D. Sissom and S. J. McCormick. 1981. Predators of scorpions: field data and a review. J. Arid Environ., 4:309-326.

Riddle, W. A. 1978. Respiratory physiology of the desert grassland scorpion *Paruroctonus utahensis*. J. Arid Environ., 1:243-251.

Riddle, W. A. 1979. Metabolic compensation for the temperature change in the scorpion *Paruroctonus utahensis*. J. Thermal Biol., 4:125-128.

Riddle, W. A. 1981. Cuticle water activity and water content of beetles and scorpions from xeric and mesic habitats. Comp. Biochem. Physiol., 68A:231-235.

Riddle, W. A., C. S. Crawford and A. M. Zeitone. 1976. Patterns of hemolymph osmoregulation in three desert arthropods. J. Comp. Physiol., 112:295-305.

Riddle, J. A. and S. Pugach. 1976. Cold hardiness in the scorpion, *Paruroctonus aquilonalis*. Cryobiology, 13:248-253.

Rowland, J. M. and J. R. Reddell. 1976. Annotated checklist of the arachnid fauna of Texas (excluding Acarida and Araneida). Occas. Pap. Mus., Texas Tech Univ., No. 38, 25 pp.

Sissom, W. D. and O. F. Francke. 1981. Scorpions of the genus *Paruroctonus* from New Mexico and Texas (Scorpiones, Vaejovidae). J. Arachnol., 9:93-108.

Soleglad, M. E. 1972. Two new scorpions of the genus *Paruroctonus* from southern California (Scorpionida: Vejovidae). Wasmann J. Biol., 30:71-86.

Soleglad, M. E. 1973. Scorpions of the mexicanus group of the genus *Vejovis* (Scorpionida, Vejovidae). Wasmann J. Biol., 31:351-372.

Stahnke, H. L. 1970. Scorpion nomenclature and mensuration. Entomol. News, 81:297-316.

Stahnke, H. L. 1974. Revision and keys to the higher categories of Vejovidae (Scorpionida). J. Arachnol., 1:107-141.

Williams, S. C. 1968. Two new scorpions from western North America (Scorpionida: Vejovidae). Pan-Pacific Entomol., 44:313-321.

Williams, S. C. 1972. Four new scorpion species belonging to the genus *Paruroctonus* (Scorpionida: Vaejovidae). Occas. Pap. California Acad. Sci., No. 94, 16 pp.

Williams, S. C. 1976. The scorpion fauna of California. Bull. Soc. Vector Ecol., 3:1-3.

Williams, S. C. and N. F. Hadley. 1967. Scorpions of the Puerto Peñasco area (Cholla Bay), Sonora, Mexico, with description of *Vejovis baergi*, new species. Proc. California Acad. Sci., Ser. 4, 35:103-116.

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