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

SMERINGURUS, A NEW SUBGENUS OF *PARUROCTONUS* WERNER (SCORPIONES, VAEJOVIDAE)

Richard M. Haradon

9 High Street
Stoneham, Massachusetts 02180

ABSTRACT

Paruroctonus Werner consists of two sympatric subgenera, the nominate and *Smeringurus*, new subgenus. *Smeringurus* is defined by the presence of numerous short setae on the ventral intercarinal surfaces of metasomal segments I-IV, and by having a significantly more slender metasoma. *Smeringurus* consists of four species endemic to the southwestern deserts of North America: *P vachoni* Stahnke (type species), *P. mesaensis* Stahnke, *P. grandis* (Williams), and *P. aridus* Soleglad. Two subspecies of *P. vachoni* are defined by the numbers of primary denticles on the grasping edge of the pedipalp fingers: *P. v. vachoni*, from the northern Mojave Desert region, and *P. v. immanis* Soleglad, new combination, from the central and southern Mojave Desert and the Colorado Desert. *Paruroctonus vachoni, P, grandis* and *P. aridus* are allopatric, occupying rocky substrates; each occurs sympatrically with *P. mesaensis*, a psammophilous species.

INTRODUCTION

Within the North American scorpion genus *Paruroctonus* Werner, 1934, is a distinct element that includes *Paruroctonus vachoni* Stahnke, 1961, and four other nominal species. Soleglad (1972) described two of these species, and discussed for the first time the distinctive characteristics of the group. Stahnke (1974) doubted the status of both of Soleglad's species, implicitly, by omitting them from a list of what Stahnke considered to be the valid *Paruroctonus* species. The purposes of this report are to evaluate new and previously employed taxonomic characters, clarify the status of each nominal species, and to propose a subgeneric name for this species group.

METHODS

The measurements I have used are those standard in scorpion systematics, with the difference from some workers of the definition of pedipalp chela width. For this measurement, I have followed Stahnke (1970:304), measuring the greatest width from the inner secondary carina to the exterior marginal carina (= inner and outer carinae respectively in Soleglad 1973:354, 355, figs. 1-12). This is invariably the widest measurement on the chela at any point of rotation, and does not correspond to the width of the chela observed dorsally on a live animal in repose.

To reduce any allometric influence upon the sample distributions of morphometric ratios, the raw data for each sample were first sorted into three size groups. The carapace

length provides an adequate estimate of maturity where ratios are involved, and requires a single measurement that can be made with reasonable precision, and which relates directly to the usual series of comparative measurements and ratios. It is used in preference to the total length of the scorpion, a precise measurement of which involves the summation of 14 lengths, including the often difficult measurement of each tergite. Specimens with a carapace shorter than 5.0 mm were designated as immatures. Specimens with a carapace equal to or longer than 5.0 mm, but which were not yet adults, were designated as juveniles. Adults were determined primarily by the development of scalloping, distinct or subtle, along the grasping edge of the pedipalp fingers. In determining adult females it was usually necessary to consider such scalloping in relation to the coloration of the cuticle (which tends to be somewhat darker in adults), and to the carinal granulation (which tends to be coarser in adults).

The rows of primary denticles (Fig. 2) on the pedipalp fingers are numbered 1 (distal) to 6 (proximal), after Williams (1980:2). The numbers of primary denticles in rows 1-5 are used to define subspecies, and are reported as the whole number nearest each sample mean, in the manner 1/2/3/4/5. The denticle counts exclude the enlarged denticles that delimit the six rows.

Statistical data are given as: mean ± one standard deviation; n = sample size; d.f. = degrees of freedom.

DIAGNOSTIC CHARACTERS

The species considered herein are defined by unique developments in one or more, or by a unique combination of developments in all four, of the following characters: (1) The scalloping of the grasping edge of the pedipalp fingers in adult males, (2) number and pattern of setae on the basitarsus of legs 1-3, (3) number of ventrolateral setae on metasomal segment V, and (4) the basic pattern of fuscous pigmentation. Two subspecies are defined by the numbers of primary denticles on the pedipalp fingers. Each of the other diagnostic characters used herein consists of two or more distinct, but not always unique, states of development. To correctly identify specimens, the variability of the characters might require that the entire series of diagnostic criteria given for each taxon be evaluated.

1. Scalloping of adult male pedipalp fingers. Three characteristic developments are recognized. The first two are exemplified by Figures 4 and 6. The range of variability of the third condition is shown by Figures 8 and 10.

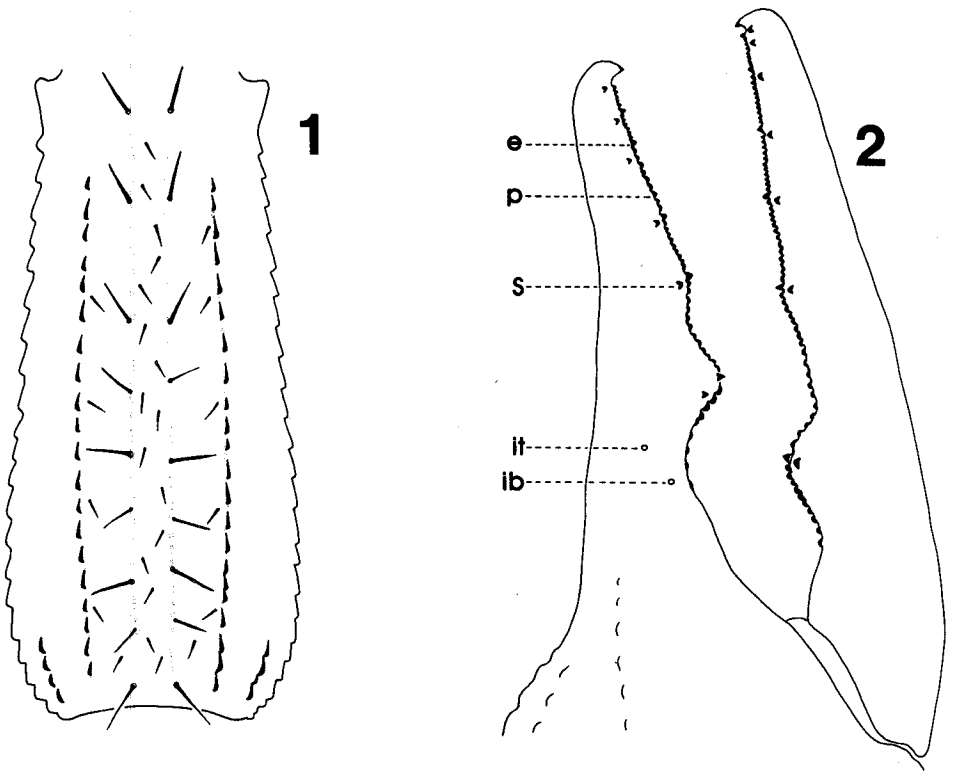
2. Leg setae. In *P. mesaensis* there are typically nine or more very long setae in an essentially even series along the retrolateral surface of the basitarsus of the third pair of legs (Fig. 17). The other three species in the subgenus bear eight or fewer, irregularly positioned, short and moderately long setae along the retrolateral surface (Fig. 16). There is a similar, but less conspicuous, difference between *P. mesaensis* and the other three species in the setation of the first two pairs of legs, as well.

Heretofore, tarsal setae otherwise have been ignored as taxonomic characters in *Paruroctonus*, and in the family Vaejovidae generally. The minute setae which form three inferior rows (one each more or less in line with, and one between, the prolateral and retrolateral pedal spurs, or calcars) on the basitarsus of legs 1-3 are herein referred to as spinules. Three of the four species in the subgenus bear on legs 1-3 a stout bristle at about mid-length of the basitarsus along the inferior retrolateral row of spinules (Fig. 18). The bristle is distinctly stouter than any, and shorter than most, of the large setae in the

retrolateral series. *Paruroctonus mesaensis* lacks this bristle on legs 1 (Fig. 19) and 2.

3. Metasomal setae. There are typically eight pairs of ventrolateral setae on metasomal segment V in all the species of the subgenus except *P. mesaensis.* The number in *P. mesaensis* usually ranges from 10 to 14. In all the species the number of setae varies from loss, or by the presence of extraneous setae that are usually smaller and offset from the main series. Immatures typically lack two or more setae from the full complement exhibited by juveniles and adults. The development of the dorsal metasomal setae I-IV varies among the species, and in some species among populations.

4. Fuscous markings. In this study I have distinguished between the basic carapacial and tergal pattern, or design, that might characterize a species, and the relative intensity, or darkness, or that pattern which various specimens or populations might exhibit. With rare expections, *P. mesaensis* entirely lacks fuscosity, and thus presents a dichotomy generally reliable in distinguishing that species from the other species in the subgenus, all three of which exhibit unique basic patterns of fuscosity on the carapace and tergites. Conspicuous differences occur in the quantity of melanin present within and among populations, but such differences represent tendencies along a common gradient and are not considered important taxonomically. There is, apparently, a correlation between the amount of fuscosity present and the darkness of the local substrate. (See "Remarks" under *Paruroctonus vachoni immanis* Soleglad below).



Figs. 1-2.–1, *P. mesaensis*, ventral aspect of metasomal segment III, showing large paired carinal setae, and smaller intercarinal setae; 2, *P. vachoni*, interior aspect of adult male pedipalp fingers, showing enlarged (e), primary (p) and supernumerary (s) denticles, and *ib* and *it* trichobothrial positions.

5. Dentition of pedipalp fingers. The numbers of primary denticles in rows 1-5 on the grasping edge of each pedipalp finger are not clearly discernible until about the second instar. The number of denticles in row 6 on the fixed and movable fingers increases during the first two, and probably the third, instars. Although the denticles are subject to considerable wear, damage, and occasional loss, these conditions are rarely an obstacle to identifying taxa. The numbers of denticles in rows 1-5 show no evidence of sexual dimorphism. The number of denticles in row 6 of adult males is correlated with the extent of scalloping on the fingers, and can be useful for diagnosing three of the four species in the subgenus. The possible error in row 6 counts (see below) makes subtle differences observed between subspecies of doubtful value, and the counts are omitted here.

A correlation was found in the numbers of denticles among various rows, and thus has a bearing on the usefulness of the counts as diagnostic characters. For example, in a sample of *Paruroctonus grandis* (Williams) (n = 246), tests for independence (chi square analysis) in various numbers of denticles between row 1 and each of rows 2 through 5 on the same movable finger indicated that the counts in the first three rows were not independent (rows 1 and 2, $\chi^2 = 50.18$, d.f. = 21, $P < 0.01$; rows 1 and 3, $\chi^2 = 40.09$, d.f. = 21 $P < 0.01$; rows 1 and 4, $\chi^2 = 30.92$, d.f. = 21, $P > 0.05$; rows 1 and 5, $\chi^2 = 30.78$, d.f. = 33, $P > 0.05$). Similar correlations were observed in counts on the fixed finger of *P. grandis*, and on the fingers of other taxa, as well.

In the same *P. grandis* sample there was a significant correlation between the counts (sum of rows 1-5) on the fixed and movable fingers on the same chela ($r = 0.636$, n = 257). The sum of rows 1-5 on the left and right fixed fingers, and the left and right movable fingers, were more than 95% of the time asymmetrical. On each chela the movable finger always bore more denticles (sum of rows 1-5) than the fixed finger.

The denticle counts in row 6 on the movable and especially the fixed fingers are among the more variable. Obtaining exact counts in row 6 is often hampered by the gradual reduction in size and obsolescence of the denticles toward the articular membrane. This is particularly so among mature males of *Paruroctonus vachoni* Stahnke, which typically lose 50% or more of the juvenile complement from row six on the fixed finger, and usually two to four denticles from the juvenile series on the movable finger. Mature male *P. grandis* typically lose about 33% of the juvenile series from the fixed finger; there is no significant loss on the movable finger. In adult males of *P. vachoni* and *P. grandis* there are seldom more than 12 large denticles in series on row 6 before there is an abrupt reduction in size, and increase in spacing, of the denticles.

6. Pigmentation of pedipalp fingers. In species having darkly pigmented pedipalp fingers, the pigmentation usually becomes distinct among late immatures. The color, and the contrast between the fingers and the palm, observed in live specimens is often obscured in preserved material.

7. Trichobothria. The most significant variability evident within the subgenus involves the digital series. The position of *ib* on the fixed finger (Fig. 2) is indicative of the relative positions (distal or proximal) of the remaining digital trichobothria. The position of *ib* is measured by the ratio, fixed finger length/distance *ib* to finger tip. This ratio increases as the scorpion matures, lending the appearance of ontogenetic "migration" of *ib* distally. There is also significant variation in the position of *ib* among species and subspecies, and among some populations of *P. vachoni* and *P. mesaensis.*

8. Metasomal carinae. The development and granulation of the ventral and ventrolateral carinae on metasomal segments I-III are directly correlated, the latter generally being more sharply defined and somewhat more granular. Only the ventral carinae are

referred to diagnostically. Sexual dimorphism and intraspecific variability can be considerable, and differences between species are often obscured. Two states of adult development are used diagnostically; smooth and granular.

9. Morphometric ratios. Although a number of ratios were found to differ significantly ($P < 0.05$) between taxa, due to overlapping ranges of variation, few ratios permitted as much as 90% separation of taxa.

10. Pectinal tooth counts. There was little or no difference observed in the numbers of pectinal teeth among the species of the subgenus. Within a species, significant differences in the means occur among certain populations.

11. Adult size. Adults were determined as outlined in "Methods" above. In the paratopotypic sample of *P. grandis* (n = 261), the 20 longest carapaces among females averaged 1.15 times greater than the 20 longest carapaces among males. The slightly larger average adult size attained by females in this sample supports a general impression perceived in the course of examining these and other specimens that in the subgenus adult females are generally larger than adult males. Whether females attain maturity within a larger size range than males do is not certain.

Polis and Farley (1979b:527) defined mature *P. mesaensis* males by inference, according to a sudden divergence from the linearity shown by earlier instars in the correlation between the logarithmic growth rates of the pectines (dentate margin length) and the distance between the median eyes and the anterior margin of the carapace. It is uncertain, though, whether the point of deviation from prior linearity indicates maturity or only another step toward maturity. It is impossible to interpret the point or region of female maturity from the same graph, in which females are represented by a single straight line.

Smeringurus, new subgenus

Fig. 1

Paruroctonus (in part): Stahnke 1957:253, 1965:262, 263, 1974:119 (key), 136; Williams 1972:2, 1974:15 (key), 1980:4 (key), 31; Soleglad 1972:71, 1973:351, 353, 359, figs. 13, 14; Sissom and Francke 1981:93, 102.

Vejovis (Paruroctonus) (in part): Gertsch and Allred 1965:4, 9; Gertsch and Soleglad 1966:2, 3, 1972:553, 559; Williams and Hadley 1967:103, 112; Williams 1968a:7, 1968b:313, 1970a:7, 1970b:277.

Vaejovis (Paruroctonus) (in part): Hjelle 1972:20, 26.

Vaejovis (in part): Diaz-Nájera 1975:3, 6.

Type species.–*Paruroctonus vachoni* Stahnke, 1961.

Diagnosis.–Subgenus of genus *Paruroctonus*; species bearing numerous short setae on the ventral intercarinal surfaces of metasomal segments I-IV (Fig. 1); setae between ventral metasomal carinae I-IV total 20 or more in adults and juveniles, 10 or more on immatures with a carapace 4.0-5.0 mm long, five or more on immatures with a carapace 2.5-3.9 mm long (apparently second instars and earlier); all metasomal segments longer than wide, except in very early instars; segment III length/width in adult males greater than 2.00, in adult females greater than 1.90, in immatures of both sexes greater than 1.70.

The intercarinal metasomal setae are often inconspicuous in early instars, but when discernible on any specimen are slightly to conspicuously shorter than the paired setae positioned along the ventral carinae. Individual intercarinal setae occur only rarely among individuals belonging to the nominate subgenus.

Description.—Carapace length of adult males 6.5-10.4 mm, adult females 7.0-11.7 mm; total length of adults (including telson) about 60-100 mm; carapace length represents about 11-13% of total length in juveniles and adults. Anterior margin of carapace in adults with subtle medial concavity; on immatures and some juveniles and young adults straight to convex. Median ocular tubercle width/carapace width at mid-length, adults 0.25-0.33 (usually nearer 0.33), immatures and juveniles 0.33-0.45. Chelicerae: on movable digit, superior distal tine subparallel to, and 1/2 (rarely less) to 2/3 length of, inferior distal tine; three to eight (usually four to six) well developed denticles, often worn to crenulations, on inferior margin; on fixed digit, inferior margin near bicusp with one to four, usually pigmented, denticles. Chelae with all eight carinae well developed, moderately to coarsely granular (see Soleglad 1972:fig. 7). Pedipalp fingers (Fig. 2): six supernumerary denticles on fixed finger, seven on movable finger; primary denticles divided into six rows by five and six enlarged denticles on fixed and movable fingers respectively; sum of primary denticles in rows 1-5, 38-69 on fixed finger, 55-91 on movable finger. Leg 2 basitarsus with three stout bristles (excluding variably developed distal bristle) along inferior prolateral series of spinules. Pectines extend beyond distal margin of trochanter on adult males, to or beyond mid-length of trochanter on adult females; carapace length/pectine length, adult males less than 1.00, adult females less than 1.10; middle lamellae in two rows; teeth on males 28-40 (30-35 more than 95% of the time), females 20-29 (22-26 more than 90% of the time). Paired metasomal setae counts on segments I-IV: dorsolateral setae 0,2,2,3; ventrolateral setae 3,5,5,5; ventral setae usually from 3,3,3,4 in early instars, becoming 3,4,4,5 to 4,5,5,7 or more in juveniles and adults.

Subordinate taxa.—*Paruroctonus mesaensis* Stahnke, 1957; *Paruroctonus vachoni vachoni* Stahnke, 1961; *Paruroctonus vachoni immanis* Soleglad, 1972, new combination; *Paruroctonus grandis* (Williams, 1970b); *Paruroctonus aridus* Soleglad, 1972.

Distribution.—Deserts of southern California, southwestern Nevada, western and southwestern Arizona (U.S.A.), northeastern Baja California and northwestern Sonora (including several Gulf of California islands), Mexico.

Etymology.—*Smeringurus* (masculine) is derived from Greek combining forms, and refers to the ventral intercarinal metasomal setae by which this subgenus is defined.

Remarks.—*Smeringurus* is herein assigned subgeneric rank for two reasons. First, the present definitions and relationships of the several nominal vaejovid genera are not at all clear, and placement among such poorly defined concepts poses problems that go beyond the intent or proper scope of this report. Second, although the presence of ventral intercarinal metasomal setae is apparently unique within Vaejovidae, with the exceptions of that and of having a relatively slenderer metasoma, *Smeringurus* is morphologically subordinate to the generic concept of *Paruroctonus*. Although other characteristics in combination also distinguish *Smeringurus* from the nominate subgenus, each characteristic represents only a general tendency toward one end of a modification series shared by all species in the genus.

The proposed subgenera of *Paruroctonus* are based upon first hand studies of all the nominal, and several undescribed, species in the genus. That significant phylogenetic divergence has occurred at several levels (species, species group, subgenus) within the genus is indicated by three observations. First, *Smeringurus* and the nominate subgenus are sympatric throughout the lesser range of the former. Second, within the nominate subgenus are two major species groups that are widely sympatric. Third, certain species of each species group within the nominate subgenus coexist with one another, as well as with species belonging to *Smeringurus*.

Paruroctonus vachoni Stahnke
Figs. 3, 4, 11, 12, 15, 16, 18

Paruroctonus vachoni Stahnke 1961:206-212, 1974:138, tbl. 4; Williams 1972:3, 1976:2; Soleglad 1972:72 (key), 75, 1973:355, tbl. 2; Haradon 1974:26.
Vejovis (Paruroctonus) vachoni: Gertsch and Allred 1965:9; Gertsch and Soleglad 1966:6 (key), 23-26, figs. 14, 15, 22, 49-51, 64, 66, tbl. 3; Williams 1970b:277, 281.

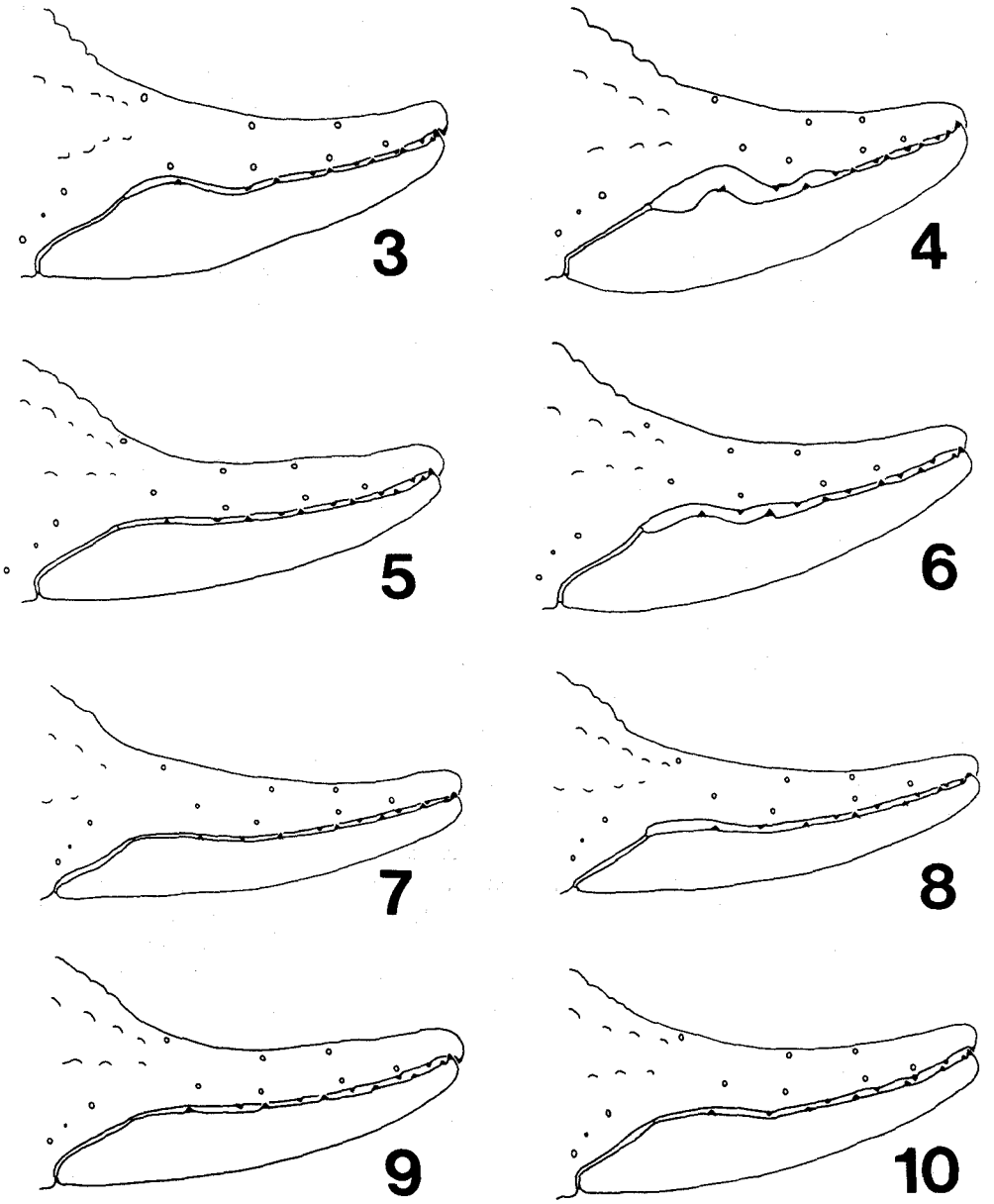
Diagnosis.–A species of subgenus *Smeringurus;* adult males with deeply scalloped pedipalp fingers, closed fingers form prominent proximal gap (Fig. 4), 15 or fewer primary denticles in row 6 of fixed finger; legs 1 and 2 with large bristle at mid-length of basitarsus along inferior retrolateral row of spinules (Fig. 18); eight or fewer irregularly positioned retrolateral setae on basitarsus of third pair of legs (Fig. 16); eight pairs of ventrolateral setae on metasomal segment V; dorsal setae on metasomal segment II about as long as dorsal setae on segments III-IV; fuscous markings usually distinct and extensive, extend into most or all of the interocular triangle (Fig. 11) and to the entire posterior margin of tergites 1-6 (Fig. 12); juveniles and adults with light to dark reddish or reddish-brown pedipalp fingers, fingers darker than yellowish or yellowish-orange palm; ventral carinae on metasomal segments I-III granular in males, at least crenulate posteriorly in females; chela length/width, less than 2.95 in adult males; telson depth/metasomal segment V width, in adults greater than 0.96.

Variation.–The scalloping and resulting proximal gap on the pedipalp fingers in adult males varied from what is shown in Figure 4 to a slightly more deeply scalloped state, especially in large males. The pedipalp fingers on adult females were weakly scalloped, and when closed formed at most a narrow proximal gap (Fig. 3); fingers were essentially unscalloped on immatures and juveniles. The cuticle varied from pale yellow to pale dusky orange. Fuscous markings on the carapace and tergites were most clearly defined on immatures and juveniles. At least vestigial markings were present on the carapace and usually the tergites of adults. In all specimens except early instars the fingers were darker than the palm. Primary denticles in row 6 of the fixed pedipalp finger in adults varied 2 to 18; counting only the larger contiguous denticles of similar size, the number seldom exceeded 12. Chela length/width, among adult males 2.71 ± 0.14, n = 17; adult females 2.78 ± 0.14, n = 44. Telson depth/metasomal segment V width, among adults 1.05 ± 0.07, n = 60.

Distribution.–(Fig. 15). Rocky desert habitats from the northern Mojave Desert in California and adjacent areas of Nevada, south into the Colorado Desert to the U.S.A.-Mexico border, remaining north and east of the Imperial Valley of California.

Remarks.–Stahnke (1961:206) originally described *P. vachoni* as having "a carapace that has a somewhat light yellow interocular triangle followed by a darker posterior portion." In some specimens that I have studied, the interocular area appeared somewhat lighter than the rest of the carapace due to a thinner distribution of fuscosity. In some specimens the fuscosity did not extend to the anterior margin. However, in all known populations of *P. vachoni* most of the interocular area is occupied by fuscosity that is readily discernible up to at least the juvenile stage, and in most specimens into the adult stage.

Two subspecies of *P. vachoni* are distinguished by the numbers of primary denticles in rows 1-5 on the pedipalp fingers. In the samples studied, approximately 96% separation of the two subspecies was possible by comparing each specimen to the mean denticle counts of Death Valley area samples and Coachella Valley - Imperial Valley samples.



Figs. 3-10.–Pedipalp fingers, adult state, exterior aspect: 3, *P. vachoni*, female; 4, *P. vachoni*, male; 5, *P. grandis*, female; 6, *P. grandis*, male; 7, *P. aridus*, female; 8, *P. aridus*, male; 9, *P. mesaensis*, female; 10, *P. mesaensis*, male.

Along the Colorado River, particularly in Arizona, the distinction between the two subspecies is obscure (see discussion below).

Paruroctonus vachoni vachoni Stahnke
Fig. 15

Paruroctonus vachoni Stahnke 1961:206-212, 1974:138, tbl. 4 (in part); Williams 1972:3 (in part), 1976:2 (in part); Soleglad 1972:72 (key), 75 (in part), 1973:355, tbl. 2 (in part).

Vejovis (Paruroctonus) vachoni: Gertsch and Allred 1965:9 (in part ?); Gertsch and Soleglad 1966:6 (key), 23-26, figs. 14, 15, 22, 49-51, 64, 66, tbl. 3 (in part); Williams 1970b:277, 281 (in part).

Types.–*Paruroctonus vachoni:* Holotype female from U.S.A., California, San Bernardino County, Sheep Creek Springs, 37 miles N Baker (1800 ft.), 4 December 1960 (R. L. Swett). Allotype from same locality, 21 November 1960 (collector not reported). Depository: H. L. Stahnke collection, Tempe, Arizona.

Diagnosis.–Primary denticle counts in rows 1-5 closer to 6/7/9/10/12 (not 7/8/11/11/13) on fixed pedipalp finger, and 8/10/12/12/19 (not 9/11/13/13/19) on movable pedipalp finger (Table 1); from Inyo County and extreme northern San Bernardino County in California, and southwestern Nevada.

Variation.–Of more than 200 specimens examined, only one (Saline Valley, Inyo County) essentially lacked distinct fuscosity. Adult carapace length, males 7.8-10.4 mm, females 8.3-11.7 mm. Pectinal tooth counts are given in Table 2. Fixed finger length/distance *ib* trichobothrium to finger tip, adult males 1.37 ± 0.04, n = 26; adult females 1.34 ± 0.04, n = 30.

Distribution.–(Fig. 15). Rocky canyons and slopes, northern Mojave Desert region.

Remarks.–The "Trona, California" record cited by Stahnke (1961:206) was later cited by Gertsch and Soleglad (1966:25) as occurring in Imperial County, California. Trona is in the extreme northwestern corner of San Bernardino County, a region southwest of, but geographically associated with, the known range of *P. v. vachoni.* This record is here tentatively referred to the nominate subspecies.

Specimens examined.–U.S.A.: CALIFORNIA; *Inyo County*, Saline Valley and Inyo Mts., 1959-1960 (B. Banta), 43 males, 38 females (CAS, AMNH), Death Valley National Monument, Scotty's Ranch (3000 ft.), 13 April 1968 (G. Lytle et al.), 8 males, 17 females (CAS), Ubehebe Crater (2500 ft.), 10 April 1968 (S. C. Williams et al.), 1 male, 5 females (CAS), Grapevine Spring (2100 ft.), 12 April 1968 (S. C. Williams et al.), 8 males, 10 females (CAS), Stovepipe Wells (seal level), 9 April 1968 (S. C. Williams, V. Lee), 1 female (CAS), 2 mi. N Bennett's Well, 15 April 1968 (G. Lytle et al.), 1 male, 2 females (CAS), Travertine Springs, 1/2 mi. E Furnace Creek Inn, 11 April 1968 (S. C. Williams et al.), 6 males, 5 females (CAS), Midway Well (-100 ft.), 11 April 1968 (S. C. Williams et al.), 4 females (CAS), Midway Well, 11 April 1968 (J. Bigelow et al.), 1 female (CAS), Twenty Mule Team Canyon, 14 April 1968 (J. Bigelow, M. A. Cazier), 5 males, 15 females (CAS); *San Bernardino County*, 1/2 mi. E. Saratoga Springs, 10 April 1968 (G. Lytle, J. Bigelow), 1 male, 2 females (CAS), Sheep Creek Springs, 14 May 1971 (R. M. Haradon, R. Leutcke), 1 male, 1 female (CAS): NEVADA; *Clark County*, Tulle Springs, near Charleston Mts., 12 July 1966 (T. Coss), 1 Female (CAS).

Table 1.–Statistical summary of primary denticle counts in rows 1-5 on the pedipalp fixed and movable fingers of *P. vachoni vachoni* and *P. vachoni immanis.* Data include: mean ± one standard deviation above, sample size (range) below.

	Fixed Finger		Movable Finger	
Row	*vachoni*	*immanis*	*vachoni*	*immanis*
1	5.64 ± 0.63 151(4-8)	7.07 ± 0.95 87(4-9)	7.81 ± 0.73 108(6-10)	8.78 ± 0.95 64(5-11)
2	7.26 ± 0.71 151(5-9)	8.25 ± 0.72 87(7-10)	9.94 ± 0.81 108(8-12)	11.45 ± 0.87 64(9-13)
3	9.01 ± 0.85 151(7-11)	11.17 ± 0.94 87(9-14)	11.60 ± 1.06 108(9-14)	13.33 ± 2.02 64(10-16)
4	9.68 ± 0.80 151(7-12)	11.00 ± 1.15 86(9-15)	11.97 ± 0.98 108(10-15)	13.36 ± 1.15 64(11-16)
5	11.54 ± 1.09 150(9-14)	12.56 ± 1.27 85(10-15)	18.57 ± 1.48 108(15-22)	19.05 ±1.97 64(15-23)

Paruroctonus vachoni immanis Soleglad, new combination
Fig. 15

Vejovis (Paruroctonus) vachoni: Gertsch and Allred 1965:9 (in part ?); Gertsch and Soleglad 1966:6 (key), 23-265, figs. 14, 15, 22, 49-51, 64, 66, tbl. 3 (in part); Williams 1970b:277, 281 (in part).
Paruroctonus vachoni: Williams 1972:3 (in part), 1976:2 (in part); Soleglad 1972:72 (key), 75 (in part), 1973:355, tbl. 2 (in part); Haradon 1974:26; Stahnke 1974:138, tbl. 4 (in part).
Paruroctonus immanis Soleglad 1972:73 (key), 75-82, figs. 1, 3, 4, 6, 8-10, 11-13, tbl. 1, 1973:355, tbl. 2.

Types.–*Paruroctonus immanis:* Holotype male and allotype from U.S.A., California, Riverside County, Indio Hills, 2 miles NW Thousand Palms, 1.2 miles N intersection Varner and Rio del Sol Roads, 17 October 1970 (C. S. and M. E. Soleglad, J. and J. L. Springer). Depository: AMNH. Type locality restricted (M. E. Soleglad, pers. comm. 25 June 1981) from: "two miles west of Thousand Palms."

Diagnosis.–Primary denticle counts in rows 1-5 closer to 7/8/11/11/13 (not 6/7/9/10/12) on fixed pedipalp finger, and 9/11/13/13/19 (not 8/10/12/12/19) on movable pedipalp finger (Table 1); from central San Bernardino County southward in California.

Variation.–Fuscosity variable, ranging from extensive dark markings present to lacking all but vestigial markings on the carapace and tergites. The pale phase occurs with the dark phase along the border of the Coachella Valley and Imperial Valley, is apparently dominant only in the Coachella Valley area, and is unknown from the Mojave Desert. Adult carapace length, males 7.5-9.0 mm, females 7.7-10.4 mm. Pectinal tooth counts are given in Table 2. Fixed finger length/distance *ib* trichobothrium to finger tip, adult males 1.29 ± 0.03, $n = 8$; females 1.29 ± 0.06, $n = 14$.

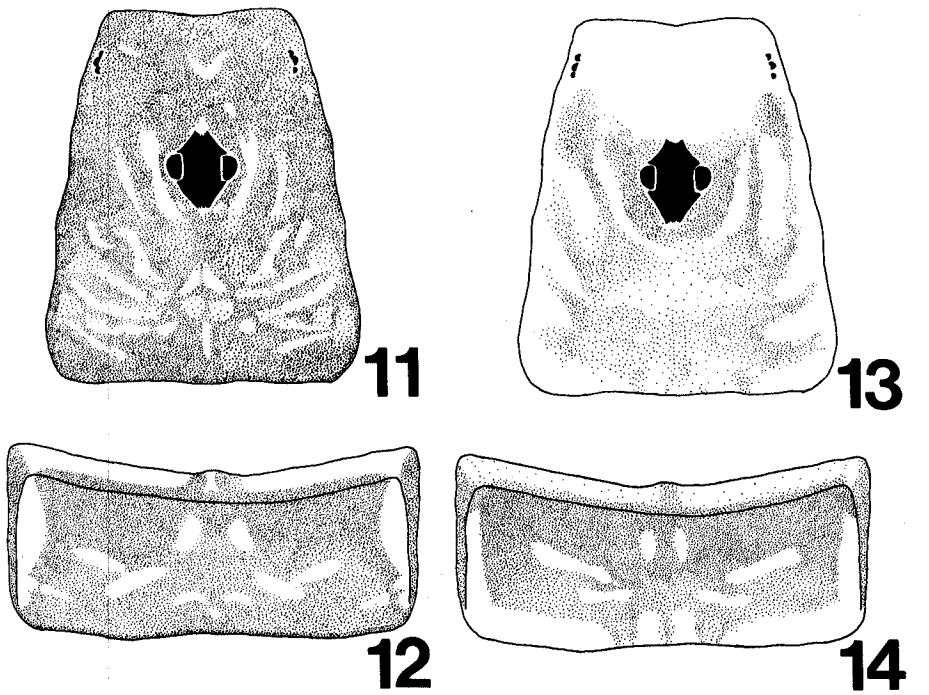
Distribution.–(Fig. 15). Rocky canyons and slopes, central Mojave Desert southward, remaining on northeast side of the Coachella Valley and eastern side of the Imperial Valley, but west of the Colorado River, to U.S.A.-Mexico border.

Remarks.–The *P. immanis* type locality is restricted because the original description placed the locality in what is essentially a sand dune habitat, a habitat in which *P. vachoni* does not occur.

Soleglad (1972) described *P. immanis* from a single locality in the Coachella Valley, California, distinguishing that species from *P. vachoni* by the former essentially lacking dorsal fuscous markings and having a slenderer telson. In addition to specimens from the Coachella Valley area, I have examined several pale specimens intermediate to the *immanis* and typical pigmentation phases from a population near Glamis (Imperial County), a population in which most specimens bear distinct fuscosity. Two relatively pale specimens from Salton Sea (Imperial County) were also examined. All the pale specimens I have seen have had at least vestigial fuscosity around the median ocular tubercle. Although often very faint, traces of underlying fuscosity usually could be seen

Table 2.–Distribution of pectinal tooth counts in *P. vachoni vachoni* and *P. vachoni immanis.*

males	29	30	31	32	33	34	35	36	37
vachoni		1	4	6	14	13	11	4	1
immanis	2	4	10	10	16	8	2	1	
females	20	21	22	23	24	25	26	27	
vachoni		2		24	39	49	19	2	
immanis	1	2	6	15	29	16	1	1	



Figs. 11-14.–Representative dorsal fuscous patterns: 11, *P. vachoni*, carapace; 12, *P. vachoni*, fifth tergite; 13, *P. grandis*, carapace; 14, *P. grandis*, fifth tergite.

on at least some of the tergites. Fuscosity, particularly within the interocular triangle, is more evident in immatures and juveniles than in adults.

There appears to be among some scorpion species a sensitive genetic responsiveness to local substrate shades, resulting in correspondingly lighter or darker dorsal patterns. This correlation has been observed in various species, notably *P. grandis* (Williams 1970b:281, 1980:36; pers. obs.). Considerable variation within a single population has also been observed. Although differences in fuscous patterns or designs can be taxonomically useful, as between *P. vachoni* and *P. grandis*, or between *Paruroctonus boreus* (Girard) and *Paruroctonus silvestrii* (Borelli), variation in the intensity of a basic pattern does not appear to be significant at the species or subspecies level. Because the Coachella Valley area appears to provide a generally lighter substrate than is typical of other areas inhabited by *P. vachoni*, I consider the Coachella Valley *immanis* population to be simply an edaphic variant within the subspecies *P. v. immanis* as defined herein.

The ratio, telson depth/metasomal segment V width, reveals no sexual dimorphism among adult *P. vachoni* ($t = 0.98$, $P > 0.05$, $n = 60$), nor any significant difference between *P. v. vachoni* and *P. v. immanis* ($t = 1.92$, $P > 0.05$, $n = 60$). The *P. immanis* type population falls well within the range of variation for this ratio reported for *P. vachoni* above. In immatures and juveniles the telson depth is always much less than the width of segment V.

Specimens examined.–U.S.A.: CALIFORNIA; *San Bernardino County*, approx. 26 mi. E. Yermo, 16 April 1965 (V. Lee), 1 male (CAS), 3 mi. W Amboy, 11 May 1968 (Foster, M. A. Cazier), 1 male (CAS), 3 mi. W Amboy. 11 May 1968 (Foster, M. A. Cazier), 1 male (CAS), 3 mi. W Amboy, 17 May 1968 (J. Bigelow et al.), 2 females (CAS), approx. 25 mi. E Twentynine Palms, 6 May 1972 (R. M. Haradon, J. L. Marks), 2 males, 4 females (CAS), approx. 27 mi. E Twentynine Palms, 2 September 1972 (R. M. Haradon, J. L. Marks), 2 males (CAS); *Riverside County*, Indio Hills, 2 mi. NW Thousand Palms, 17 October 1970 (M. E. Soleglad et al.), male holotype, allotype (AMNH), approx. 20 mi. E North Palm Springs along Dillon Rd., 13 May 1972 (R. M. Haradon), 1 male (CAS), Little San Bernar-

dino Mts., Berdoo Canyon, 2.7 mi. NE jct. Dillon Rd., 6 May 1972 (R. M. Haradon), 1 male, 5 females (CAS), 3.4 mi. NE jct. Dillon Rd., 9 April 1972 (R. M. Haradon, J. L. Marks), 1 female (CAS), 2.4 ± 0.1 mi. NE jct. Dillon Rd., 1 April 1972 (R. M. Haradon, J. L. Marks), 2 males, 3 females (CAS); *Imperial County*, Salton Sea, 26 December 1964 (V. Roth), 1 male, 1 female (AMNH), 11 mi. NE Glamis, 28 October 1967 (M. A. Cazier et al.), 1 male, 1 female (CAS), 10 mi. NE Glamis (approx. 200 ft.), 28 October 1967 (M. A. Cazier et al.), 5 males, 6 females (CAS), 9 mi. NE Glamis, 28 October 1967 (M. A. Cazier et al.), 6 males, 12 females (CAS), 9 mi. NE Glamis, 14 October 1967 (M. A. Cazier), 2 males, 2 females (CAS), Chocolate Mts., N inspection station, 24 December 1959 (V. Roth), 1 female (AMNH), 3 mi. N Winterhaven, 2 April 1960 (V. Roth), 1 male (AMNH).

Paruroctonus vachoni, intermediate populations

Distribution.–See Figure 15.

Remarks.–Samples of *P. vachoni* from along the Colorado River in Arizona were generally morphologically intermediate to *P. v. vachoni* and *P. v. immanis*, but were more similar to the former in the primary denticle counts on the pedipalp fingers (mean denticle counts on fixed finger 7/8/10/10/11, on movable finger 8/10/12/12/18). The subspecies dentition formulas given above permitted 83% separation of the *P. v. immanis* and Arizona samples. The mean pectinal tooth counts of males was relatively low (32.2

subspecies dentition formulas given above permitted 83% separation of the *P. v. immanis* and Arizona samples. The mean pectinal tooth counts of males was relatively low (32.2 ± 1.62, n = 56), but moderately high among females (24.5 ± 1.15, n = 146). The ratio, fixed pedipalp finger length/distance *ib* trichobothrium to finger tip, among adults was similar to that of *P. v. immanis* (one male 1.32, females 1.27 ± 0.04, n = 32). The adult size of the Arizona scorpions was similar to *P. v. immanis* (carapace length of one male 7.8 mm, 32 females 7.8-10.3 mm). All the Arizona specimens were very darkly pigmented. In addition to the Arizona specimens, two *P. vachoni* specimens from California, near the Colorado River, were also morphologically intermediate to the two subspecies.

Specimens examined.–U.S.A.: ARIZONA; *Mohave County*, Lake Mead Natl. Recreation Area, Willow Beach, 29 August 1965 (V. Lee), 1 male (CAS), Willow Beach, 18 October 1971 (Foster and Cazier), 1 male, 4 females (OFF), Topock, no other data, 1 female (OFF); *Yuma County*, "P" (= Black) Mt., 6 mi. E Parker, 5 April 1969 (Cazier et al.), 14 males, 27 females (OFF), 14 March 1976 (M. A. Cazier, O. F. Francke), 5 females (OFF), 2 mi. N Parker, 1 October 1970 (F. Ennik), 1 female (CAS), Trigo Mts., 15 mi. S Cibola Lake Rd., 3-4 April 1969 (Cazier et al.), 10 males, 33 females (OFF), 1/4 mi. N McPaul Bridge, near Gila River, 24 October 1973 (M. Kolner, R. Garrison), 1 male, 2 females (OFF): CALIFORNIA; *San Bernardino County*, 1 mi. N Earp on U.S. 520, 31 October 1970 (F. Ennik et al.), 3 males, 1 female (CAS); *Riverside County*, Mule Mts. Coon Hollow, 9 November 1961 (D. Richman), 1 female (AMNH).

Paruroctonus mesaensis Stahnke
Figs. 1, 9, 10, 17, 19

Paruroctonus mesaensis Stahnke 1957:253-259, 1961:206, 207, tbl. 1, 1965:262, 1974:138; Gertsch 1958:15-17 (erratum p. 17, *"imperialis"*), tbl. 5; Williams 1972:3, 1976:2, 1980:32 (key), 37-38, figs. 37D, 39, 44 (in part, misidentification); Soleglad 1972:72 (key), 75, 1973:355, tbl. 2, fig. 7; Tourtlotte 1974:178; Bowerman 1976:363; Brownell 1977:479; Hadley and Jackson 1977:85; Wright et al. 1977:197, 203; Polis and Farley 1979a:33, 1979b:517, 1980:620.

Vejovis (Paruroctonus) mesaensis: Gertsch and Allred 1965:9; Gertsch and Soleglad 1966:6 (key), 35-37, 39, 40, figs. 26, 42-45, 55, 61, 62, 67, 70, tbl. 5; Williams and Hadley 1967:106 (key), 113-114; Hadley and Williams 1968:727; Williams 1968b:313, 1969:291, 1970b:277, 281; Newlands 1972:248.

Vaejovis mesaensis: Diaz-Nájera 1975:7, 10, 31.

Types.–*Paruroctonus mesaensis:* Holotype female from U.S.A., Arizona, Maricopa County, city dump NW Mesa, 13 March 1947 (F. Parrat, I. F. Nichols). Allotype from same locality, 14 September 1939 (H. L. Stahnke). Depository: H. L. Stahnke collection, Tempe, Arizona.

Diagnosis.–A species of subgenus *Smeringurus*; adult males with weakly scalloped pedipalp fingers, closed fingers form at most a narrow proximal gap (Fig. 10); legs 1 and 2 lacking large bristle at mid-length of basitarsus along inferior retrolateral row of spinules (Fig. 19); nine or more very long retrolateral setae in an even row on basitarsus of third pair of legs (Fig. 17); 10 to 14 pairs of ventrolateral setae on metasomal segment V; fuscosity usually entirely lacking (when present, markings are few and extremely weak); pedipalp fingers light yellow, not darker than light yellow palm; ventral carinae on metasomal segments I-III obsolete or smooth; telson depth/metasomal segment V width, less than 0.96.

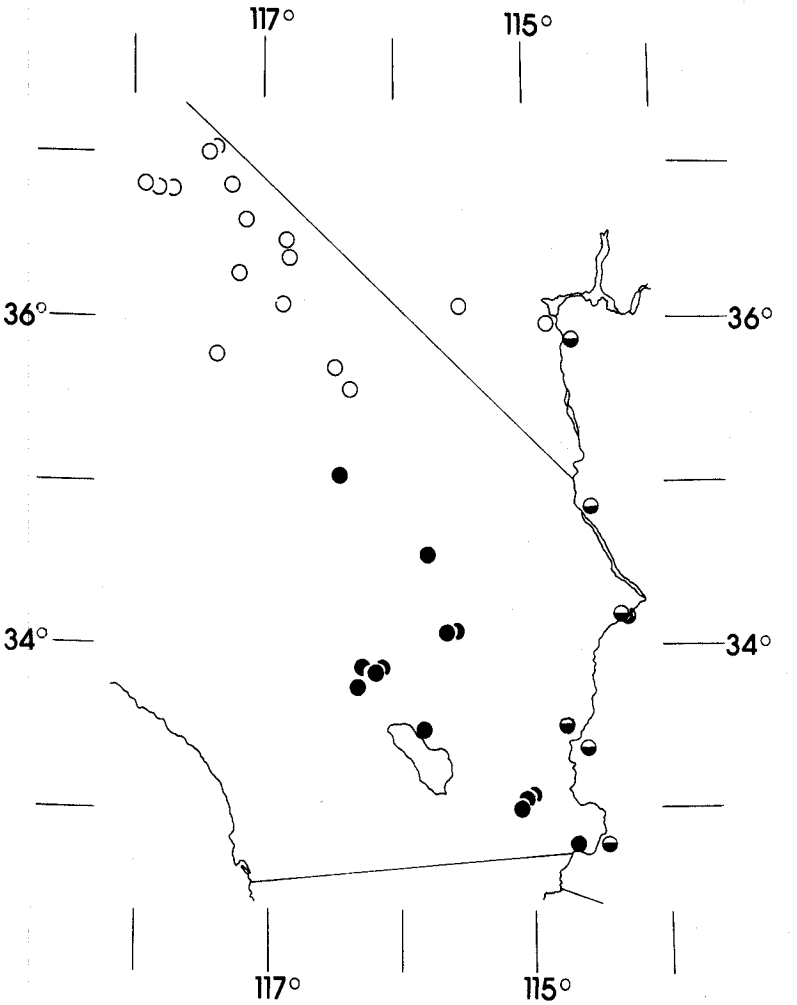


Fig. 15.–Southern California and adjacent areas, showing distribution of *P. vachoni vachoni* (white circles), *P. vachoni immanis* (black circles), and *P. vachoni vachoni* X *immanis* (white and black circles).

Variation.—The scalloping and the resulting proximal gap on the pedipalp fingers varied among adult males from that shown in Figure 10 to that shown for *P. aridus* in Figure 8, and among adult females from what is shown in Figure 9 to a slightly more scalloped state. The anterior margin of the carapace in most specimens was concave, but in some specimens was essentially straight or slightly convex. The number of primary denticles in row 6 on the fixed pedipalp finger in adult males varied from 11 to 20, and thus overlaps the ranges of the other three species in the subgenus. Of the four species in *Smeringurus, P. mesaensis* is the most widely distributed and the most morphologically variable. Eight relatively distinct populations were identified, all of which differed significantly from one another in one or more of the following characters: Adult size, mean number of pectinal teeth, morphometric ratios, numbers of primary denticles on the pedipalp fingers, and number and development of the carinal setae on the metasoma. Specimens from Saratoga Springs (San Bernardino Co.) in California had faint fuscous markings on the carapace and tergites. A few specimens from near Borrego Springs (San Diego Co.) in California also had faint fuscous markings on the carapace, and yellowish-orange pedipalps, carapace, and mesosoma, which contrasted with the typically pale yellow metasoma. All other samples of *P. mesaensis* from the Borrego Desert that I have studied have been uniformly pale yellow, and entirely lacked fuscosity.

Distribution.—Open desert areas, primarily eolian sand; in California, from Inyo County (Stovepipe Wells), southward throughout the Mojave and Colorado Deserts; in Arizona, from Maricopa County (Phoenix area) southwest to Yuma County, and along the Colorado River north into Mohave County; in Mexico, northeastern coast of Baja California Norte, south to near Puertecitos, and northwestern Sonora, south to Cabo Lobos.

Remarks.—Geographic variation in *P. mesaensis* has become the subject of a separate study. The above account is based upon samples from the several thousand specimens of *P. mesaensis* in the collection of the California Academy of Sciences, representing more than 120 localities throughout the range stated. The record (Williams 1980:38) of *P. mesaensis* from Bahia San Luis Gonzaga, Baja California Norte (CIS), has now been identified as *P. grandis.* Questionable records include: Jaraguay Summit, Baja California Norte, Mexico (Williams 1980:38), and Isla Tiburon, Sonora, Mexico (Gertsch and Soleglad 1966:40).

Paruroctonus grandis (Williams)
Figs. 5, 6, 13, 14

Vejovis (Paruroctonus) grandis Williams 1970b:277-281, figs. 1-2, tbl. 1.
Paruroctonus grandis: Williams 1972:3, 1980:32 (key), 35-36, figs. 39, 42; Soleglad 1972:72 (key), 75, 1973:355, tbl. 2; Stahnke 1974:138.
Vaejovis grandis: Diaz-Nájera 1975:6, 9.
Paruroctonus mesaensis: Williams 1980:38 (in part, misidentification, from Bahia San Luis Gonzaga, Baja California Norte, Mexico).

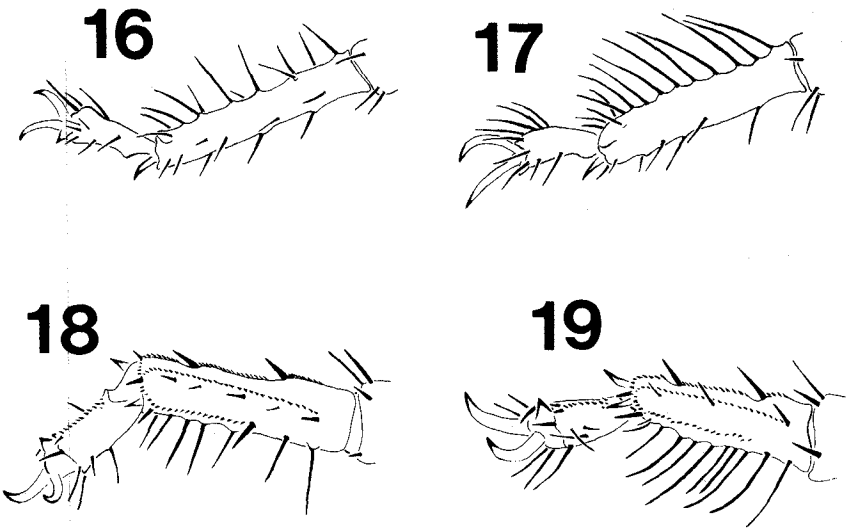
Types.—*Vejovis grandis:* Holotype male and allotype from Mexico, Baja California Norte, Oakies Landing, 27 mi. S Puertecitos, 12 June 1968 (S. C. Williams et al.). Depository: CAS, Type No. 10417.

Diagnosis.—A species of subgenus *Smeringurus;* adult males with moderately scalloped pedipalp fingers, closed fingers form distinct proximal gap (Fig. 6), 15 or fewer primary denticles in row 6 of fixed finger; legs 1 and 2 with large bristle at mid-length of basitar-

sus along inferior retrolateral row of spinules (similar to Fig. 18); eight or fewer irregularly positioned retrolateral setae on basitarsus of third pair of legs (similar to Fig. 16); eight pairs of ventrolateral setae on metasomal segment V; dorsal setae on metasomal segment II absent or distinctly smaller than dorsal setae on segments III-IV; fuscous markings usually distinct and extensive, but do not extend into interocular triangle (Fig. 13) or to the lateroposterior margin of tergites 3-6 (Fig. 14); juveniles and adults with light to dark reddish or reddish-brown pedipalp fingers, fingers darker than light yellowish palm; chela length/width, less then 2.96 in adult males; telson depth/metasomal segment V width, in adults equal to or less then 0.96; fixed finger length/distance *ib* trichobothrium to finger tip, in adults equal to or less then 1.22.

Variation.–The scalloping and resulting gap on the pedipalp fingers varied among adult males from slightly more to slightly less then the state shown in Figure 6, and among adult females from what is shown in Figure 5 to a slightly more scalloped state; fingers were essentially unscalloped on immatures and juveniles. The primary denticles in row 6 on the fixed pedipalp finger in adult males varied from 4 to 18; counting only the larger contiguous denticles of similar size, the count seldom exceeded 12. At least vestigial fuscous markings were always present on the carapace and tergites. Fuscosity was most distinct in juveniles and immatures. In the paratopotypic sample: Chela length/width, in adult males 2.78 ± 0.14, n = 40, in adult females 2.86 ± 0.14, n = 46; telson depth/metasomal segment V width, in adults 0.89 ± 0.05, n = 83; fixed finger length/distance *ib* trichobothrium to finger tip, adults 1.17 ± 0.03, n = 85. Samples representing other populations fell within these ranges of variation, with the exception of adult insular samples having the chela length/width in males 2.50 ± 0.03, n = 3, and in females 2.64 ± 0.10, n = 6.

In all peninsular samples the metasomal setae were well developed, but in the coastal samples from Puertecitos to Bahia San Luis Gonzaga the dorsal setae, particularly in males, were very long, slender, and more hairlike than bristly. In these samples the telson setae were also proportionately longer and slenderer, and occasional specimens had nine retrolateral setae on the basitarsus of leg 3.



Figs. 16-19.–Apotele and tarsal leg segments: 16, *P. vachoni*, right third leg, dorsal aspect; 17, *P. mesaensis*, right third leg, dorsal aspect; 18, *P. vachoni*, right first leg, ventral aspect; 19, *P. mesaensis*, right first leg, ventral aspect.

The insular populations differed from those on the peninsula in having very short dorsal metasomal setae on adults. The adult size attained on the islands is apparently greater than that of any known peninsular population. Carapace lengths on the peninsula varied among males 6.5-8.1 mm, and among females 7.5-9.6 mm (but usually less than 9.0 mm); on the islands males varied 8.5-9.1 mm, and females varied 9.6-11.0 mm. One female from Isla Angel de la Guarda with a carapace 7.8 mm long did not appear mature. Although gigantism has been reported for Gulf of California island populations among other Baja California scorpion species (Williams 1980:121), the relatively large size of the insular *P. grandis* specimens is not unusual for the subgenus, being comparable to certain populations of *P. vachoni.* In large insular adults the depth of the concavity of the anterior margin of the carapace was greater than what was observed among peninsular specimens. Several morphometric ratios among adults differed significantly ($P < 0.05$) between the insular and peninsular samples, reflecting positions along an apparently common, rather than a divergent, ontogenetic regression line. The morphometric differences observed did not provide a practical separation of these populations, and were of questionable significance, given the small island samples. Three specimens out of 44 from the islands bore a fuscous pattern similar to that of *P. vachoni.*

Distribution.–Rocky desert habitats in northeastern Baja California, Mexico, from near the U.S.A.-Mexico border south to Punta Trinidad, Baja California Sur, and from Isla Mejia, Isla Angel de la Guarda, and Isla Estanque in the Gulf of California.

Remarks.–The above account is based upon the samples of more than 1500 specimens reported by Williams (1970b:280-281, 1980:36).

Paruroctonus aridus Soleglad
Figs. 7, 8

Paruroctonus aridus Soleglad 1972:72 (key), 82-86, figs. 2, 5, 7, 9, tbl. 1, 1973:355, tbl. 2; Williams 1976:2.

Types.–*Paruroctonus aridus:* Holotype male from U.S.A., California, San Diego County, Anza-Borrego Desert State Park, 1 mile W Seventeen Palms Oasis, 24 October 1970 (C. S. and M. E. Soleglad, J. and J. L. Springer). Allotype from same locality, 12 June 1971 (M. E. Soleglad, L. R. Erickson). Depository: AMNH.

Diagnosis.–A species of subgenus *Smeringurus;* adult males with weakly scalloped pedipalp fingers, closed fingers form at most a narrow proximal gap (Fig. 8), 18 or more primary denticles in row 6 of fixed finger; legs 1 and 2 with large bristle at mid-length of basitarsus along inferior retrolateral row of spinules (similar to Fig. 18); eight or fewer irregularly positioned retrolateral setae on basitarsus of third pair of legs (similar to Fig. 16); eight pairs of ventrolateral setae on metasomal segment V; dorsal setae on metasomal segment II about as long as dorsal setae on segments III-IV; fuscosity essentially limited to faint interocular crescent; juveniles and adults with light to dark reddish or reddish-brown pedipalp fingers, fingers darker than pale yellow palm; chela length/width, adult males greater than 2.95; fixed finger length/distance *ib* trichobothrium to finger tip, adults equal to or greater than 1.23.

Variation.–The scalloping and resulting proximal gap on the pedipalp fingers varied among adult males from what is shown in Figure 8 to that shown for *P. mesaensis* in Figure 10; adult females were as shown in Figure 7. The primary denticle counts in row 6 of the pedipalp fixed finger among adult males varied from 20 to 26; the lower limit given

in the diagnosis above is a statistical estimate based upon a small sample (n = 12). One immature male, in which the full complement of primary denticles presumably had not yet developed, had counts of 14 and 16. The same immature specimen showed slightly more fuscosity around the median eyes and posterior region of the carapace. Chela length/width, adult males 3.22 ± 0.14, n = 6; two adult females, 2.83 and 3.16. Fixed finger length/distance *ib* trichobothrium to finger tip, adult males 1.28 ± 0.03, n = 6; two adult females, 1.27 and 1.33. The development of the ventral metasomal carinae I-III was intermediate to that of *P. mesaensis* (smooth) and *P. grandis* (usually weakly granular), making any distinction between taxa very subjective. The anterior margin of the carapace tended to be slightly convex in young adult and earlier instars. This margin in older adults was essentially straight but with a subtle medial concavity.

Distribution.–Known only from the type locality, where it inhabits rocky, sedimentary soil.

Remarks.–Two characters used by Soleglad (1972:82) to separate *P. aridus* from *P. immanis (= P. vachoni immanis)* were found, among additional specimens, to be no longer useful. The numbers of pectinal teeth in *P. aridus* males (33-40) and females (25-27) essentially coincide with the ranges in *P. vachoni* (Table 2). A similar range in numbers of pectinal teeth is shared by all the species in the subgenus. Tendencies toward higher or lower counts within this range appear to vary among populations within each species. On the holotype male of *P. aridus* I counted 34/32 pectinal teeth, not 36/36 as reported by Soleglad (1972:tbl. 1).

The ratio, telson depth/metasomal segment V width, is quite variable in both *P. aridus* and *P. vachoni.* Among adults I found no significant difference ($P > 0.05$) between the sexes in either species. There was a significant difference between the species ($t = 2.54$, n = 66; where *P. aridus* = 0.976 ± 0.073, n = 6, and *P. vachoni* = 1.050 ± 0.068, n = 60), but the respective ranges in variation do not permit a practical separation.

The convex anterior carapacial margin illustrated by Soleglad (1972:78, fig. 5) appears to be characteristic of young adult and earlier instars of *P. aridus.* Larger and presumably older specimens, including the holotype and allotype, of this species have an essentially straight anterior margin. Rounded anterior-lateral margins also occur in large specimens of *P. grandis.*

Specimens examined.–U.S.A.: CALIFORNIA: *San Diego County*, Anza-Borrego Desert State Park, 1 mi. W Seventeen Palms Oasis, 24 October 1970 (M. E. Soleglad et al.), holotype male (AMNH), 12 June 1971 (M. E. Soleglad, L. R. Erickson), allotype (AMNH), 10 August 1974 (R. M. Haradon, W. E. Savary), 6 males, 2 females (CAS).

KEY TO SUBGENERA OF *PARUROCTONUS* WERNER

1. Numerous intercarinal setae on ventral surface of metasomal segments I-IV present (Fig. 1); in adults and juveniles, metasomal segment III length/width greater than 1.90 . . . . . *Smeringurus*, new subgenus
   Numerous intercarinal setae on ventral surface of metasomal segments I-IV absent; in adults and juveniles, metasomal segment III length/width less than 1.90. . . . . *Paruroctonus*

KEY TO SPECIES AND SUBSPECIES OF SUBGENUS *SMERINGURUS*

1. Basitarsus on legs 1 and 2 lacking large bristle along inferior retrolateral row of spinules (Fig. 19); 10 or more pairs of ventrolateral setae on metasomal segment V . . . . . *mesaensis* Stahnke
   Basitarsus on legs 1 and 2 bearing large bristle along inferior retrolateral row of spinules (Fig. 18); eight or fewer pairs of ventrolateral setae on metasomal segment V . . .2
2. Closed pedipalp fingers of adult male form at most a narrow proximal gap (Fig. 8), with 18 or more primary denticles in row 6 of fixed finger; fuscosity limited to vestigial interocular crescent . . . . . *.aridus* Soleglad
   Closed pedipalp fingers of adult male form conspicuous proximal gap (Figs. 4, 6), with 15 or fewer primary denticles in row 6 of fixed finger; fuscosity extensive on carapace and tergites (Figs. 11-14) 3
3. Closed pedipalp fingers of adult male form moderate gap (Fig. 6); fuscosity essentially lacking in interocular triangle (Fig. 13), and does not extend to lateroposterior margin on tergites 3-6 (Fig. 14); paired dorsal metasomal setae on segment II absent or much smaller than dorsal setae III-IV. . . . . *.grandis* (Williams)
   Closed pedipalp fingers of adult male form prominent gap (Fig. 4); fuscosity extends into most or all of interocular triangle (Fig. 11), and to lateroposterior margin on tergites 3-6 (Fig. 12); paired dorsal metasomal setae on segment II about as long as setae III-IV. 4
4. Primary denticle counts in rows 1-5 on pedipalp fingers close to 6/7/9/10/12 on fixed finger, 8/10/12/12/19 on movable finger; from Death Valley region in California and southwestern Nevada (Fig. 15). . . . . *vachoni vachoni* Stahnke
   Primary denticle counts in rows 1-5 on pedipalp fingers close to 7/8/11/11/13 on fixed finger, 9/11/13/13/19 on movable finger; from southern Mojave and Colorado Deserts in California (Fig. 15). . . . . *vachoni immanis* Soleglad

ACKNOWLEDGMENTS

Loans of specimens were made available through the courtesy of Dr. Norman I. Platnick, American Museum of Natural History (AMNH), Dr. David H. Kavanaugh and Dr. Wojciech J. Pulawski, California Academy of Sciences (CAS), Dr. Oscar F. Francke, Texas Tech University (OFF), and Dr. John A. Chemsak, California Insect Survey, University of California (CIS). I would also like to thank Dr. David H. Kavanaugh and Dr. Paul H. Arnaud for making available to me the research facilities at the California Academy of Sciences. Mr. Michael E. Soleglad, Lemon Grove, California, very kindly provided additional data on the type locality of *P. immanis*. Mr. Joseph L. Marks, Santa Monica, California, helped collect specimens upon which an important part of this study is based. Dr. Stanley C. Williams, San Francisco State University, helped immeasurably by reviewing an early draft of this report, and also by extending encouragement and numerous courtesies without which this work would not have been completed.

LITERATURE CITED

Bowerman, R. F. 1976. An electrophysiological survey of joint receptors in the walking legs of the scorpion, *Paruroctonus mesaensis*. J. Comp. Physiol., 105:363-366.

Brownell, P. H. 1977. Compressional and surface waves in sand: Used by desert scorpions to locate prey. Science, 197:479-482.

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

Gertsch, W. J. 1958. Results of the Puritan-American Museum Expedition to western Mexico. 4. The scorpions. Amer. Mus. Novitates, No. 1903, 20 pp.

Gertsch, W. J. and D. M. Allred. 1965. Scorpions of the Nevada Text 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. Novitates, No. 2278, 54 pp.

Gertsch, W. J. and M. Soleglad. 1972. Studies of North American scorpions of the genera *Uroctonus* and *Vejovis* (Scorpionida, Vejovidae). Bull. Amer. Mus. Nat. His. 148:549-608.

Hadley, N. F. and L. Jackson. 1977. Chemical composition of the epicuticular lipids of the scorpion, *Paruroctonus mesaensis.* Insect Biochem., 7:85-89.

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. 1974. *Vaejovis spicatus:* A new scorpion from California (Scorpionida: Vaejovidae). Pan-Pacific Entomol., 50:23-27.

Hjelle, J. T. 1972. Scorpions of the northern California Coast Ranges. Occas. Pap. California Acad. Sci., No. 92, 59 pp.

Newlands, G. 1972. Notes on psammophilous scorpions and a description of a new species (Arachnida: Scorpionides). Ann. Transvaal Mus., 27:241-254.

Polis, G. A. and R. D. Farley. 1979a. Behavior and ecology of mating in the cannibalistic scorpion. *Paruroctonus mesaensis* Stahnke (Scorpionida: Vaejovidae). J. Arachnol., 7:33-46.

Polis, G. A. and R. D. Farley. 1979b. Characteristics and environmental determinants of natality, growth and maturity in a natural population of the desert scorpion, *Paruroctonus mesaensis* (Scorpionida: Vaejovidae). J. Zool., London, 187:517-542.

Polis, G. A. and R. D. Farley. 1980. Population biology of a desert scorpion: Survivorship, microhabitat, and the evolution of life history strategy. Ecology, 61:620-629.

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. 1957. A new species of scorpion of the Vejovidae, *Paruroctonus mesaensis.* Entomol. News, 68:253-259.

Stahnke, H. L. 1961. A new species of scorpion of the Vejovidae, *Paruroctonus vachoni.* Entomol. News, 72:206-212.

Stahnke, H. L. 1965. Observations on the type specimen of the scorpion *Syntropis macrura* Kraepelin. Proc. California Acad. Sci., 4th ser., 30:257-263.

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.

Tourtlotte, G. I. 1974. Studies on the biology and ecology of the northern scorpion, *Paruroctonus boreus* (Girard). Great Basin Nat., 34:167-179.

Werner, F. 1934. Scorpiones. Pp. 1-316. *In:* Klassen und Ordnungen des Tierreichs (H. G. Bronn, ed.). Akad. Verlag., Leipzig, Bd. 5, Abt. 4, Buch 8, 512 pp.

Williams, S. C. 1968a. Scorpions from northern Mexico: Five new species of *Vejovis* from Coahuila, Mexico. Occas. Pap. California Acad. Sci., No. 68, 24 pp.

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

Williams, S. C. 1969. A new species of *Syntropis* from Baja California Sur, Mexico, with notes on its biology (Scorpionida: Vejovidae). Pan-Pacific Entomol., 45:285-291.

Williams, S. C. 1970a. Three new species of *Vejovis* from Death Valley, California. Pan-Pacific Entomol., 46:1-11.

Williams, S. C. 1970b. Scorpion fauna of Baja California, Mexico: Eleven new species of *Vejovis* (Scorpionida: Vejovidae). Proc. California Acad. Sci., 4th ser., 37:275-332.

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. 1974. A new genus of North American scorpions with a key to the North American genera of Vaejovidae (Scorpionida: Vaejovidae). Proc. California Acad. Sci., 4th ser., 40:1-16.

Williams, S. C. 1976. The scorpion fauna of California. Bull. Soc. Vector Ecol., 3:1-4.

Williams, S. C. 1980. Scorpions of Baja California, Mexico, and adjacent islands. Occas. Pap. California Acad. Sci., No. 135, 127 pp.

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., 4th ser., 35:103-116.

Wright, R. P., T. K. Chen, L. Honetschlager, D. E. Howell and G. V. Odell. 1977. Enzymes and toxins of the scorpion venom *Palamneus gravimanus*. Toxicon, 15:197-205.

Manuscript received November 1981, revised April 1982.