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CHARACTER VARIATION IN THE SCORPION *PARABUTHUS VILLOSUS* (PETERS) (SCORPIONES, BUTHIDAE): A CASE OF INTERMEDIATE ZONES

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ABSTRACT

The scorpion *Parabuthus villosus* (Peters) shows variation in leg colors over its range. The distributions of the color morphs are parapatric. A fairly narrow intermediate zone is found where the yellow and black legged morphs meet. A similar zone is present at the parapatric interface between *P. villosus* and *P. brachystylus*. Using multivariate morphometrics the morphological variation was found to be insignificant between the color morphs, but intermediates between *P. villosus* and *P. brachystylus* show morphology in-between that of the presumed parental forms. Factors that may be involved in the maintenance of the step lines are also suggested. Finally, *P. brachystylus* is given subspecific status.

INTRODUCTION

The scorpion *Parabuthus villosus* (Peters) is a large buthid widespread in Namibia. It differs from other members of the genus in that it is partly diurnal (Newlands 1974, Harington 1982). The species is characteristic of dry rocky habitats in Namibia and the northwestern Cape Province of South Africa. It does not occur in the sand dune areas of the Namib and Kalahari Deserts proper, but is sometimes found in places where dunes and rocky hills run together. It is a rupicolous species, sheltering under stones, where scrapes are sometimes constructed. Currently, *Parabuthus brachystylus* Lawrence is considered to be most closely related to *P. villosus* and is found predominantly in the northern third of Namibia (Lamoral 1979). This scorpion occurs in similar habitats to those described for *P. villosus.*

In spite of the large range occupied by *P. villosus*, little morphological variation is noticed. In contrast, there is considerable variation in the colors of the legs and pedipalps. In the present contribution the nature of this variation in *P. villosus* is analysed and the relationship between *P. villosus* and *P. brachystylus* is investigated.

METHODS

Collection of specimens was done manually by turning over rocks, and by the use of ultraviolet lamps in the summer months. In spite of the wide distribution of *P. villosus*, it is not easy to find. To supplement the specimens collected, all available preserved material of *P. villosus* and *P. brachystylus* in South African and Namibian museums was examined.

Because the morphological differences among the color variants and between *villosus* and *brachystylus* are not marked, a multivariate morphometrical method was employed to assess the importance of various characters. About 150 adults were available for the multivariate analysis. Fifteen measurements per specimen were made using an ocular micrometer. As the *Parabuthus* cauda contains a wealth of taxonomical characters most measurements were taken there. The length and width of the caudal segments (including the telson), the length of the stridulatory patch on caudal segment two, and the lengths of the first and fourth patellae on the right side of the scorpion were measured. Width, being the maximum distance between the bases of the median lateral keels, was measured dorsally. Length, as the minimum distance between the condyles, was measured dorsally. and the width of caudal segment five taken ventrally as the maximum distance between the bases of the ventrolateral keels. The landmarks used are illustrated in Fig. 1. Assignments to color classes was not particularly difficult since the color is largely stable in preservation and ontogeny.

Direct micrometer readings were used as data for computer analysis. One micrometer unit was equivalent to 0.15 mm. In the discriminant analysis, a Statistical Package for the Social Sciences program (see Klecka 1975) was used and run on an IBM 37T/158 computer.

COLOR VARIATION IN *PARABUTHUS VILLOSUS*

Color variation in scorpions is well known and fairly common (see Lamoral 1979, Williams 1970, 1980). Before describing it in *P. villosus* it is useful to consider its nature as known in other scorpions. Generally color differences are of an intraspecific nature.

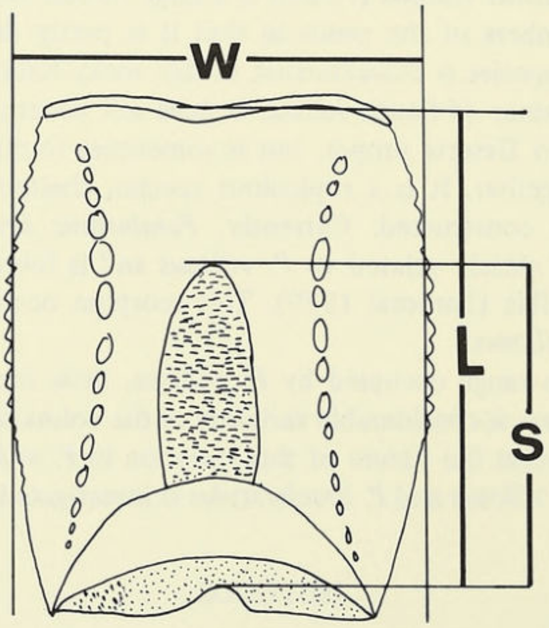


Fig. 1.—Reference points used for measurement of metrical parameters of the cauda of *Parabuthus*. Dorsal view of caudal segment 2 illustrated. *w*, *l*, and *s* indicate width of caudal segment, length of caudal segment, and length of stridulatory patch respectively.

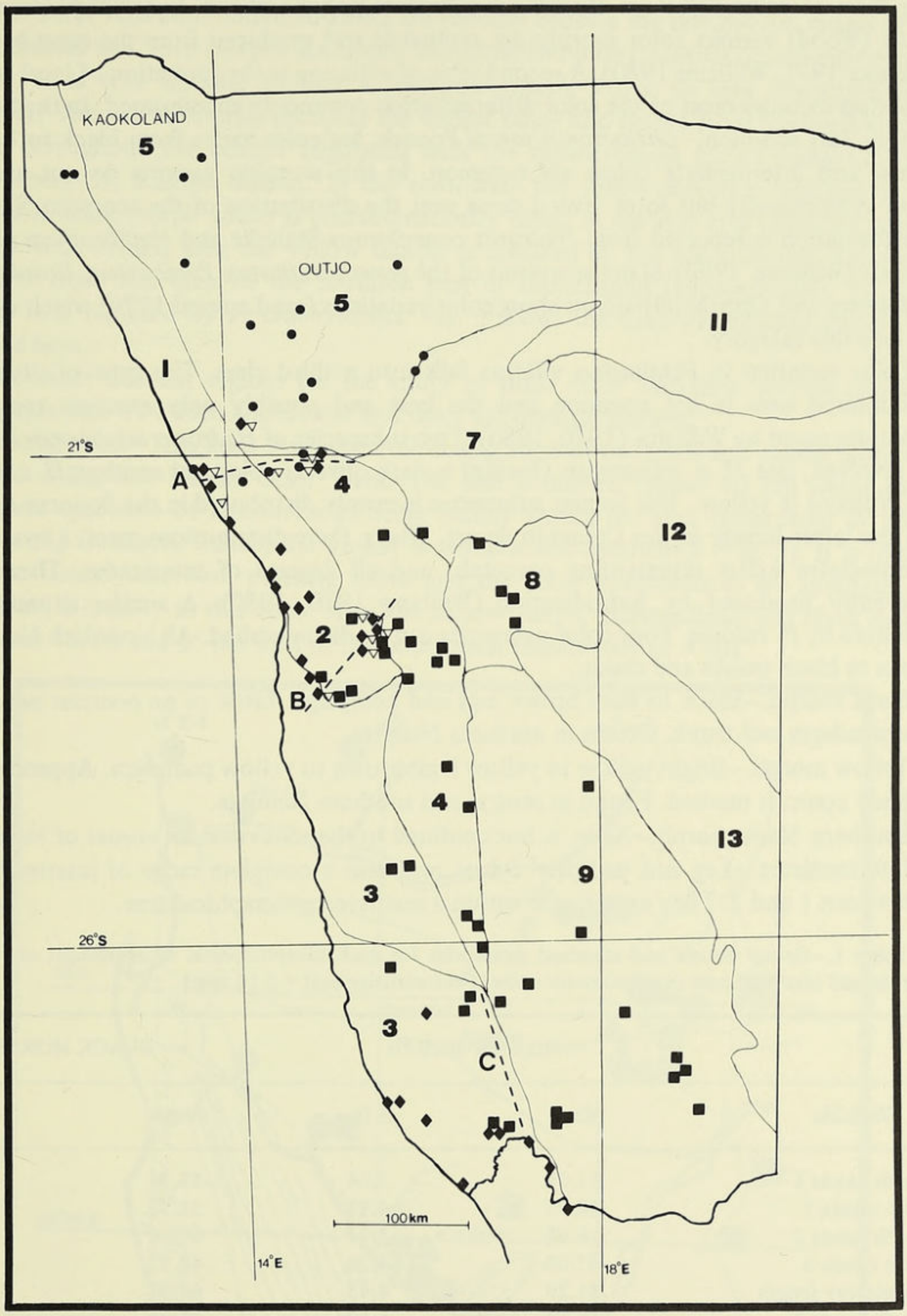


Fig. 2.–Map showing distributions of the color morphs of *Parabuthus villosus* and *P. brachystylus* superimposed on vegetation zones. Note correlation of distributions of scorpions and location of the intermediate zones with vegetation. Scorpions: dots-*brachystylus;* northern triangles-*villosus-brachystylus* intermediates; northern diamonds-black morph; southern triangles-color intermediates; squares-yellow morph; southern diamonds-southern black morph. Intermediate zones: A, *villosus brachystylus;* B, Central; C, Southern. Vegetation: 1-Northern Namib; 2-Central Namib; upper 3-Southern Namib; lower 3-Desert and Succulent Steppe; 4-Semi-desert and Savannah Transition; 5-Mopane Savannah; 7-Thornbush Savannah; 8-Highland Savannah; 9-Dwarf Shrub Savannah; 11, 12 and 13-Kalahari Savannahs.

One form of color difference reported is a type of polymorphism. In *Centruroides exilicauda* (Wood) various color morphs are sympatric and produced from the same broods (Stahnke 1971, Williams 1980). A second type of variation is the formation of local races. This class includes most of the color differentiation commonly encountered. In the South African turf scorpion, *Cheloctonus jonesi* Pocock, leg color varies from black to bright yellow and intermediate colors are common. In this scorpion variants do not usually occur sympatrically but form several races over the distribution of the scorpion. Similar race formation is reported from *Hadrurus concolorous* Stahnke and *Nullibrotheas allenii* (Wood) (Williams 1980). Many scorpions of the genera *Buthotus, Parabuthus, Uroplectes, Hadogenes* and *Opisthophthalmus* show color variations (see Lamoral 1979) which would fall into this category.

Color variation in *Parabuthus villosus* falls into a third class. The type of situation encountered here is not common and the best and possibly only example reported is that discussed by Williams (1970, 1980). Two subspecies of *Hadrurus arizonensis* Ewing are involved, one *H. a. arizonensis* (Ewing) is dark olive in color and another, *H. a. pallidus* Williams is yellow. The former subspecies is mainly distributed in the Sonoran desert and the latter largely in the Colorado desert. Where there distributions meet, a swarm of intermediates exists representing parentals, and all degrees of intergrades. These are apparently produced by hybridization (Williams 1970, 1980). A similar situation is presented by *P. villosus.* Four color categories can be distinguished. All have dark blackish brown to black trunks and cauda:

1. Black morph.—Black to dark brown legs and pedipalps. Little or no contrast between appendages and trunk. Occurs in northern Namibia.
2. Yellow morph.—Bright yellow to yellow legs, brown to yellow pedipalps. Appendages - body contrast marked. Found in central and southern Namibia.
3. Southern black morph.—As in 1, but confined to the southwestern corner of Namibia.
4. Intermediates.—Leg and pedipalp colors represent a complete range of intermediates between 1 and 2. They are present within a restricted geographical area.

Table 1.—Group means and standard deviations for each morphometric measurement of yellow morphs and black morphs in micrometer units (1 micrometer unit = 0.15 mm).

	YELLOW MORPH		BLACK MORPH	
Variable	Mean	S.D.	Mean	S.D.
Length cauda 1	51.79	5.04	53.94	4.66
Width cauda 1	48.75	4.97	51.72	4.47
Length cauda 2	58.68	5.74	61.06	4.83
Width cauda 2	47.00	4.28	49.72	3.94
Stridulatory length	41.29	4.43	43.58	3.40
Length cauda 3	59.43	6.12	61.94	4.67
Width cauda 3	46.32	4.04	48.72	3.59
Length cauda 4	64.50	6.21	67.28	5.05
Width cauda 4	44.64	3.88	47.39	3.85
Length cauda 5	66.57	6.31	69.17	5.06
Width cauda 5	38.14	3.74	41.06	3.59
Length telson	83.99	7.74	85.88	7.03
Width telson	41.19	5.27	44.67	5.25
Length patella 1	43.79	3.38	45.00	2.74
Length patella 4	71.36	6.18	74.39	5.18

The color variations described above are peculiar because the distribution ranges of the first, second and third morphs are largely allopatric and intergradation occurs over narrow zones. It is very unusual to find a particular morph within an area characteristic of another. The yellow morph occupies the widest range and occurs from the northwestern Cape throughout the central Highlands with the northernmost record being the farm Krantzberg 59, Karibib district. In the southwest the yellow morph is replaced by the southern black morph which is characteristically found in the very arid Diamond Area 1. In the west central area the yellow morph is replaced by the black morph. This latter extends from this area to the southern part of Damaraland (approximately 21°20′S) where it is replaced by *P. brachystylus.* Fig. 2 shows the basic distribution pattern described here.

The most relevant regions for the study of these color variations are the zones of intergradation. Two such zones exist and these are discussed below.

Central zone.–This zone resulting from intergration of the black and yellow morphs is located within the Namib Desert Park. The belt is narrow (about 40 km wide) and a complete spectrum of intermediates occur mainly within the area demarcated by a line connecting Gobabeb, Ganab, the Tinkas Mountains and Swartbank (Fig. 3). It is important to notice that both parental forms and the color intermediates are sympatric at Gobabeb, a locality in this zone. Here the yellow morph, intermediates and black morph comprise 45, 30 and 25 per cent of the population respectively (n = 40).

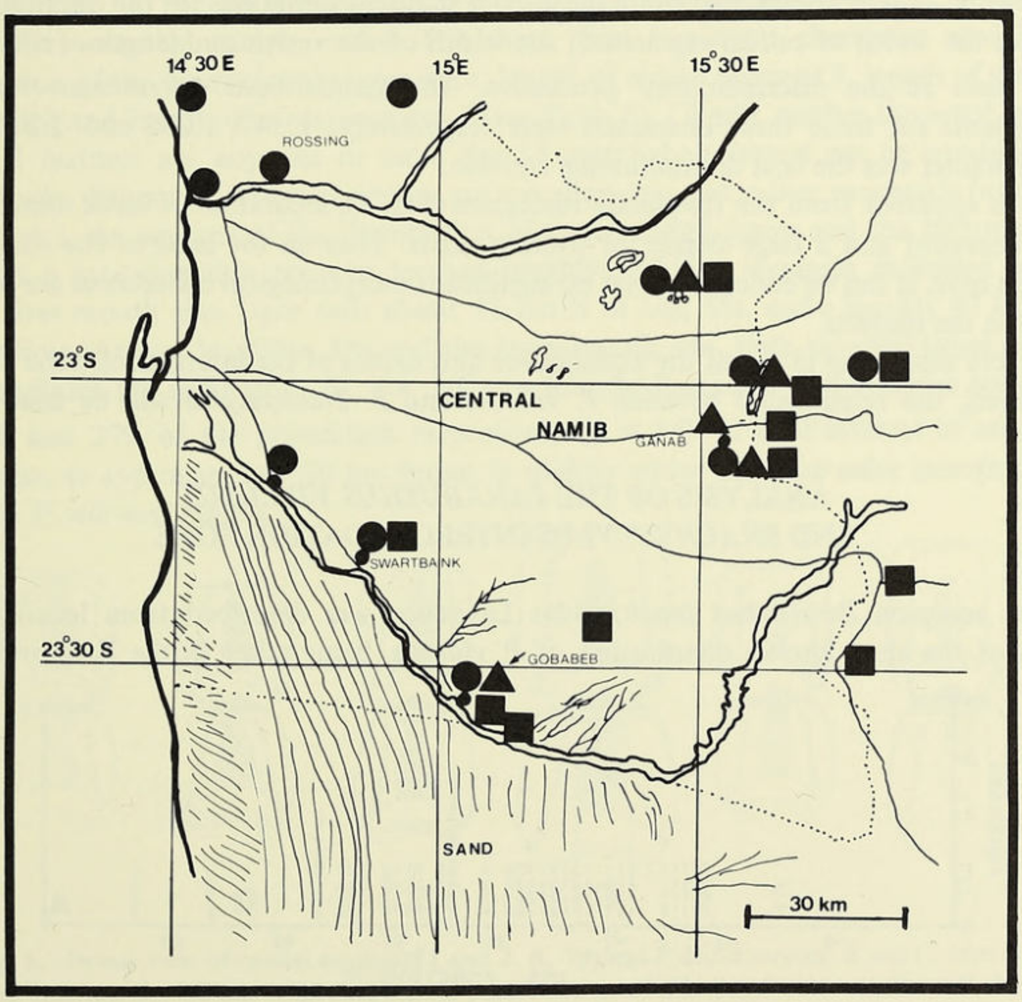


Fig. 3.–Map of Central Namib desert showing location of the central intermediate zone. Squares represent the yellow morph, dots the black morph and triangles color intermediates.

Southwestern zone.—This area is located along the eastern border of Diamond Area 1. At one locality, the farm Tsirub 13, Lüderitz district, the yellow morph and the southern black morph are sympatric but no intermediates have been found. Here the black/yellow transition is abrupt. At a second known locality of sympatry (Rosh Pinah - Namuskluft 88), much further south, intermediates are present. Due to lack of material the southwestern zone is too poorly known to allow much further analysis.

As the color variants already described are largely allopatric it was decided to investigate whether any morphological differences exist between the morphs. Twenty scorpions from Rössing Uranium Mine (black morph) and twenty from Gobabeb (yellow morph) were used in the multivariate analysis. These sample sizes are fairly large and the localities relatively close. Discriminant function analysis involves the simultaneous analysis of several variable characters and is one of the most sensitive methods known for separating groups on the basis of morphology. After measurements have been taken, a discriminant function is derived from them. This is a complex procedure involving the calculation of vectors and weighting coefficients for each particular variable. These discriminant functions express the differences between the groups in terms of a few common gradients of variation rather than all the possible gradients. The functions are designed to maximise group separation and make these as statistically distinct as possible. More detailed explanation of the theory behind multivariate discriminant function analysis is provided by Klecka (1975).

Results.—Table 1 gives the group means and standard deviations. In the discrimination process the width of caudal segment 5, the width of the vesicle and length of the vesicle were used in the discriminatory procedure. The standardised discriminant function coefficients for these three characters were respectively: 1.547, 1.088 and -2.215. The last character was the best discriminating variable.

As is apparent from the frequency histogram (Fig. 4), separation of black morphs was not successful and a large degree of overlap exists. Thus on the basis of the characters studied here, it can be concluded that no significant morphological differences are present between the morphs.

Before discussing in detail the significance and causes of the intergration zone already described, the relationship between *P. villosus* and *P. brachystylus* will be dealt with.

ANALYSIS OF THE *PARABUTHUS VILLOSUS* AND *BRACHYSTYLUS* INTERGRADATION ZONE

The scorpion *Parabuthus brachystylus* Lawrence was described from localities far north of the then known distribution of *P. villosus*, being taken in the Kaokoveld and

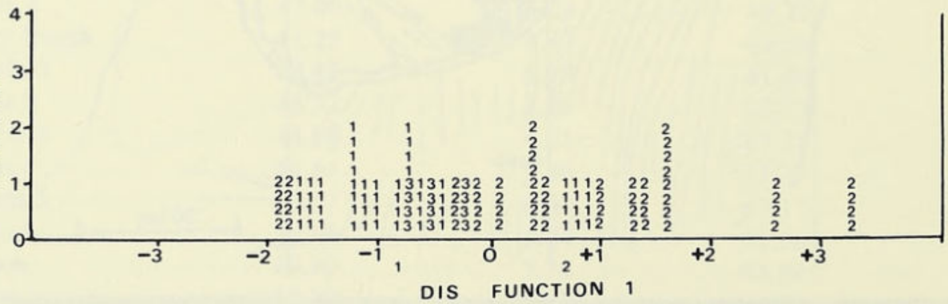


Fig. 4.—Frequency histogram of discriminant function 1 versus frequency. Each column of four figures represents a specimen. 1 denotes the yellow morph, 2 the black morph and 3 overlapping cases. Small 1 and 2 below baseline show group centroids.

Outjo districts (Lawrence 1928). Although the two scorpions are very similar morphologically, certain differences are apparent. The most obvious one lies in the length of the stridulatory patch on caudal segment 2. In *villosus* this shagreened area is oval and restricted to the anterior two thirds of the segment. In *brachystylus* it extends as a broad parallel-sided row of granules to the hind end of the segment. In addition to this, the first caudal segment is longer than wide in *villosus* and *vice versa* in *brachystylus* (Fig. 5). The width percentage of length was reported to be 92 - 98% in *villosus* and 103 - 109% in *brachystylus* (Lamoral 1979).

Differences in haemolymph phoreograms between *villosus* and *brachystylus* have been reported (Lamoral 1979). Electrophoresis of venom and haemolymph on Sodium Dodecyl Sulphate polyacrylamide gels, resolving up to 25 bands per sample, failed to reveal significant differences between *P. villosus* and *P. brachystylus* (Harington pers. obs.). Non denaturing disc electrophoresis of haemolymph did not show any differences either.

On reanalysis the "diagnostic" morphological features proved to be subject to extensive variation. This flux is concentrated in an area juxtaposed between the main distributions of the two scorpions. The nature of this variation is apparent in Fig. 5. Two ratios, w/l_1 (width/length of caudal segment 1) and s/l_2 (length of stridulatory area/length of caudal segment 2) were calculated to track the change in morphology. These parameters were then plotted against latitude (Figs. 6, 7). In addition, the discriminant scores of three classes, namely *villosus*, intermediates and *brachystylus*, were plotted against latitude (Fig. 8). The discriminant score gives a more inclusive assessment of morphological differences than simple ratios. The three most important characters used in the calculation of the discriminant scores were: length of caudal segment 3, length of stridulatory patch and length of caudal segment 1 (see Table 6). Clearly, neither the usual morphological features nor any one or more the 15 metrical characters can be considered as being truly diagnostic. These scorpions are not allopatric, but rather parapatric (narrowly sympatric). An analysis of the distribution of two parental forms and the intermediates allowed a intergradation zone be located roughly within a rectangle delimited by the Ugab river mouth site, Ugab drift about 32 km N of Uis, Uis, and a locality 43 km N of Cape Cross. At two localities, Uis and the Ugab mouth site, both parental types and the intermediates are sympatric. At Uis, *villosus*, intermediates and *brachystylus* composed 13, 60 and 27% of the population respectively (n = 15). It is of interest to note that this zone, at approximately 50 km broad, is slightly wider than the color intergradation zone of *P. villosus* (Fig. 9).

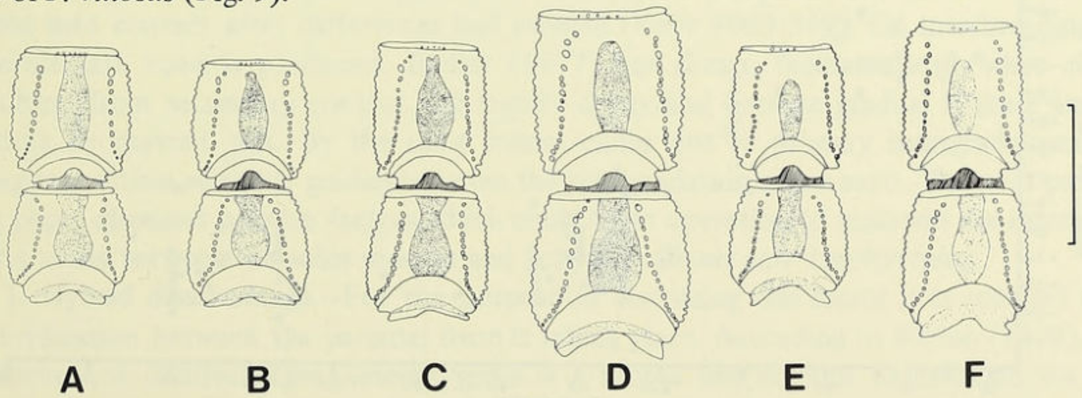
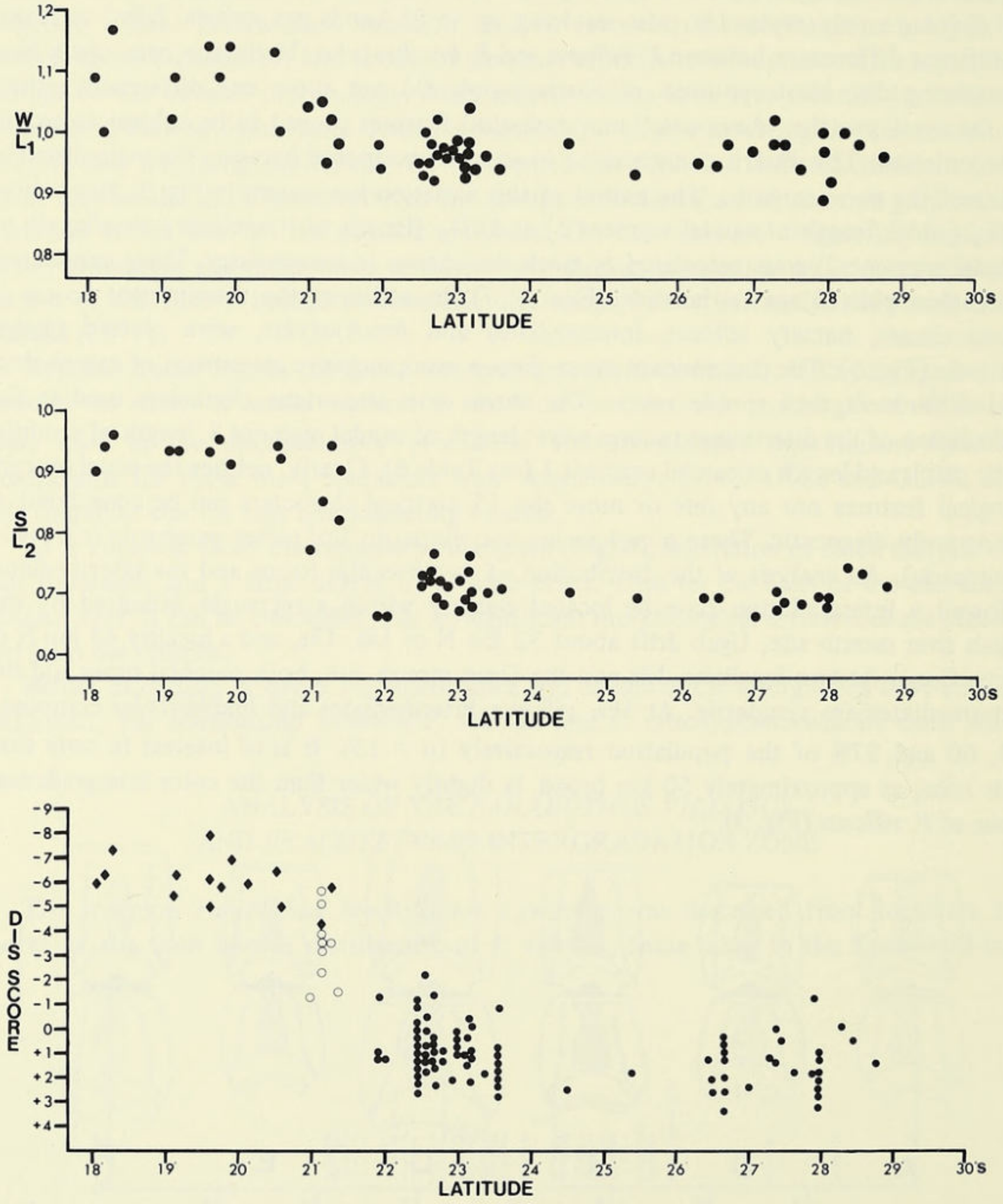


Fig. 5.–Dorsal view of caudal segments 1 and 2. A, Typical *P. brachystylus;* B and C, intermediates close to *brachystylus* (C has a tail shape more characteristic of *villosus*); D, intermediate; E, *P. villosus* with *brachystylus* - like first caudal segment; F, typical *P. villosus.* Setation has not been illustrated and the scale represents 1 cm.
]

Stepped clines as illustrated in Figs. 6, 7 and 8 are often characterized by increased variability within the intergradation zone. In order to assess this variation and to further analyse the importance of morphological differences between *villosus* and *brachystylus*, a multivariate analysis was done. Specimens were assigned to their particular group on the basis of the length of the stridulatory patch.

Results.—Table 2 gives the group means and standard deviations of variables measured. Table 3 gives standardised discriminant function coefficients. Fig. 10 is a scatterplot of discriminant scores against the two discriminant functions. Several interesting conclusions can be drawn from the results. The increased variability present within the intermediates



Figs. 6-8.—Fig. 6, the ratio w/l_1 plotted against latitude; 7, the ratio s/l_2 plotted against latitude; 8, discriminant score of *brachystylus* (diamonds), intermediates (circles), and *villosus* (dots), is plotted against latitude.

Table 2.–Group means and standard deviations for each morphometric measurement of *P. villosus*, *P. brachystylus* and intermediates in micrometer units (1 micrometer unit - 0.15 mm).

	VILLOSUS		BRACHYSTYLUS		INTERMEDIATES	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.
Length cauda 1	53.78	5.56	44.00	8.84	51.73	8.95
Width cauda 1	51.58	5.27	47.33	8.24	53.72	9.13
Length cauda 2	60.67	5.79	50.37	9.44	58.45	9.67
Width cauda 2	50.00	4.88	46.20	7.50	52.36	8.66
Stridulatory length	42.94	4.83	46.83	8.77	48.95	7.84
Length cauda 3	61.16	5.88	51.90	9.50	59.68	9.71
Width cauda 3	48.83	4.64	45.27	7.28	51.32	8.68
Length cauda 4	66.23	6.38	56.30	10.58	65.66	10.65
Width cauda 4	47.37	4.68	44.03	7.28	49.64	8.14
Length cauda 5	69.21	7.02	57.87	10.35	67.18	10.63
Width cauda 5	40.34	4.05	38.17	6.27	42.73	7.63
Length telson	85.98	7.78	76.27	13.50	86.79	12.62
Width telson	43.88	6.73	39.60	8.37	45.86	8.74
Length patella 1	44.12	3.37	38.47	6.72	43.18	5.90
Length patella 4	72.73	5.68	62.60	10.45	71.36	9.74

in spite of their restricted geographical distribution is clearly apparent. The length of the stridulatory patch as an indicator of the intermediate class is slightly biased in that it chooses intermediates that are slightly closer to *brachystylus*. However, designation of intermediates by this means remains very efficient as a reclassification success of 97% (Table 4) was obtained.

DISCUSSION

Intergradation zones and their associated step clines can be produced in two ways. In the case of primary intergradation, the clines developed while the populations were in continuous contact (Mayr 1963:369). Natural selection played a direct role in the differentiation process. In the case of secondary intergradation, two populations now connected by a steeply sloping character gradient were completely separated at one time but have come into contact after differences had evolved (Mayr 1963:369). On interbreeding an intermediate zone is produced. Endler (1977) has shown mathematically that clines resulting from secondary contact will rapidly decay and become gradual if there are no factors to prevent this. By the same token, clines due to primary intergradation will disappear unless selective gradients across the intergradation zones exist. The next part of the paper discusses possible factors which could be in operation to maintain the intergradation zones between the color morphs and between *villosus* and *brachystylus*.

1. **Hybrid disadvantage.**–For the purpose of discussing this factor it is assumed that hybridization between the parental form is taking place. According to Barton (1979), the existence of disadvantaged heterozygotes is a simple and obvious explanation for the existence of a narrow hybrid zone. Such hybrids may be interior in viability, fertility, fecundity or mating success *(vide supra)*. While this may be a factor maintaining the step clines described, all living intermediates I have seen are very fit. This does not necessarily extend to their Darwinian fitness. The fact that a range of intermediates is encountered

in both zones suggests that further crossing is probable. A test of this would be to demonstrate that hybridization is occurring and that gravid hybrid females exist.

2. **Adaptation of morphs to different physical environments.**—Studies on skinks (Huey and Pianka 1977) and desert geckos (Huey 1979) have shown that adaptations to different physical environments may well account for some parapatric distributions. An analysis of the distribution patterns of color morphs, *brachystylus*, and intergradation zones, revealed a good correlation with the occurrence of vegetation types determined by Geiss (1971) (Fig. 3). Furthermore, the width of the step clines correlates with the abruptness of the vegetation changes. In broad terms, the black morph is found in the Central Namib and Semi-desert areas (2 and northern 4) with *brachystylus* in the Mopane Savannah (5) to the north of this. Towards the south, the yellow morph dominates, in the Savannah Transition (4), Highland Savannah (8) and Dwarf Shrub Savannah (9) vegetation zones. The southern black legged morph is virtually confined to the very arid Desert and Succulent Steppe (lower 3). It is interesting to note the absence of all these scorpions in the Kalahari Savannah (11, 12, 13) probably due to the absence of rock cover.

All three of the intergradation zones lie in areas where change in vegetation type is abrupt. Other less significant changes in vegetation type take place within the ranges of the scorpions.

(a) *villosus-brachystylus* intergradation zone: Change over in vegetation here occurs over about 50 km (E. R. Robinson, pers. comm.) which corresponds to the intergradation zone. A drop in altitude occurs simultaneously.

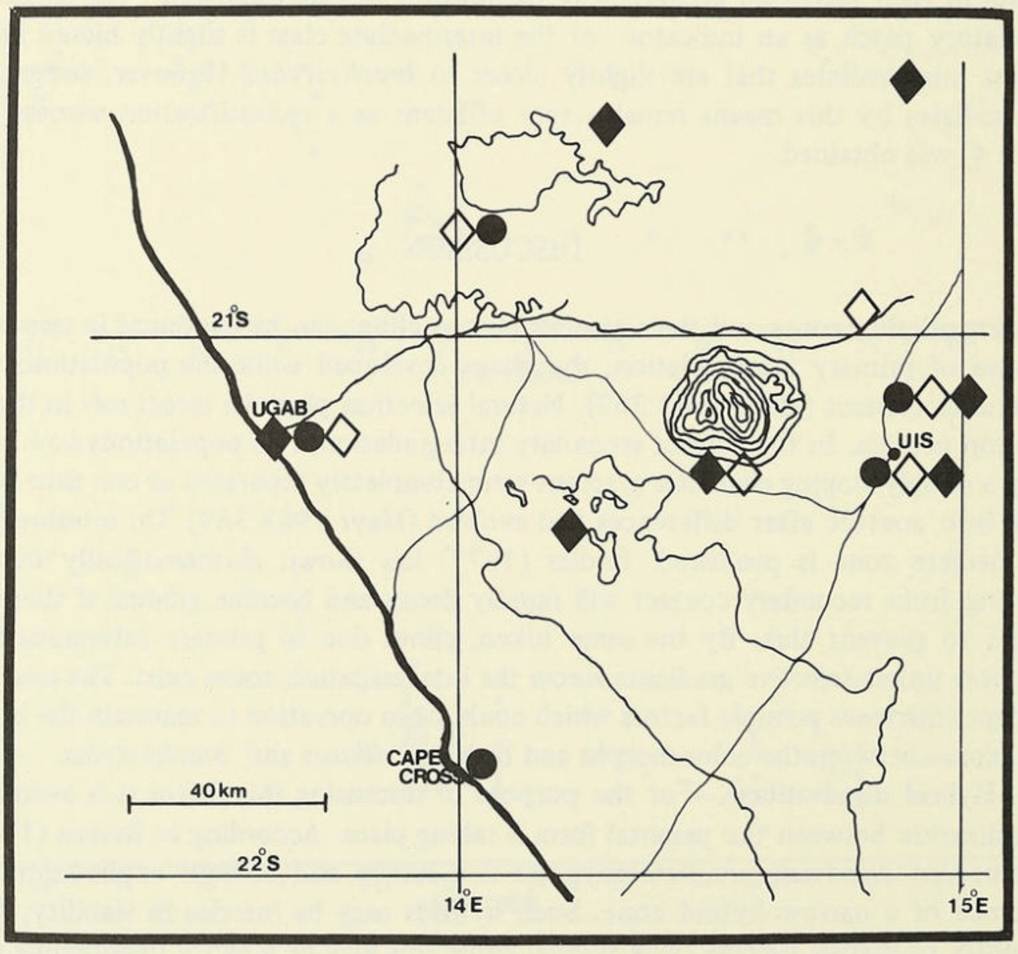


Fig. 9.—Map showing location of the *villosus-brachystylus* intermediate zone. Black diamonds represent *brachystylus*, open diamonds and dots denoting intermediates and *villosus* respectively.

Table 3.–Standardised discriminant function coefficients for each variable used in discrimination procedure of *villosus* - *brachystylus* analysis. Best discriminating variables are indicated by asterisks.

Variable	Function 1	Function 2
Length cauda 1	2.079*	-0.010
Width cauda 1	-1.719	-1.070
Length cauda 2	1.754	-1.676*
Width cauda 2	1.531	3.452*
Stridulatory length	-2.381*	-0.287
Length cauda 3	-2.503*	-1.311
Length cauda 4	1.476	2.996*
Width Cauda 4	-1.081	-1.050
Length cauda 5	0.606	-1.260
Width cauda 5	-0.640	-0.145
Length patella 4	0.808	1.018

(b) Central zone: An estimate for the vegetation transition zone is 10 -20 km (E. R. Robinson, pers. comm.) which corresponds to the observed color intergradation zone. The presence of the savannah-associated yellow morph within the Central Namib may be associated with mountains and riverbeds where less xeric habitats and vegetation are found. The yellow morph is mainly found in association with the Kuiseb river and the Arachadmab - Tumas mountain area.

(c) Southwestern zone: The transition in vegetation between Dwarf Shrub Savannah (9) and Desert and Succulent Steppe (lower 3) is very sharp and changes over a distance of about 10 km (E. R. Robinson, pers. comm.). Towards the southern area of this zone where intermediates are known, the transition in vegetation is less abrupt due to presence of mountains and rivers (E. R. Robinson, pers. comm.). Although the farm Tsirub 13 falls within Succulent Steppe (lower 3) observations in the field clearly show that it is a marginal locality in terms of vegetation. No southern black morphs have been taken 40 km eastwards on the more vegetated farms Aar 16 and Plateau 38 where the yellow morph is common.

3. **Low vagility.**–It has been shown (Endler 1977) that the width of a cline is affected by the amount of gene flow between the interacting taxa. If gene flow is minimized a cline can remain differentiated for long periods. According to Endler, gene flow is generally increased by large numbers of individuals moving long distances. Alternatively, if gene flow takes place over short distances differentiation may be very high. Scorpions are

Table 4.–Classification results of *P. villosus* - *brachystylus* analysis. Percent of grouped cases correctly classified 97.3%.

Actual group	No. of cases	Predicted 1	group 2	membership 3
1. *villosus*	123	121	0	2
		98.4%	0.0%	1.6%
2. *brachystylus*	15	0	14	1
		0.0%	93.3%	6.7%
3. intermediates	12	0	1	11
		0.0%	8.3%	91.7%

not particularly mobile and this low vagility may well be an important factor involved in the maintenance of the step clines.

In conclusion, hybrid inviability, adaptations to different physical environments and low vagility may all be involved to a lesser or greater degree in the maintenance of the parapatric distribution described.

CONCLUSION

Whether primary or secondary intergradation is involved, there is little doubt that the various color morphs and *P. brachystylus* are members of the same species. If natural selection played a direct role in the creation of the cline (primary intergradation) sympatric speciation would have to take place. This is highly unlikely (Futuyma and Mayer 1980). If the clines are caused by hybridization after change in allopatry (secondary intergradation) speciation should largely be complete or occur by parapatric interaction. The frequency of intermediates (which would be hybrids if secondary intergradation is implicated) is sufficiently high to suggest that the parentals would be recognizing each other efficiently. This is indicative of conspecificity (Paterson 1980). Lastly, parapatric speciation is not probable (see Futuyma and Mayer 1980).

P. brachystylus is thus regarded as a subspecies of *P. villosus*. This is partly an arbitrary decision since the color morphs have integration zones as steep as that in the *P. villosus-brachystylus* case. The degree of morphological divergence over such a zone is not relevant to determining whether the "pure" forms on either side of the zone are good species.

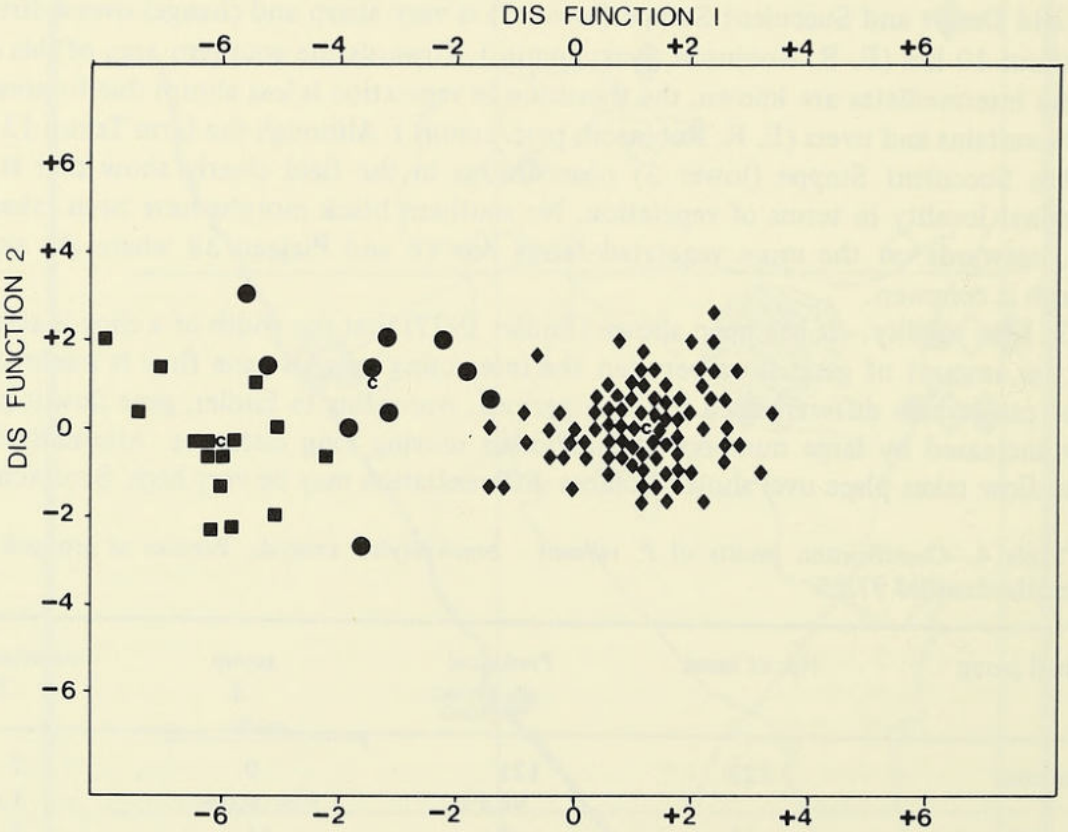


Fig. 10.–Scatterplot of the discriminant scores of discriminant functions 1 and 2 plotted against each other. Squares, dots and diamonds denote *brachystylus*, intermediates and *villosus* respectively. Group centroids are indicated by c. Note that some intermediates share certain discriminant scores with the parental groups.

Morphology has a strictly secondary role as a criterion of species rank (Mayr 1963, Short 1969).

TAXONOMIC CHARACTERIZATIONS

Parabuthus villosus (Peters) 1862.
Buthus villosus Peters 1862:26.

Within the genus *Parabuthus*, *P. villosus* can be diagnosed as follows.

Diagnosis.–Caudal segment 4 with 10 strong granular keels. Ventral keels indistinct posteriorly on this segment. Tail narrowing posteriorly, caudal segment 4 narrower than 1 (rarely equal in width). Dorsal view of dorso-lateral keels subparallel. Stridulatory area on caudal segment 1 broad, composed of strong granules, occasionally forming short ridges. Color of trunk blackish brown to black. Cauda usually pilose.

Parabuthus villosus villosus (Peters)

Diagnosis.–Dorsal stridulatory area on caudal segment 2 confined to a narrow oval and usually depressed area. Does not approach posterior margin of segment appreciably, s/l_2 ratio between 0.63 and 0.82 (mean = 0.71). Width of caudal segment 1 usually less than length, w/l_1 ratio from 0.88 to 1.08 (mean = 0.97). Distributed south of 21°10′S, Namibia.

Parabuthus villosus brachystylus, new combination

P. brachystylus·Lawrence 1928:270-73.

Diagnosis.–Dorsal stridulatory area on caudal segment 2 present as fairly narrow channel, reaching posterior margin of segment. s/l_2 ratio between 0.90 and 0.96 (mean = 0.93). Width of caudal segment 1 generally greater than length, w/l_1 ratio between 0.96 and 1.17 (mean = 1.08). Found north of 21°10′S, Namibia.

P. v. villosus – *P. v. brachystylus* intermediates

Dorsal stridulatory area approaching posterior margin of segment, s/l_2 ratio between 0.77 and 0.90 (mean = 0.85). w/l_1 ratio between 0.98 and 1.11 (mean = 1.05). Distributed in a narrow zone between 21°10′ - 21°20′S, Namibia.

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