



## **Polymorphism in the snake *Psammophis schokari* on both sides of the desert edge in Israel and Sinai**

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*(Received 7 March 1997, accepted 2 July 1997)*

The snake *Psammophis schokari* (Colubridae) occurs in Israel and Sinai, Egypt, in three phenotypically indistinguishable morphs: (1) striped, with four dark longitudinal stripes; (2) non-striped, plain or lightly dotted; and (3) rear-striped, dark stripes on the posterior part merge anteriorly (this pattern is first described herein). From 100 museum specimens it appears that the striped snakes occur mainly in the northern mesic parts of Israel, the non-striped mainly in the southern deserts, and the rear-striped mainly in a central belt. The distributions are correlated to rainfall, solar radiation and vegetation. This polymorphism may be maintained by crypsis, thermoregulation or both.

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**Keywords:** *Psammophis*; snakes; polymorphism; coloration; eco-geographic gradient

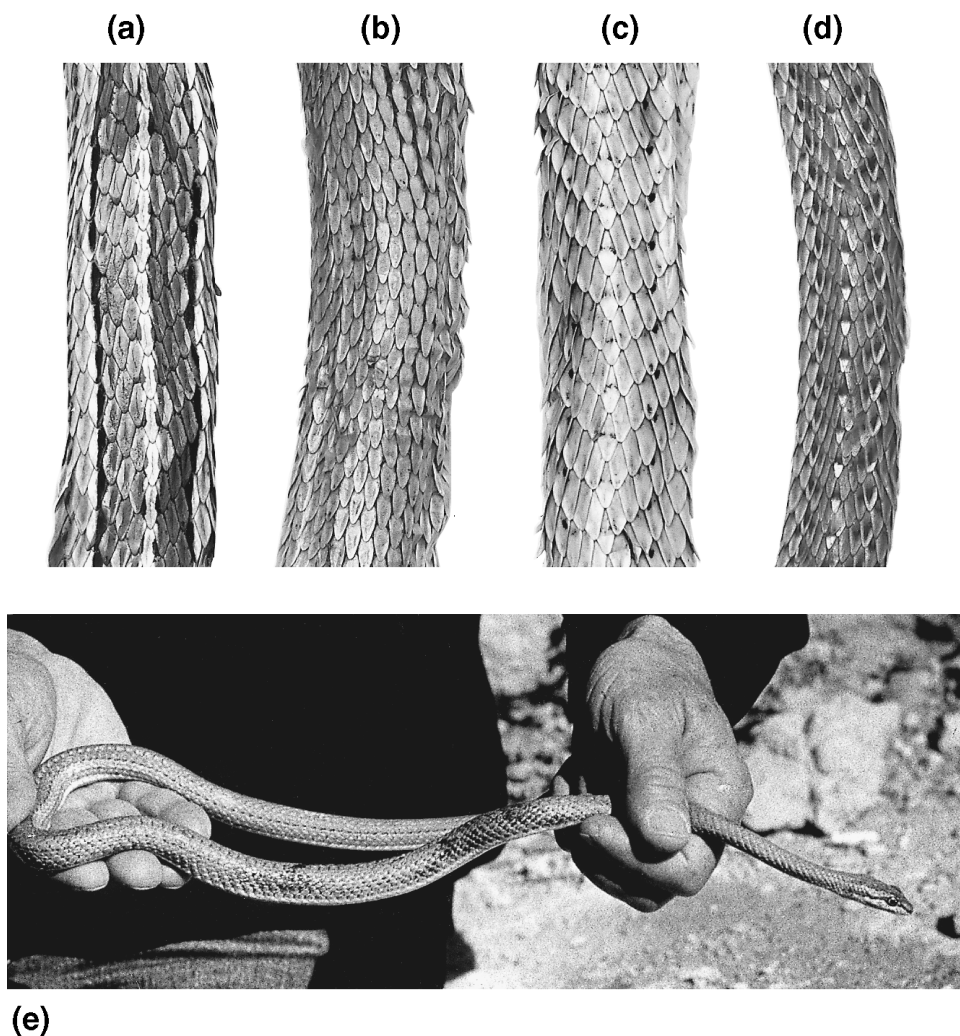
### **Introduction**

Colour polymorphism has been described in various taxonomic groups (reviewed in Mayr, 1963). Colour and stripe polymorphism is also known in some species of snake (Jackson *et al.*, 1976; Gibson & Falls, 1979; Forsman & Ås, 1987; King, 1988; Brodie, 1989, 1992; Wolf & Werner, 1993, 1994; Forsman, 1995). Most studies dealing with colour polymorphism in snakes describe two distinct morphs of the same species. Often one is very dark in colour, and the other lighter, as in the cases of the common garter snake *Thamnophis sirtalis* (Linnaeus) (Gibson & Falls, 1979) and the adder *Vipera berus* (Linnaeus) (Forsman & Ås, 1987; Forsman, 1995).

In the diurnal Saharo-Sindian snake *Psammophis schokari* (Forskål) (Colubridae), variability in the longitudinal stripe pattern along the body has not been thoroughly examined, although considerable variability in colour pattern was reported in a few regions of its Saharo-Sindian distribution range (Anderson, 1898; Minton, 1966; Gasperetti, 1988). In Israel and the Sinai Peninsula, two different 'phases', which differ in dorsal stripe pattern, have been known to herpetologists and amateurs for many years. One is striped along the dorsal part of its body, with four dark brown

stripes on a uniform yellowish or beige background, and the other lacks dark stripes (Werner, 1995, fig. 9; Fig. 1).

The goals of this research were to define and characterize the stripe patterns of the snake *P. schokari* in Israel and Sinai, Egypt, to map their distribution ranges, to reveal the ecological correlates of their distribution, and finally, to try to determine whether this is a case of polymorphism, continuous variation in stripe pattern, or possibly two distinct species. We examined these factors in the circumscribed study area of Israel and Sinai, a relatively well-surveyed portion of the species' range, from which we have accurate collection data (Werner, 1988).



**Figure 1.** Stripe patterns of *Psammophis schokari*, mid-dorsal sections of preserved specimens: (a) Striped (HUJR 8585 from north of Gesher, Upper Jordan Valley, Israel); (b) Non-striped, plain (HUJR 8329 from Wadi Kid, Sinai); (c) Non-striped, dotted, light dotting (HUJR 4148 from Mashabbe Sade, Negev, Israel); (d) Non-striped, dotted, heavy dotting (HUJR 8787 from near Feiran Oasis, Sinai); (e) Rear-striped (alive, from Sede Boqer, photographed by Y.L. Werner at Hai-Ramon, Mizpe Ramon).

## Materials and methods

### *Material*

The sample comprised 100 preserved snakes of the species *Psammophis schokari*, from the Hebrew University Reptile Collection. Material was limited to that in the Hebrew University, where snakes were rarely held alive between capture and preservation, a frequent source of errors in data on collection site (Y. L. Werner, unpub. obs.). The snakes were caught between 1917–1992 in Israel and the Sinai Peninsula (Werner, 1988), and were preserved in alcohol after fixation in formalin. As far as is known, preservation does not change patterns involving melanin. In order to verify this issue for the species concerned, the pattern in three museum specimens of *Psammophis schokari* from the Hebrew University Reptile Collection was examined and characterized in July 1996, and compared with scores given independently to the same individuals based on their photographs taken before preservation (see Appendix A for methods and results). The advantage of working with collection material is that it provides data across a wide temporal as well as spatial scale, and can be compared with data from other collections efficiently.

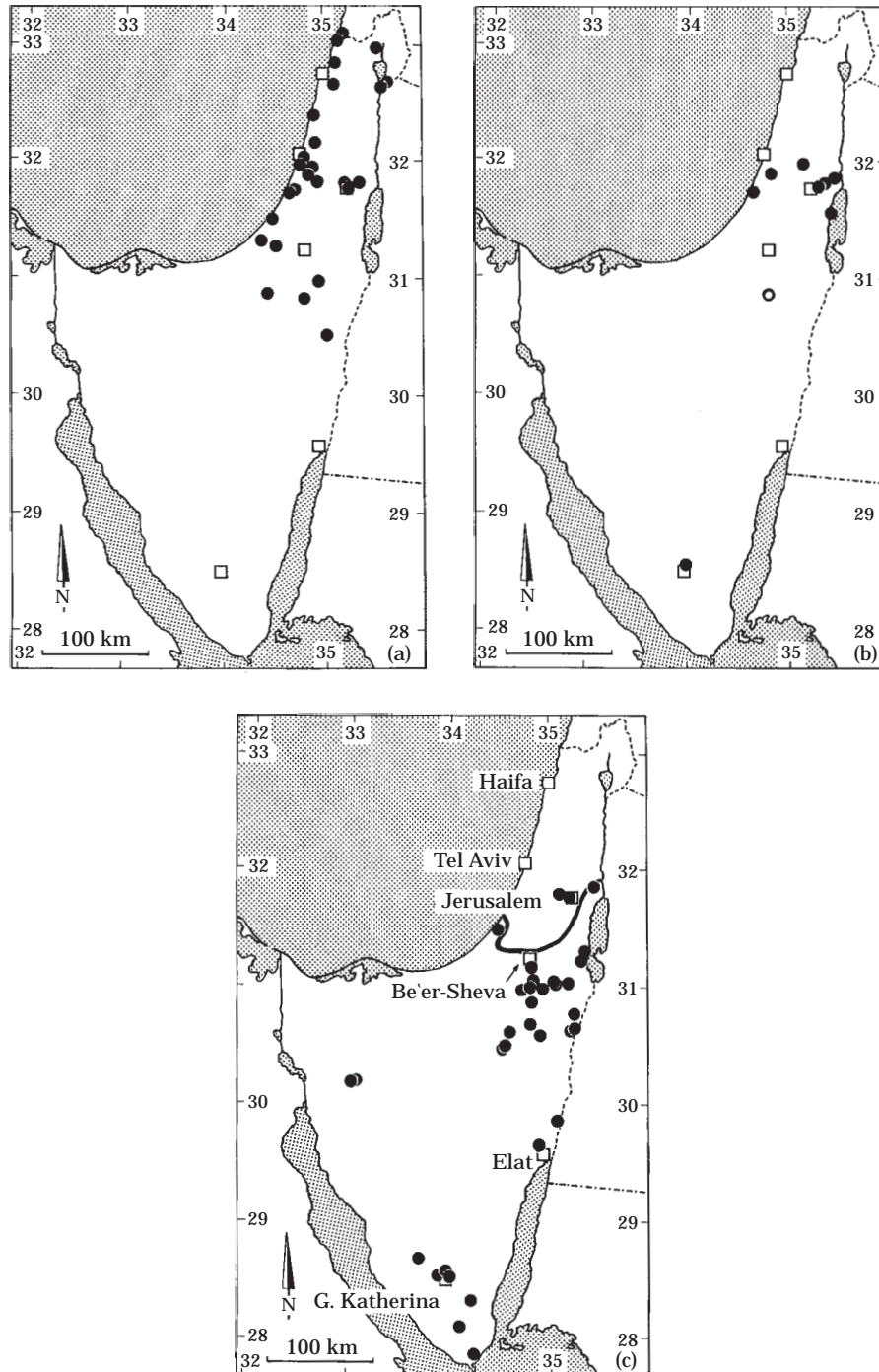
### *Characters*

For each snake, location and date (month and year) of capture were obtained using data from the collection catalogue. In addition, each snake was examined for the following features: (1). sex: because in *Psammophis* the hemipenis is uniquely thin (Dowling & Savage, 1960) and it might be difficult to distinguish hemipenis from hemiclitoris (Ziegler & Boehme, 1996), sex was ascertained by opening the abdomen and checking the gonads. Thus three categories were defined: male, female and juvenile (gonads undeveloped); (2) stripe pattern along the dorsal part of the body (excluding the head, which usually has a unique pattern); (3) morphological traits defined in Appendix B: rostrum–anus length, head length, tail length, pileus length, parietal width, mid-dorsal scale length, eye diameter, numbers of upper and lower labials on both sides of head, gular scales along midline, pre- and postoculars on both sides (the two sides were considered separately, due to the frequent occurrence of significant directional asymmetry; Werner *et al.*, 1991a), temporals, dorsal scale rows at midbody, ventrals, division of anal, and subcaudal scale pairs. The measurements were taken conventionally (Werner *et al.* 1991b), using a mm ruler and callipers, except head length which was measured axially (not obliquely) using modified callipers (Goren & Werner, 1993).

Seven ratios between traits were calculated: head length/rostrum–anus length, tail length/rostrum–anus length, pileus length/head length, parietal width/rostrum–anus length, mid-dorsal scale length/rostrum–anus length, eye diameter/head length, and eye diameter/pileus length.

After classifying the specimens according to the different stripe patterns, the distribution of each pattern in Israel and Sinai was mapped on 1:2,000,000 base maps (Werner, 1977). Each circle on the map (Fig. 2) represents a location from which at least one snake was examined.

Next, using the zoocartographic method (van Dijk, 1971), the relationship between the distributions of stripe patterns and each of the following variables was tested: (1) average annual rainfall (Shachar, 1995); (2) solar radiation in June (Rosenan, 1970); (3) average annual temperature (Shachar, 1995); (4) average summer temperature (Shachar, 1995); (5) vegetation zone: many different divisions of Israel and Sinai into vegetation zones have been proposed, having distinct emphases. We used the latest phytogeographical division available (Shachar, 1995). Based on this, we divided the



**Figure 2.** Geographical distribution of the stripe patterns in the survey area (Israel and Sinai). Closed circles on the map represent locations from which at least one snake originated. Open circle in (b) represents snake captured alive and photographed in Hai-Ramon mini-zoo, see Fig.1(e) and text for detail. Squares = localities for orientation (explained in map (c)). The heavy solid line (in map (c)) represents the border between the Mediterranean phytogeographical region to the north and the Saharo-Arabian region to the south. (a) = Striped; (b) = rear-striped; (c) = non-striped.

area into two major vegetation zones: Mediterranean and Saharo-Arabian (the boundary is shown in Fig. 2(c)). The Mediterranean zone includes in its south-eastern regions invasions from the Irano-Turanian zone, and the Saharo-Arabian zone includes in its more northern parts invasions from the Irano-Turanian zone, and in the south, Sudanian invasions (Plitman & Danin, 1987).

### *Statistics*

In order to reveal the ecological correlates of the stripe patterns and test whether this case represents a polymorphic system or rather two (or more) distinct species, each stripe pattern was treated as a population, and ecological correlates, morphological trait means in both mensural and meristic characters and ratios between traits in mensural characters were examined for each of the described patterns. These were compared among the patterns, using Student's *t*-test for comparison of means for the meristic characters, and using analysis of variance (ANOVA) for the ratios. The null hypothesis tested in both comparisons was that there is no difference between snakes of the striped and non-striped patterns. Statistical analyses were performed for snakes of the striped and non-striped patterns in all cases, and only when sample size permitted were the rear-striped snakes included. The comparisons were made using SAS software (SAS PROC *t*-test, PROC GLM) (see Appendix B for details). Simultaneous Test Procedure (modified Bonferroni Correction) (Sokal & Rohlf, 1981; Abramson, 1988) was used to correct the rejection level in the analysis of the morphological traits, due to multiple tests within each sex.

## **Results and comments**

### *Stripe patterns*

Among the 100 snakes examined, three distinct and consistent stripe patterns were found (Fig. 2): (1) striped: four distinct dark stripes along the lighter coloured body ( $N = 38$  snakes); (2) non-striped: pattern was either plain, totally uniform, or dotted, but forming no continuous stripes ( $N = 50$  snakes); (3) rear-striped: non-striped on the front part of the body and striped along the posterior part ( $N = 12$  snakes). The stripes which exist posteriorly, coalesce anteriorly, so that the anterior is dark. This pattern has not been described before.

### *Distribution*

Each stripe pattern had a different and unique distribution range within the survey area (Fig. 2): Striped snakes were found mainly in the central, northern and coastal Mediterranean parts of Israel, and not in the Southern Negev or Sinai Deserts (Fig. 2(a)). Non-striped snakes were found mainly in the Negev and Sinai Deserts. They were not collected in the north of Israel (Fig. 2(c)). Most of the rear-striped snakes had been caught, interestingly, in the latitude belt of Jericho-Jerusalem-Ashdod, in the centre of Israel, where snakes of both of the other stripe patterns (striped and non-striped) coexist. But one rear-striped snake originated from southern Sinai, and recently one such individual was caught at Sede Boqer in the Negev, and held live at the Hai-Ramon mini-zoo, Mizpe Ramon (see Fig. 2(b)).

*Morphological correlates**Sex*

The sex ratio was examined within each stripe pattern to exclude the hypothesis that this is a case of sexual dimorphism. Each pattern occurred in each of the sexes. But an interesting trend appeared: the sex distribution was significantly different ( $\chi^2_1 = 5.28$ ,  $p < 0.025$ ) in the two common (striped and non-striped) morphs (Table 1). The sex ratio of the few rear-striped snakes was closer to 1:1, 43% being male.

*Date of capture*

The date was examined to test the hypothesis that the frequency of the different patterns may be changing at either of two levels: (a) seasonally, resulting from different activity patterns of the stripe patterns throughout the year, or (b) over a period of years, the polymorphism being only transient (Ford, 1940). No evidence was found of any seasonal variation in morph frequency. There was also no evidence for any trend in morph frequency over the 70 years during which the snakes were collected in the region.

*Morphological traits*

Averages and ranges of the different mensural and meristic traits were calculated for the two common patterns, and compared. Due to the small sample size, this comparison was not conducted for the snakes of the rear-striped pattern. Comparisons were made for each sex separately (thus adult snakes only), in order to avoid any effects of sexual dimorphism. In general, in both sexes, no statistically significant difference was observed between the averages of the two stripe patterns (see Appendix B for more detailed results). In addition, no significant difference was revealed in the comparison of proportions among traits between the two common patterns (striped vs. non-striped).

*Ventral and subcaudal scale numbers*

Although non-significant (after application of the Simultaneous Test Procedure) a nearly significant difference appeared in the number of ventral and subcaudal scales in

**Table 1.** *Characteristics of the three morphs of Psammophis schokari from Israel and Sinai, Egypt (and sample size)*

	Striped	Rear-striped	Non-striped
Distribution of sex among adults			
Males	69.6% (16)	42.9% (3)	38.9% (14)
Females	30.4% (7)	57.1% (4)	61.1% (22)
Mean numbers of ventral scales from the overlap zone			
Males	165.3 (3)	165.5 (2)	165.8 (9)
Females	168.4 (7)	174.3 (4)	169.0 (13)
Mean numbers of subcaudal scales from overlap zone			
Males	115.0 (2)	96.5 (2)	109.4 (5)
Females	112.4 (5)	116.6 (3)	110.3 (8)

females of the striped *vs.* the non-striped morph (Appendix B). For this reason, this was further examined in both sexes and in all morphs, as discussed below.

Differences among populations of different climatic areas in their vertebral numbers or ventral and subcaudal scale numbers have been discovered in several species of reptiles, especially snakes (Klauber, 1941; Werner, 1964), and presumably were related to the temperature of embryonic development (Fox, 1948; Ehrlich & Werner, 1993). We therefore asked whether the nearly significant differences between averages of the two main stripe patterns may be explained by their different geographical distributions or otherwise indicate reproductive isolation of the patterns. The numbers of ventral and subcaudal scales of snakes from all three stripe patterns which originated only from the area of overlap between the three was examined (Table 1), males and females separately. For both sexes, but especially for the females where the sample size is larger, no difference was found among the means of the ventral and subcaudal scale numbers of the different stripe patterns, although the sample size is too small to allow conclusions.

#### *Ecological correlates*

Correlations with environmental factors were tested only for the snakes that originated from Israel since reliable environmental data from Sinai are incomplete. The following trends were found. (1) Annual rainfall average: in a comparison, by pattern, of the mean annual rainfall at the capture sites for all the snakes from Israel for which data were available ( $N = 73$ ), a trend of increasing mean annual rainfall moving from the localities of the non-striped snakes, through the rear-striped up to the localities of the striped snakes was found (Table 2). A significant difference ( $p < 0.05$ ) was found between the means of the annual rainfall at the localities of the non-striped and at those of each of the two other patterns — striped and rear-striped. The 200 mm annual rainfall average line, often considered to be the multi-year desert borderline in Israel, at which the distribution limits of several reptile species coincide (Werner, 1987), was taken and the proportion of each of the two common morphs on both sides tested. Of the non-striped snakes 83.9% were caught in an area with less than 200 mm per year, against 9.4% of the striped pattern ( $\chi^2_1 = 35.17$ ,  $p < 0.0001$ ).

(2) Solar radiation: the distributions of the patterns were related to total solar radiation incident on a horizontal surface in June (multi-annual average); 78.8% of the non-striped snakes originated in the area with over 750 gram calories  $\text{cm}^{-2} \text{ day}^{-1}$ , compared with 46.2% of the rear-striped snakes, and only 16.7 % of the striped snakes ( $\chi^2_2 = 24.3$ ,  $p < 0.0001$ ).

(3) Annual and summer temperature: no significant difference was found between mean annual temperatures and stripe pattern or between mean summer temperatures and stripe pattern (Table 2). However, meteorological temperature data probably do

**Table 2.** *Climatic characteristics for collection sites of snakes of the different morphs from Israel*

	Striped	Rear-striped	Non-striped
Mean (+SE) annual rainfall (mm)			
Average	174.2	345.0	445.3
SE	5.4	20.1	4.9
Mean (+SE) summer temperatures (°C)			
Average	26.9	—	26.9
SE	0.6	—	0.7

not totally correlate with the temperatures which the snake experiences in its microhabitat.

(4) Vegetation zone: stripe pattern was strongly associated with the vegetation zone. This is not surprising following the previous results, since the vegetation zone is strongly related to the annual rainfall average and solar radiation. The distribution of the three stripe patterns differed over the two main phytogeographical zones in Israel: Mediterranean and Saharo-Arabian. In the Mediterranean zone most snakes were striped, whilst in the Saharo-Arabian zone most were non-striped (Table 3). The rear-striped snakes occurred in small numbers in both zones (this relation between pattern and vegetation zone was statistically significant with  $\chi^2_2 = 22.9$ ,  $p < 0.0001$ ).

### Discussion

Polymorphism has been defined by Ford (1940): occurrence together in one habitat of two or more forms of a species in such proportions that the rarest cannot be accounted for by recurrent mutation. The situation in *Psammophis schokari* seems to fit this definition: we describe three discrete stripe patterns, which occur together in a certain area (central Israel) and at high frequencies, hence this is neither a case of continuous variation nor one of recurrent mutations. Research and conclusions as to the status of the newly described rear-striped snakes must await further findings of snakes of this pattern. In this research statistical analysis for snakes of this pattern was partial, due to the small sample size. Nevertheless, their distribution was described, and seems to show a rather consistent pattern.

The distribution of the distinct morphs was strongly related to environmental variables: rainfall, solar radiation and vegetation. The case can be concluded as a change in frequencies of the morphs along an eco-geographical gradient. In a research pattern such as the one used by us, the inter-related variables associated with the geographical distribution range, such as rainfall, solar radiation and vegetation, all remain potential, non-exclusive explanations. The relationship between stripe pattern and sex may result from confounding factors, such as different congruence of the activity hours and activity patterns of the snakes of the two sexes and of the collectors in the different geographical regions (desert vs. Mediterranean) (Leinz *et al.*, 1992), or may be a case of non-balanced survival amongst the sexes, acting in different directions in each of the morphs, as that described in *Vipera berus* by Forsman (1995). Studying marked polymorphic populations of the adder for 6 years, he found that the fitness, as expressed in survival rates, differed between the two sexes: zig-zag males had higher survival rates than melanistic males, while in the females the opposite was true.

In our study we tried to verify whether this is really a case of polymorphism, rather than two, or more, distinct species. Conventionally in snake systematics, the separation to species relies on differences in morphological and sometimes physio-

**Table 3.** Percentage (and numbers) of snakes of the different morphs in the major phytogeographical vegetation zones in Israel (each morph totals 100% in the two vegetation zones)

Vegetation zone	Striped	Rear-striped	Non-striped
Mediterranean	80.0 (24)	58.3 (7)	20.6 (7)
Saharo-Arabian	20.0 (6)	41.7 (5)	79.4 (27)



logical and behavioural criteria. Only rarely is the existence of a reproductive barrier examined directly. Usually a combination of several traits which differ between the two candidate populations is used. For example, the distinction of the species *Psammophis aegyptius* Marx from *P. schokari* was based on the number of ventral scales, scale rows at mid-body and lower labials, the belly punctuation pattern and on tail length (Marx, 1958).

In this case of *P. schokari* in Israel and Sinai, comparison of morphological traits of the two common morphs, striped and non-striped, shows that the two morphs are very similar: the various traits and ratios do not significantly differ in their means, and their ranges are similar or largely overlapping. Although non-significant, the only indication of a possible difference between these two patterns is in the number of ventral and subcaudal scales in the females. But when compared exclusively among those individuals of the three morphs which originate from the geographical overlap zone, no difference appears. Thus the apparent trends from the whole study area may relate to different geographical distributions of the different morphs. Hence we cannot support a hypothesis invoking separate species.

A physiological difference appears between the striped and non-striped snakes in skin resistance to water loss (Lahav & Dmi'el, 1996). Skin resistance to water loss is considered a reliable parameter for comparing different reptiles. Resistance to water loss was tested in two individuals of each of the two common morphs, at three body temperatures (25°C, 30°C, 34°C). At all three temperatures resistance was much higher in the non-striped morph, which in principle inhabits the more arid zone (Lahav & Dmi'el, 1996). Unfortunately it remains unknown whether these experimental animals had been collected in the allopatric or the sympatric parts of the morph distributions, precluding any systematic and evolutionary interpretation at this stage.

Apart from the physiological difference described above, the question that arises is: are there selective forces, which relate more directly to coloration, that may give advantage to each of the various morphs in different environments, especially in the desert vs. the Mediterranean, and may thus maintain this polymorphism?

Two major hypotheses for the maintenance of polymorphic systems in snakes are suggested (Forsman, 1995): (1) crypsis, camouflage, background colour-matching (Norris & Lowe, 1964) as a means of reducing predation (Jackson *et al.*, 1976; Wolf & Werner, 1994) or increasing the snakes' foraging efficiency. This may account for the maintenance of pattern polymorphism in *P. schokari*. The striped morph may be advantageous in the more densely covered Mediterranean vegetation zones, where it is mainly found, and the non-striped morph may be more cryptic in the more open Saharo-Arabian desert vegetation zones.

Brodie (1989, 1992) showed in *Thamnophis ordinoides* that stripe pattern is correlated with an antipredator escape behaviour termed reversals (see Brodie, 1989). He suggests that the stripe pattern and the behavioural character (reversals) acting together may be responsible for the optical illusion of a visually foraging predator. Their joint effect can increase the survival after an initial detection of the snake by a predator, giving it a chance to escape and reuse crypsis as a defence (Brodie, 1989, 1992).

(2) Thermoregulation (Gibson & Falls, 1979; Forsman & Ås, 1987; King, 1988); in these cases, the morphs differ in the degree of melanism: one is darker, and the other lighter. In the case of *P. schokari* in Israel the frequencies of the morphs are correlated with solar radiation, although not with annual or summer mean temperature. The non-striped morph is usually lightly coloured (its hues approximating the light interspaces of the striped morph) and presumably more efficiently reflects the excessive insolation in the arid desert environment.

The crypsis and the thermoregulation hypotheses are not mutually exclusive; both may be involved in maintaining the polymorphic system described in *P. schokari*.

### Conclusions

(1) Three discrete pattern morphs of the snake *Psammophis schokari* occur in Israel and Sinai: striped, non-striped and rear-striped.

(2) The three morphs vary in their frequency in different regions within the study area, and show partly different distributions: the striped morph is found mainly in the more mesic northern, coastal and central parts of Israel, the non-striped morph mainly in the southern Negev and Sinai Deserts, and the rear-striped mainly in the central latitude belt of Jericho–Jerusalem–Ashdod, where the two other morphs overlap.

(3) The distribution pattern is related to environmental factors, including rainfall, solar radiation and vegetation. Hence all or any of these factors may be related to the maintenance of this polymorphic system.

(4) There is no evidence that the morphs described should be considered distinct species.

We thank Simona Lerner-Bar-El, Naomi Sivan and Yael Bogin for their help in laboratory work, Avi Shmida for information on vegetation maps, Uzi Motro and Eran Rezin for statistical advice, Tamar Keasar for help with the SAS programming, and the cartographers in the Department of Geography at the Hebrew University of Jerusalem for their assistance. This paper derives from the first author's project in the course "Guided Introduction to Biological Research" at the Hebrew University.

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### Appendix A

In order to verify whether patterns recorded from preserved snakes are valid, in July 1996 we examined the pattern and coloration of museum specimens of *Psammophis schokari* from the Hebrew University of Jerusalem Reptile Collection (HUI-R), which had been photographed on colour slides when alive, before preservation. Specimens and slides were scored independently, using a list of three colour characters: dorsal pattern (nine character states), dorsal coloration (eight states) and ventral coloration (six states). Three specimens were available, as tabulated below. As shown, even after 16 years, the scoring, especially dorsally, did not change.

HUI-R Locality	Photography film date	Coloration	
		Alive (slides)	Preserved (July 1996)
8987 Tunis: 483 Tozeur (28 – 32)	Sept 80	Dorsal: 3+ dark bands; not contrasty. Ventral: marginal black dotting; central band spotted black.	Dorsal: 3+ dark bands; not contrasty. Ventral: marginal black dotting; central band spotted black.
16454 Israel: 664 Rishon LeZiyyon (19 – 21)	4 Nov 84	Dorsal: 3·5 dark bands; not contrasty. Ventral: yellow band; margins dotted black.	Dorsal: 3·5 dark bands; not contrasty. Ventral: yellow band; margins dotted black.
16994 Israel: 799 Ashdod Sands (34 – 36)	28 Sept 90	Dorsal: 4 dark bands, contrasty. Ventral: marginal black dotting, yellow band spotted black.	Dorsal: 4 dark bands, contrasty. Ventral: marginal black dotting, remnant of yellow band.

## Appendix B

### *Abbreviations, units and definitions for the morphological traits*

#### *Mensural characters*

RA — Rostrum–anus length (Werner, 1971): distance from tip of snout to cloaca (in mm).

Head — Head length, parallel to long axis of body: distance from tip of snout to line joining posterior tips of mandibulae, measured with special callipers (Goren & Werner, 1993) (0.1 mm).

Tail — Tail length: distance from cloaca to tip of tail, only when complete (mm).

Pileus — Pileus length: overall length of plate-covered top of head, measured axially from tip of snout to transverse line connecting posterior tips of parietals (0.1 mm).

>Parietal — Parietal width: greatest width of both parietals together (0.1 mm).

Scale — Dorsal scale length: the combined length (in 0.1 mm) of a sequence of five scales of the mid-dorsal scale row, measured halfway between tip of snout and tip of tail, then divided by five.

Eye — Eye diameter: longest diameter of visible part of eye (average of left and right; 0.1 mm).

#### *Meristic characters*

u-labials — Upper labials: beginning with the first behind the rostral, ending with the last conspicuously large one (separately for left (L) and right (R)).

l-labials — Lower labials: beginning with the first behind the mental, ending with the last completely covered by the last upper labial (separately L and R).

Gulars — Gulars: number of consecutive scales along midline, between chinshields and first ventral.

Preoculars — Preoculars: bounding the orbit anteriorly, between supraocular and labials (separately L and R).

Postoculars — Postoculars: bounding the orbit posteriorly, between supraocular and labials (separately L and R).

Temporals — Anterior temporals: bounding the postoculars posteriorly, between parietal and labials (on one side; usually symmetrical).

Dorsals — Dorsals: number of dorsal scale rows counted across the back at half rostrum–anus length.

Ventrals — Ventrals: number of ventral scales from the first scale that is distinctly wider than long, to (excluding) anal plate.

Anal — Anal: coded 1 if whole, 3 if divided, 2 if intermediate.

Subcaudals — Subcaudals: number of subcaudal scale pairs from first pair behind the cloaca to tip of tail (included).

**Table B1.** Summary of means  $\pm$  S.D. of morphological traits and proportions and p-values of t-tests for meristic characters in striped vs. non-striped*Psammophis schokari* males and females from the sympatric zone in Israel.N = sample size; NS = non significant ( $p > 0.0036$ , after the Simultaneous Test Procedure). See text for detailed statistical methods

Morphological variable	Males			Females		
	Striped (N = 13)	Non-striped (N = 14)	p-value (where relevant)	Striped (N = 7)	Non-striped (N = 22)	p-value
RA	515.8 $\pm 123.5$	506.1 $\pm 120.6$		461.9 $\pm 133.4$	483.0 $\pm 113.6$	
Head	212.6 $\pm 41.2$	200.0 $\pm 42.5$		190.4 $\pm 45.9$	190.9 $\pm 35.1$	
Tail	274.6 $\pm 75.7$	246.2 $\pm 73.4$		196.1 $\pm 92.2$	216.7 $\pm 62.3$	
Pileus	155.7 $\pm 26.6$	149.0 $\pm 26.3$		143.1 $\pm 31.5$	141.4 $\pm 23.1$	
Parietal	73.2 $\pm 11.9$	69.9 $\pm 11.0$		69.3 $\pm 14.1$	67.1 $\pm 10.6$	
Scale	163.2 $\pm 40.1$	159.0 $\pm 38.6$		138.3 $\pm 42.1$	145.4 $\pm 34.8$	
Eye	40.8 $\pm 7.7$	40.1 $\pm 6.3$		35.3 $\pm 6.8$	37.5 $\pm 5.5$	
u-labials R	9.0 $\pm 0.4$	8.9 $\pm 0.3$	0.195 NS	8.9 $\pm 0.4$	8.8 $\pm 0.5$	0.499 NS
l-labials R	11.0 $\pm 0.58$	10.7 $\pm 0.48$	0.534 NS	10.7 $\pm 0.8$	10.7 $\pm 0.8$	0.856 NS
u-labials L	9.0 $\pm 0.0$	8.9 $\pm 0.3$	0.990 NS	8.9 $\pm 0.4$	9.1 $\pm 0.3$	0.366 NS
l-labials L	11.0 $\pm 0.5$	10.7 $\pm 0.5$	0.927 NS	10.9 $\pm 1.1$	10.6 $\pm 0.8$	0.282 NS
Gulars	3.1 $\pm 0.5$	3.1 $\pm 0.5$	0.886 NS	3.4 $\pm 0.5$	3.0 $\pm 0.6$	0.924 NS
Preoculars R	1.0 $\pm 0.0$	1.0 $\pm 0.0$	1.000 NS	1.0 $\pm 0.0$	1.0 $\pm 0.0$	1.000 NS
Preoculars L	1.0 $\pm 0.0$	1.0 $\pm 0.0$	1.000 NS	1.0 $\pm 0.0$	1.0 $\pm 0.0$	1.000 NS
Postoculars R	2.0 $\pm 0.0$	2.0 $\pm 0.0$	1.000 NS	2.0 $\pm 0.0$	2.0 $\pm 0.0$	1.000 NS
Postoculars L	2.0 $\pm 0.0$	2.0 $\pm 0.0$	1.000 NS	2.0 $\pm 0.0$	2.0 $\pm 0.0$	1.000 NS
Temporals	2.0 $\pm 0.0$	2.1 $\pm 0.3$	0.990 NS	2.0 $\pm 0.0$	2.0 $\pm 0.0$	1.000 NS
Dorsals	17.0 $\pm 0.0$	17.0 $\pm 0.0$	0.990 NS	17.0 $\pm 0.0$	17.0 $\pm 0.0$	0.990 NS
Ventrals	165.8 $\pm 5.4$	168.6 $\pm 7.5$	0.263 NS	168.4 $\pm 2.0$	172.1 $\pm 6.4$	0.008 NS
Anal	2.0 $\pm 0.4$	2.0 $\pm 0.0$	0.990 NS	2.0 $\pm 0.0$	1.9 $\pm 0.4$	0.990 NS
Subcaudals	114.7 $\pm 9.8$	106.4 $\pm 18.0$	0.041 NS	100.0 $\pm 36.3$	130.9 $\pm 122.6$	0.006 NS

**Table B2.** Summary of means  $\pm$  S.D. of morphological trait ratios for striped and non-striped *Psammophis schokari* males and females from Israel and Analysis of Variance p-values (ANOVA, SAS PROC GLM). N = sample size; NS = non-significant ( $p > 0.0073$ , after the Simultaneous Test Procedure)

Morphological variable	Males			Females		
	Striped (N = 13)	Non-striped (N = 14)	p-value	Striped (N = 7)	Non-striped (N = 22)	p-value
Head/RA	0.418 $\pm 0.032$	0.399 $\pm 0.042$	0.192 NS	0.420 $\pm 0.044$	0.402 $\pm 0.040$	0.323 NS
Tail/RA	0.528 $\pm 0.043$	0.482 $\pm 0.067$	0.044 NS	0.432 $\pm 0.152$	0.453 $\pm 0.082$	0.646 NS
Pileus/head	0.737 $\pm 0.036$	0.754 $\pm 0.046$	0.298 NS	0.754 $\pm 0.032$	0.744 $\pm 0.032$	0.462 NS
Parietal/RA	0.146 $\pm 0.021$	0.142 $\pm 0.022$	0.671 NS	0.154 $\pm 0.022$	0.142 $\pm 0.017$	0.140 NS
Scale/RA	0.317 $\pm 0.020$	0.315 $\pm 0.022$	0.790 NS	0.298 $\pm 0.014$	0.301 $\pm 0.017$	0.691 NS
Eye/head	0.193 $\pm 0.020$	0.204 $\pm 0.018$	0.171 NS	0.187 $\pm 0.012$	0.198 $\pm 0.015$	0.086 NS
Eye/pileus	0.263 $\pm 0.028$	0.271 $\pm 0.015$	0.369 NS	0.248 $\pm 0.018$	0.266 $\pm 0.019$	0.039 NS