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Entomology

STUDIES IN INTRASPECIFIC VARIATION

XV. A NEW PHASE CHARACTER, THE MALE CERCI IN THE DESERT LOCUST, SCHISTOCERCA AMERICANA GREGARIA (FORSKAL)

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(1) The male cerci of *Schistocerca americana gregaria* (Forskal) (Orthoptera. Acrididae) show phase differences. (2) The sensory hairs on the margins and exposed surfaces are about twice as numerous in phase *gregaria* (46-61, mean, 50·50) as in *solitaria* (22-28, mean 25·75). (3) The apical end of cerci is narrower in ph. *gregaria* than in ph. *solitaria* where it is broader and more truncated. (4) Cerci are generally smaller in ph. *gregaria*, specially in respect of the minimum (basal) width (*X*) and the maximum length (*Z*), but there is no significant phase difference in the maximum width (*Y*). (5) The ratio *Z*/*X* is significantly lower in ph. *gregaria* (mean 1·57; all are 6-eye-striped) than in 6-eye-striped *solitaria* (1·67) and in 7-striped *solitaria* (1·62).

INTRODUCTION

Several body-parts of the Desert Locust, *Schistocerca americana gregaria* (Forskal)* (Orthoptera, Acrididae), viz. lengths of elytron and hind-femur, head-width, metasternal interspace, number of eye-stripes, elytron-pigmentation, etc., have been found to show phase differences (Uvarov, 1923, 1928, 1966 ; Roonwal, 1936, 1946a, b, 1947; Roonwal & Bhanotar, 1966, 1977; Dirsh, 1953; and others). In the present account the male cerci are shown to exhibit phase polymorphism.

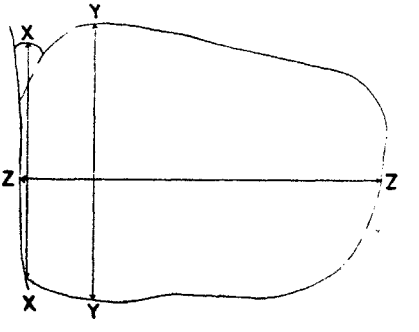

FIG. 1. Outline of male cercus (side view) of *Schistocerca americana gregaria* (Forskal) phase *solitaria*, to show method of measurement (also see text).
[*X*–*X*, minimum (basal) width; *Y*–*Y*, maximum width; *Z*–*Z*, maximum length.]

*Generally referred to in the literature as a distinct species, *S. gregaria* (Forskal), but now best regarded as a subspecies of *S. americana* (see 'Discussion' below).

Materials and Methods

A total of 56 examples (22 in phase *gregaria* from swarms, and 34 in phase *solitaria* from low density populations from the Indian Desert, were studied. A confirmation of their phase status was also obtained by measuring the body-parts (lengths of elytron, hind-femur, etc., and their ratios). The male cerci were measured *in situ* under a binocular, three measurements (all as straight line distances) being thus obtained as follows (*also see* Fig. 1) : (i) Minimum Width (*X*) at base, including the basal upper lobe ; (ii) Maximum Width (*Y*) at the projected portion of the upper margin in the proximal one-third ; and (iii) Maximum Length (*Z*). The data were statistically analysed.

Results

Description of male cerci

In both sexes the paired cerci are appendages of the eleventh abdominal segment and are present as well-formed, conspicuous structures (in males : maximum length *ca.* 1·55 - 2·05 mm ; maximum width *ca.* 1·05 - 1·30 mm). The cerci show phase differences only in males where they are flat, plate-like structures somewhat narrowed distally (Fig. 2). A male cercus consists of two sclerotized parts : the main body and a narrow 'basal lobe' at the upper end. It is broad basally and somewhat narrowed apically, and is covered over with numerous sensory hairs.

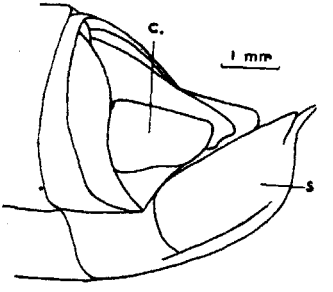

FIG. 2. Distal end of abdomen of *Schistocerca americana gregaria* (Forskal), phase *solitaria*, in side view. [*c*, cercus; *s*, subgenital plate.]

Phase variation in male cerci

The size and shape of the male cerci and the sensory hairs covering them show phase variations.

(a) *Sensory hairs*

The covering of sensory hairs is markedly denser in phase *gregaria* than in ph. *solitaria* (Figs. 3 and 4) ; their number on the margin and the visible (outer) surfaces being as follows : ph. *gregaria* 46·61 (mean 50·50); ph. *solitaria* 22 - 28 (mean 25·75).

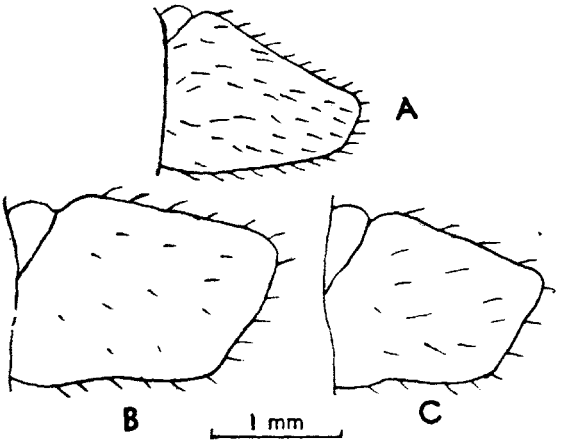

FIG. 3. Male cerci of *Schistocerca americana gregaria* (Forskal), in side view, to show phase differences. *(A)* Phase *gregaria* (all are with 6-eye stripes). *(B)* Phase *solitaria*, with 6-eye stripes. *(C)* Same, with 7-eye stripes.

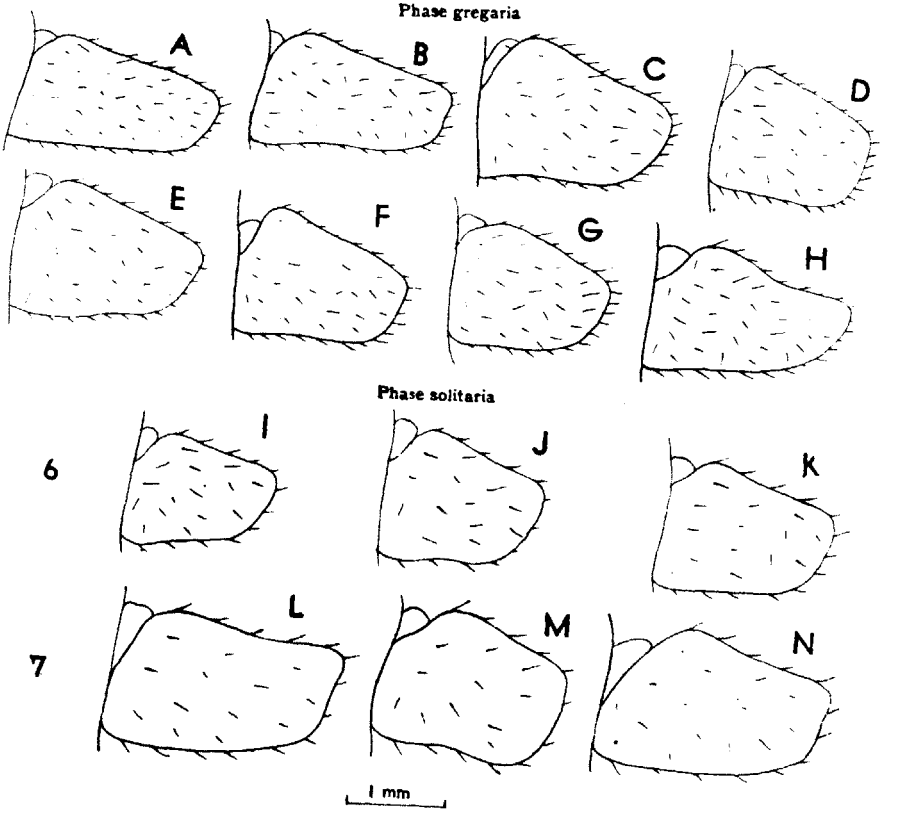

FIG. 4. Intra-phase variation in male cerci of *Schistocercana americana gregaria* (Forskal). *(A–H)*, Phase *gregaria* (all are with 6-eye stripes). *(I–K)*, Phase *solitaria*, with 6-eye stripes. *(L–N)*, Same, with 7-eye stripes.

(b) *Shape* (Figs 1-4)

The cerci are broad basally and more or less narrowed apically, the narrowing being greater in ph. *gregaria* and than in ph. *solitaria*; in the latter phase the apical end looks rather broadly truncated. The upper edge in the proximal one-third portion shows a small bulge.

(c) *Size* (Tables I and II)

The cerci in ph. *gregaria* are generally smaller than in ph. *solitaria*. Both minimum (basal) width (*X*) and maximum length (*Z*) are very significantly smaller in ph. *gregaria* than in ph. *solitaria* (especially in the 7-eye-striped or extreme *solitaria* populations). The maximum width (*Y*) shows poor phase differentiation which is noticeable only in the extreme *solitaria* population (7-eye-striped) and not in 6-eye-striped *solitaria* individuals. Within ph. *solitaria* there is no significant difference between 6- and 7-eye-striped individuals in all three measurements.

TABLE I

Size, measurements and ratios of male cerci in Schistocerca americana gregaria (*Forskal*)

Phase (and number of eye-stripes)	*n*	Range	Mean ± S. E.	S. D. ± S. E.	C.V.
		1. Minimum width (*X*) (mm)			
greg. (6)	22	1·00 – 1·25	1·08 ± 0·02	0·13 ± 0·03	12·19
sol. (6)	19	1·00 – 1·20	1·11 ± 0·01	0·05 ± 0·01	4·93
sol. (7)	15	1·05 – 1·20	1·13 ± 0·01	0·05 ± 0·01	4·31
		2. Maximum width (*Y*) (mm)			
greg. (6)	22	1·05 – 1·30	1·16 ± 0·02	0·08 ± 0·02	6·77
sol. (6)	19	1·05 – 1·30	1·18 ± 0·01	0·06 ± 0·01	5·13
sol. (7)	15	1·15 – 1·25	1·20 ± 0·01	0·04 ± 0·01	3·32
		3. Maximum length (*Z*) (mm)			
greg. (6)	22	1·55 – 1·90	1·69 ± 0·02	0·08 ± 0·02	4·85
sol. (6)	19	1·75 – 2·00	1·86 ± 0·02	0·09 ± 0·02	4·88
sol. (7)	15	1·60 – 2·05	1·84 ± 0·03	0·11 ± 0·03	5·74
		4. Ratio *Z*/*X*			
greg. (6)	22	1·29 – 1·75	1·57 ± 0·02	0·12 ± 0·02	7·63
sol. (6)	19	1·54 – 1·81	1·67 ± 0·02	0·09 ± 0·02	5·38
sol. (7)	15	1·45 – 1·86	1·62 ± 0·03	0·11 ± 0·03	6·57
		5. Ratio *Z*/*Y*			
greg. (6)	22	1·24 – 1·66	1·46 ± 0·02	0·10 ± 0·02	7·15
sol. (6)	19	1·36 – 1·73	1·56 ± 0·04	0·16 ± 0·03	9·26
sol. (7)	15	1·39 – 1·70	1·53 ± 0·01	0·03 ± 0·01	2·11

TABLE II

Schistocerca americana gregaria (Forskal). Significance of mean values of phase differences in sizes of male cerci and their ratios (cf. Table I)

Characters and ratios (see Table I)	Significance of difference					
	Mean ± S. E.			S. D. ± S. E.		
	greg. (6) vs. sol. (6)	greg. (6) vs. sol. (7)	sol. (6) vs. sol. (7)	greg. (6) vs. sol. (6)	greg. (6) vs. sol. (7)	sol. (6) vs. sol. (7)
X	***	****	NS	****	****	NS
Y	NS	***	NS	NS	***	NS
Z	****	****	NS	NS	NS	NS
Z/X	****	*	NS	NS	NS	NS
Z/Y	**	****	NS	NS	****	****

NS, not significant.
Significant at levels of probability : at 5% (*), 2% (**), 1% (***) and 0·1% (****).
greg. (6), phase *gregaria* (6-eye striped) ; *sol. (6)*, ph. *solitaria* (6-eye striped) ; *sol. (7)*, ph. *solitaria* (7-eye striped).

(d) *Ratios*

The ratio Z/X varies from 1·29-1·86. It is very significantly lower in ph. *gregaria* (mean 1·57) than in 6-eye-striped ph. *solitaria* (1·67), but only slightly so (at the 5% level) in 7-eye striped *solitaria* (1·62). The ratio Z/Y varies from 1·24-1·70. It is significantly lower in ph. *gregaria* (mean 1·46) than in ph. *solitaria* (mean 1·56 for 6-eye-striped, 1·53 for 7-eye-striped populations). Within the *solitaria* phase, there is no significant difference between 6- and 7-eye-striped individuals in both the ratios.

(e) *General variability within a phase*

Within each phase there is considerable variability in shape and size (Fig. 4), but inter-phase differences are still clearly noticeable.

DISCUSSION

Schistocerca gregaria (Forskal) has hitherto been regarded as an independent species, with *flaviventris* (Burmeister) as a synonym. In his revision of genus *Schistocerca* Stal, Dirsh (1974) has made out a convincing case for regarding both *gregaria* and *flaviventris* as subspecies (along with nine others) of a large, widespread species, *S. americana* (Drury), which extends over both the New and the Old Worlds. These eleven subspecies Dirsh regards "as a group of unstable infraspecific taxa at various evolutionary levels and accordingly of various taxonomic value" (p. 38).

Dirsh (1974) has used male cerci as a character to distinguish the subspecies of *S. americana*, but has not used them for phase differentiation. In his

figure of *S. a. gregaria* (p. 51, Fig. 8), he shows a small notch or depression in the middle of the apical margin of the male cercus; in Indian examples we could find no such notch (Dirsh's example may have come form Africa).

It may be mentioned that Dirsh rejects the existence of Uvarovian phases, and has invented two names to distinguish differences in *S. a. gregaria*, viz. form *compressa* (for the *solitaria* phase) and form *tecata* (for the *gregaria* phase). In our opinion the invention of new names is unnecessary, for the existence of phases differences is a reality, by whatever name we may call them.

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REFERENCES

Dirsh, V. M. (1953). Morphometrical studies on phases of the Desert Locust *(Schistocerca gregaria* Forskal*)*. *Anti-Locust Bull.*, London, **16**, 4+36 pp.

———(1974). *Genus Schistocerca (Acridomorpha, Insecta)*. (Ser. Entom., Vol. 10*)*. W. Junk Publ. The Hague xii+240 pp.

Roonwal, M. L. (1936). On the existence of two different types of striped eyes among solitary type specimens of the Desert Locust, *Schistocerca gregaria* Forsk. *Curr. Sci.*, Bangalore, **5**, 24.

———(1946 *a*). On a new phase character, the metasternal interspace, in the Desert Locust, *Schistocerca gregaria* (Forskal) (Orthoptera, Acrididae). *Proc. R. ent. Soc. Lond.*, A 21, 13–15.

———(1946 *b*). Studies in intraspecific variation. I. On the existence of two colour types in the adults and hoppers of the *solitaria* phase in the Desert Locust, *Schistocerca gregaria* (Forskal) [Orthoptera, Acrididae]. *Rec. Indian Mus.*, **44**, 369–374.

———(1947). Variation and structure of the eyes in the Desert Locust, *Schistocerca gregaria* (Forskal). *Proc. R. Soc. Lond.*, B **134**, 245–272.

Roonwal, M. L. & Bhanotar, R. K. (1966). Elytron-pigmentation and its phase significance in the Desert Locust. *Proc. natn. Inst. Sci. India*, B **32**, 53–96, 2 pls.

Roonwal, M. L. & Bhanotar, R. K. (1977). Studies in intraspecific variation. XIII. Size of eye and its ratios in the Desert Locust in relation to phase and eye-stripe polymorphisms. *Proc. Indian natn. Sci. Acad.*, B **43**, 92–101.

Uvarov, B. P. (1923). Notes on locusts of economic importance with some data on the periodicity of locust invasions. *Bull. ent. Res.*, **14**, 31–39.

———(1928). *Locusts and Grasshoppers — A Handbook for Their Study and Control.* Imp. Inst. Entom, London, xiii + 352 pp., 9 pls., 1 frontispiece.

———(1966). *Grasshoppers and Locusts — A Handbook of General Acridology.* Vol. 1. Cambridge University Press, Cambridge, 481 pp.