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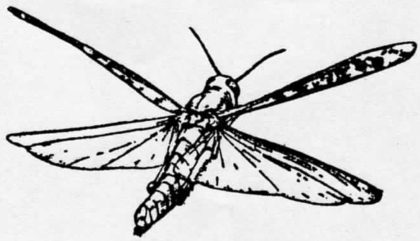

Morphometrical Studies on Phases of the Desert Locust

(*Schistocerca gregaria* Forskål)

By

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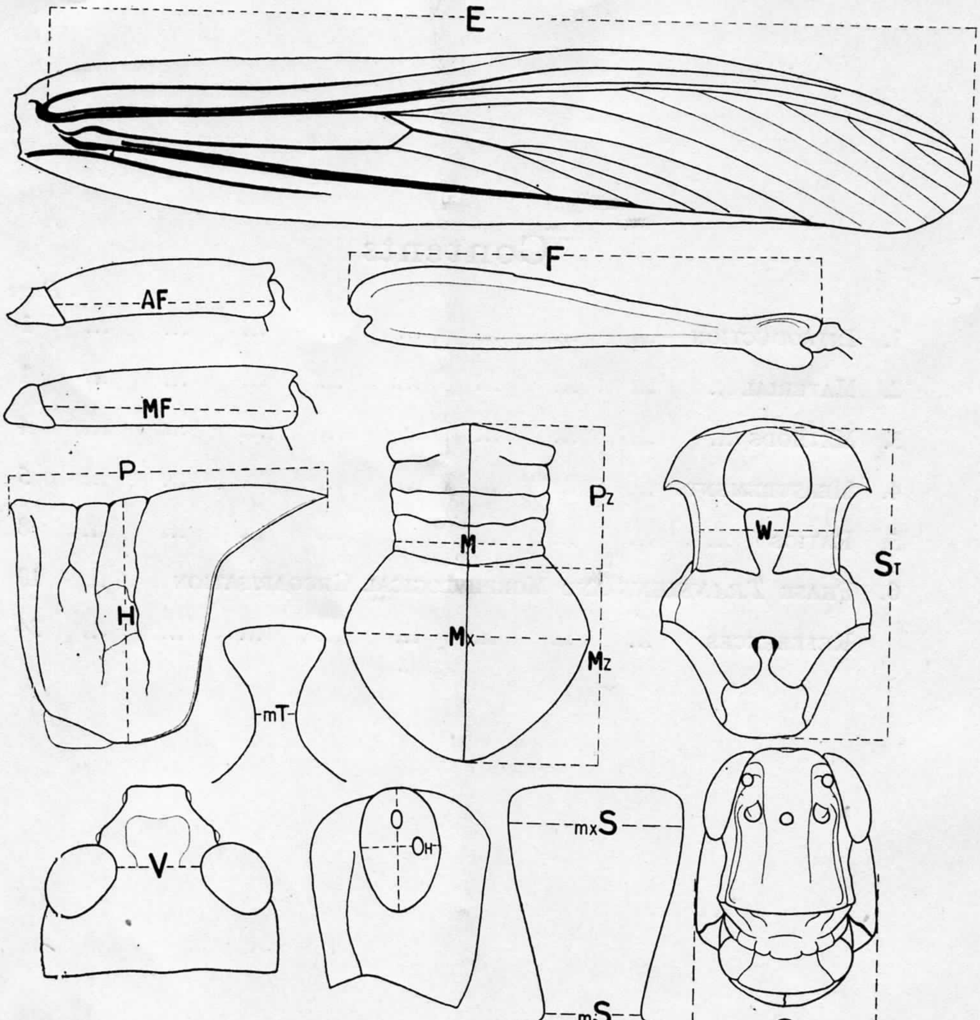

FIG. 1.—Scheme of measurements ; explanation in the text.

1. INTRODUCTION

When the phase theory was first proposed by Uvarov (1921) for *Locusta migratoria migratoria* (L.), he distinguished ph. *gregaria* from ph. *solitaria* by two morphometric indices: ratio of the length of the hind femur to the elytron length, and ratio of the maximum pronotum width to its length. Zolotarevsky (1930), in his work on *Locusta migratoria capito* (Sauss.), used the same measurements, but reversed the ratios, and introduced two new measurements—maximum width of the head and pronotum height. When morphological difference between the phases was established in *Schistocerca gregaria* (Forsk.), the elytro-femoral index of phase difference was applied to that species as well (Uvarov, 1923). Subsequently, Maxwell-Darling (1934), in his work on *S. gregaria*, used four measurements: elytron length (E), hind femur length (F), pronotum length (L) and the minimum pronotum width (B), as well as the ratios E/F, E/L, E/B, B/L, F/L and F/B.

The Fourth International Locust Conference at Cairo (International, 1936) recommended the following standard measurements and the symbols designating them for use in studies of morphometric variation in all locusts: elytron length (E), hind femur length (F), pronotum length (P), minimum pronotum width (M), pronotum height (H) and maximum width of the head (C). Methods of taking the measurements were exactly defined and illustrated.

Subsequent authors used the international system and introduced supplementary indices. Thus, Rao (1942) measured the maximum width of the head at the compound eyes, and calculated the ratio of C to it, which he claimed to be suitable for characterising the phases of *Schistocerca gregaria*. Thomas (1941) has found that the ratio of elytron length to the vertical diameter of the compound eye can be used as a phase character in *Locusta migratoria migratorioides* (R. & F.). Roonwal (1946) observed measurable differences between phases of *S. gregaria* in the structure of the sternum, and suggested the use of the ratio of the maximum to the minimum width of the metasternal interspace as a phase character. In his later papers (1949, 1949a), Roonwal used only the E/F ratio for characterising phases; other measurements and ratios were given by Roonwal and Nag (1951), and by Misra, Nair and Roonwal (1952).

In practice, the elytro-femoral ratio (E/F) has been most commonly used in studies on the morphological phase variation in different locust species and in recording the morphometric characters of populations. A considerable amount of quantitative data has been accumulated, but previous studies suffered from three main defects: (1) the measurements and the ratios which appeared useful for distinguishing phases in one species, have sometimes been automatically applied to others; (2) the material studied was not always sufficiently documented with regard to its biological history; and (3) exact statistical methods have seldom been used.

The present work was restricted to statistical treatment of the various measurable characters by which only the morphologically extreme phases *gregaria* and *solitaria* of the Desert Locust, *Schistocerca gregaria* (Forskål), can be distinguished. Its object was to investigate the relative values of the measurements and their ratios from the point of view of their being both reliable and easy to use in practice.

2. MATERIAL

This work was initiated before the present plague of the Desert Locust developed fully, and the material available in the collections of the Anti-Locust Research Centre was obtained during the previous periods. It was,

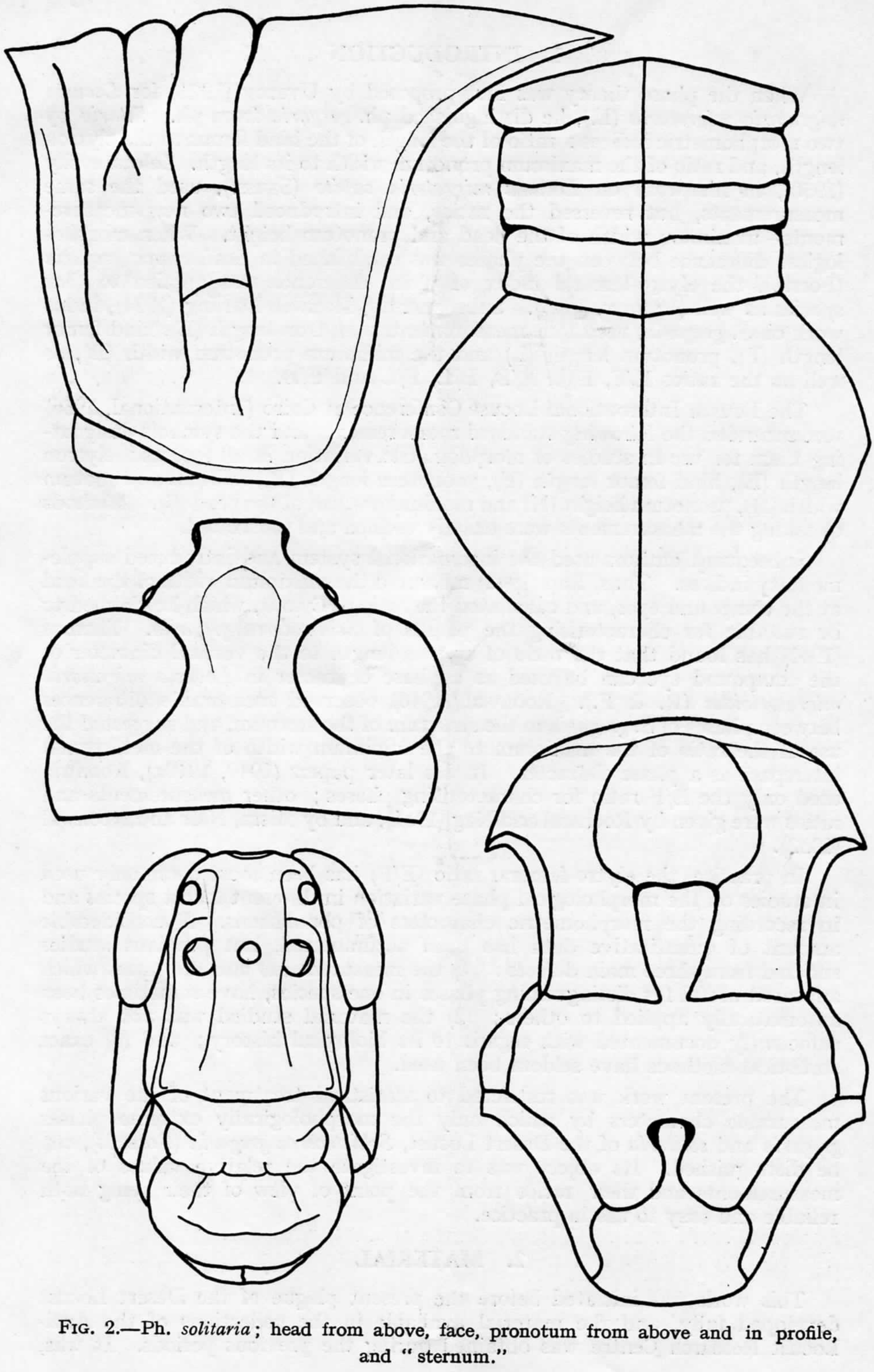

FIG. 2.—Ph. *solitaria*; head from above, face, pronotum from above and in profile, and " sternum."

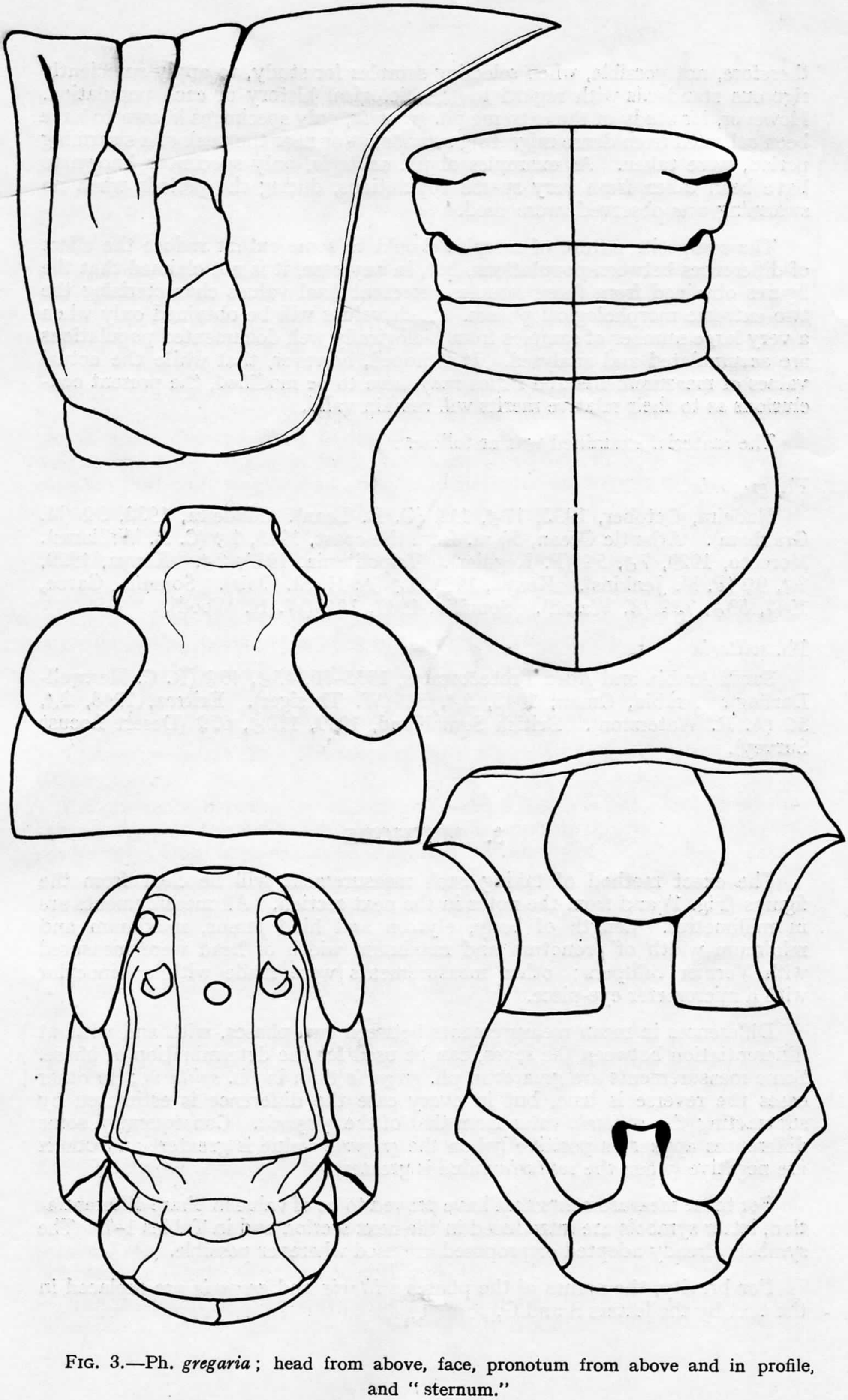

FIG. 3.—Ph. *gregaria*; head from above, face, pronotum from above and in profile, and "sternum."

therefore, not possible, when selecting samples for study, to apply sufficiently rigorous standards with regard to the biological history of each population. However, for study of the extreme ph. *gregaria*, only specimens known to have been collected from dense migrating swarms, at or near the peak of a swarming period, were taken. As examples of ph. *solitaria*, only specimens known to have been taken from very sparse populations, during the periods when no swarming was observed, were used.

The composite nature of samples should to some extent reduce the effect of differences between populations, but, in any case, it is not claimed that the figures obtained from these samples represent final values characterising the two extreme morphological phases. Such values will be obtained only when a very large number of samples from biologically well documented populations are accumulated and analysed. It is hoped, however, that while the actual values of measurements and ratios may have to be modified, the present conclusions as to their relative merits will remain valid.

The material examined was as follows :

Ph. *gregaria*

Madeira, October, 1932, 17♂, 11♀ (O. B. Lean). Madeira, 1932, 3♀ (M. Grabham). Atlantic Ocean, 50 m. from the coast, 1943, 1♂ (C. B. Williams). Morocco, 1929, 7♂, 5♀ (P. Regnier). Tripolitania, 1930, 2♂. Kenya, 1929, 7♂, 9♀ (P. M. Jenkins). Kenya, 1931, 1♂ (A. H. St. Clair). Somalia, Garoe, 1947, 53♂, 72♀ (Z. Waloff). Somalia, 1947, 12♀ (W. H. Wood).

Ph. *solitaria*

Saudi Arabia and Aden Protectorates, 1935–36, 43♂, 40♀ (R. C. Maxwell-Darling). Arabia, Oman, 1948, 5♂, 5♀ (W. Thesiger). Eritrea, 1948, 2♂, 5♀ (A. R. Waterston). British Somaliland, 1949, 110♂, 67♀ (Desert Locust Survey).

3. METHODS

The exact method of taking each measurement will be clear from the figures (Fig. 1) and from the notes in the next section. All measurements are in millimetres. Length of body, elytron and hind femur, maximum and minimum width of pronotum and maximum width of head were measured with Vernier callipers ; other measurements were made with a binocular with a micrometer eye-piece.

Differences in mean measurements between two phases, with and without differentiation between the sexes, can be used for the determination of phase. Some measurements are greater in ph. *gregaria* than in ph. *solitaria* ; in other cases the reverse is true, but in every case the difference is estimated by subtracting the *solitaria* value from that of the *gregaria*. Consequently, some differences appear as positive (when the *gregaria* value is greater) and others are negative (when the *solitaria* value is greater).

For those measurements that have proved to be of value in phase differentiation, letter symbols are introduced in the next section and in Tables 1–7. The symbols already adopted or proposed are used wherever possible.

For brevity, the names of the phases *solitaria* and *gregaria* are replaced in the text by the letters S and G.

4. MEASUREMENTS

All measurements (Tables I–IV) were made on 100♂ and 100♀ of *gregaria* and 50♂ and 50♀ of *solitaria*, except the measurements nos. 2, 16 and 20 for which the number of *solitaria* was 160♂, 117♀, and no. 1 where the number of *gregaria* ♀ was 29. Figs. 4–23 are frequency distribution curves for all the characters considered.

1. *Length of body* (**L**). Measured as distance from anterior end of head to apex of subgenital plate in male and to apex of ovipositor in female.

This character is usually not favoured in phase studies, because the abdomen is telescopic and its length may be affected by the method of preservation. However, measurements of specimens bred in the laboratory have shown that although the length of the body decreased after drying by 4·2% in males and by 4·6% in females, the correlation between weight of body when fresh and its length when dry remained as highly significant as the correlation between weight and body length in fresh specimens ($P < 0{\cdot}001$ in both cases). This suggests that body length is an acceptable measurement even in dry specimens.

As will be seen from the Tables I–IV, the length of body of G males is highly significantly greater than that of S males. In the females the length of body is greater in S, but the difference is small and not significant.

2. *Elytron length* (**E**). Measured according to the accepted international standard: from the branching of the costal (mediastinal) and the subcostal (anterior radial) veins to the apex of the elytron (Fig. 1, E).

The male elytron is longer in G than in S; in the female the elytron is longer in S, *i.e.*, this character varies in opposite directions in the sexes. In both cases the differences between means are highly significant.

3. *Pronotum length* (**P**). Measured along the median pronotal carina (Fig. 1, P).

The difference between the means for G and S males is small and its significance is low; in females the difference is in the opposite direction and is highly significant. Only females can be separated by this index.

4. *Length of prozona of pronotum* (**Pz**). Measured along the median pronotal carina, from the anterior margin to the main pronotal sulcus (Fig. 1, Pz).

The prozona of the pronotum in the male is longer in G than in S, but the difference is not significant; in the female, the prozona is longer in S and the difference is highly significant. This index is sufficiently reliable for females only.

5. *Length of metazona of pronotum* (**Mz**). Measured along the median pronotal carina, from the main pronotal sulcus to the posterior edge of the pronotum (Fig. 1, Mz).

The metazona of the pronotum is longer in S than in G in both sexes, but in males the difference is not significant; in the females it is highly significant. Another character suitable for females only.

6. *Height of pronotum* (**H**). Measured (under binocular with micrometer eye-piece) as the vertical distance between the lowest point of the lateral pronotal lobe and the level of the highest point on the median pronotal carina between the second and third sulci (Fig. 1, H).

The pronotum in both sexes is higher in S than in G. In the females, the difference is highly significant; in the males it is also significant. Curves of frequency distribution broadly overlap between phases in both sexes (Fig. 9). Since the variation is in the same direction and is significant in both sexes, this measurement may be used as a phase character.

7. *Minimum width of pronotum* (**M**). Measured (by Vernier callipers applied from above) as shown in Fig. 1, M.

The difference in the minimum width of the pronotum between males is non-significant ; in the females the minimum width is greater in S than in G and the difference is highly significant. This character holds good for females only.

8. *Maximum width of pronotum* (**Mx**). Measured as the greatest distance between the surfaces of the lateral pronotal lobes in the metazona (Fig. 1, Mx).

The maximum width of the pronotum is greater in S than in G but in males the difference in means is small and is hardly significant. In females, the difference is highly significant. This character is suitable for females only.

9. *Length of " sternum "* (**St**). Measured as the distance from the anterior suture of the mesosternum to the posterior edge of the first abdominal sternite (Fig. 1, St). The term " sternum " is anatomically inexact, and is used here for convenience.

The sternum is longer in S than G in both sexes, but in the males the difference is non-significant ; in the females the difference is highly significant. This character is suitable for females only.

10. *Width of mesosternum* (**W**). Measured across the narrowest part of the mesosternum, between the bases of the middle legs (Fig. 1, W).

The width of the mesosternum in males is greater in G than in S, but in females it is smaller in G than in S. In both cases the difference is highly significant. Although the means of this measurement differ significantly between phases in both sexes, it varies in opposite directions in the two sexes.

11. *Minimum width of mesosternal interspace* (**mS**). Measured across the narrowest posterior part of the interspace (Fig. 1, mS). The minimum width of the mesosternal interspace is greater in G than in S in both sexes. This is one of the few characters showing phase variation in the same direction in both sexes, and the significance of the difference is sufficient to accept this measurement for phase diagnosis. However, frequency distribution curves (Fig. 14) for the two phases show overlapping in both sexes.

12. *Maximum width of mesosternal interspace* (**mxS**). Measured across the widest part of the mesosternal interspace (Fig. 1, mxS).

The difference between the maximum width of the mesosternal interspace in males is not significant ; in females this measurement is greater in S than in G and the difference is highly significant. Suitable only for females.

13. *Minimum width of metasternal interspace* (**mT**). Measured across the narrowest part of the portion of the first abdominal sternite separating the metasternal lobes (Fig. 1, mT).

The minimum width of the metasternal interspace is greater in G than in S in both sexes and the differences are highly significant, particularly in males. Although undoubtedly a good phase character, this measurement has two practical drawbacks : it is difficult to make exactly, as the edges of the interspace are sunk and not clearly discernible ; and the frequency distribution curves for the two phases overlap (Fig. 16).

14. *Length of anterior femur* (**AF**). Measured along the external surface of the femur, directed forwards, from the junction between the trochanter and the femur to the distal end of the latter (Fig. 1, AF).

The anterior femur in males is longer in G than in S and this difference is highly significant ; in females, the anterior femur is longer in S than in G and the difference is significant but much less so than in the males.

15. *Length of middle femur* (**MF**). Measured along the anterior surface of the femur, from the suture between the trochanter and femur to the apex of the latter (Fig. 1, MF).

The middle femur of males is longer in G than in S and this difference is significant ; in females, the middle femur is longer in S than in G and the difference is highly significant. Although the means differ significantly in both sexes, this character varies in opposite directions in male and female.

16. *Length of posterior femur* (**F**). Measured along the external surface, as the maximum length from base to apex (Fig. 1, F).

The posterior femur is longer in S than in G in both sexes and the difference is highly significant. This character, however, has the same drawback as other absolute indices, namely, that the frequency distribution curves overlap (Fig. 19).

17. *Width of vertex between eyes* (**V**). Measured by micrometer eye-piece as the shortest distance between the compound eyes at the vertex (Fig. 1, V).

The vertex is broader in G than in S in both sexes and this difference is highly significant. The frequency distribution curves, however, overlap (Fig. 20).

18. *Vertical diameter of eye* (**O**). Measured by micrometer eye-piece as the maximum diameter (Fig. 1, O).

The vertical diameter of the eye is greater in S than in G in both sexes, and the difference is highly significant. A good phase character, but the frequency distribution curves for phases overlap (Fig. 21).

19. *Horizontal diameter of eye* (**Oh**). Measured by micrometer eye-piece as the minimum diameter (Fig. 1, Oh).

The horizontal diameter of the eye is greater in S than in G in both sexes and the difference is highly significant. The same comment applies to this index as to the preceding one.

20. *Maximum width of head* (**C**). Measured as the greatest width of the head in the genal region (Fig. 1, C). In the course of the present work this measurement was taken as follows : the calliper arms, applied from the front and kept exactly parallel to the largest (*i.e.*, the vertical) diameter of the head, were passed over the genae backwards and forwards, the screw being slowly adjusted, and the reading was taken when the arms just failed to pass (Dirsh, 1951). The alternative method would be to take the reading when the arms pass over the genae with the faintest perceptible resistance ; according to Dr. R. C. Rainey, who has carefully compared and tested this method, it reduces the chances of personal error.

The head is broader in G than in S in both sexes and the difference is highly significant. This is a good phase character, with high significance and with the same direction of variation in both sexes, though frequency distribution curves for the two phases overlap (Fig. 23).

Discussion of the measurements

When the standard errors of the means of the 20 measurements are examined, it will be seen that in all cases these are small compared with their respective means (Tables I–II). Hence, the mean values can be used as reliable estimates of the phase indices. The standard errors of the means are somewhat larger in S than in G, but still very small.

Quantitative differences between measurements of the two phases have been analysed for each character by calculating the difference between the two means and by assessing its significance (Tables III, IV).

The difference of means between males of G and S is positive in 12 cases and negative in 8, but out of 20 cases only in 13 is the significance reliable ($t > 3$). This rules out 7 measurements (Table III, Nos. 3, 4, 5, 7, 8, 9, 12).

In 9 out of the 13 reliable cases, the difference of means is positive (Table III, Nos. 1, 2, 10, 11, 13, 14, 15, 17, 20), and in 4 cases (Table III, Nos. 6, 16, 18, 19) negative, most measurements of G males having higher values than those of S males. The difference of means between females of G and S is significant ($t > 3$) in 18 cases, but only in four (Table IV, Nos. 11, 13, 17, 20) of them is it positive.

It can be concluded that there are more characters exhibiting phase differences in females than in males and in the majority of cases measurements are higher in the solitary phase. In males, there are fewer phase characters and most of them have higher values in the gregarious phase.

When means for the two sexes within each phase are compared, their differences are always highly significant (in all cases $P < 0{\cdot}001$). This sexual dimorphism is particularly great in the solitary phase since all 20 measurements show greater difference between males and females in S than in G.

In selecting, for general use, the measurements which may be regarded as characteristic for the two phases it appears impractical to accept the measurements which vary with the phase in opposite directions in the two sexes or vary only in one sex. If such measurements are rejected, only eight (Tables III, IV, Nos. 6, 11, 13, 16, 17, 18, 19 and 20) are left which exhibit phase variation in the same direction in both sexes. In four cases (Nos. 11, 13, 17 and 20) the difference between means of G and S is positive ; in four others (Nos. 6, 16, 18 and 19) it is negative (Tables III, IV).

Although the significance of the difference of means is very high in all eight cases, frequency distribution curves of all these indices show considerable overlapping (Figs. 4–23). Therefore, the indices cannot be used for practical determination of the morphological phase, but some of them may be useful for comparing and analysing populations.

5. RATIOS

Since direct measurements have been found inadequate for the practical purpose of phase differentiation by the simple statistical methods, it is necessary to resort to ratios between two suitable selected measurements.

A number of ratios have been tested and the most promising were those between two measurements which vary in opposite directions according to the phases, but in the same direction in the two sexes. Such ratios are likely to show phase differences more clearly.

Direction of variation of selected indices

♂G — O < ♂S — O	♂G — V > ♂S — V
♀G — O < ♀S — O	♀G — V > ♀S — V
♂G — mS > ♂S — mS	♂G — F < ♂S — F
♀G — mS > ♀S — mS	♀G — F < ♀S — F
♂G — mT > ♂S — mT	♂G — C > ♂S — C
♀G — mT > ♀S — mT	♀G — C > ♀S — C

A further practical criterion of suitability was the need to minimise the risk of experimental error in taking measurements. On this basis seven ratios have been selected for a comparison (Table V), as follows:

$$\frac{O}{V}, \frac{O}{mS}, \frac{O}{mT}, \frac{F}{mS}, \frac{F}{mT}, \frac{F}{V}, \frac{F}{C}.$$

As can be seen from Table VI, all these ratios show great and highly significant differences between means for the same sex of the two phases.

The difference of means between the two sexes of the same phase (Table VII) is in nearly all cases less than the difference between the phases and in all cases significant or highly significant, except F/V, where it is non-significant.

It can, therefore, be concluded that these seven ratios are reliable phase characters. However, the first five of them, viz. O/V, O/mS, O/mT, F/mS and F/mT, have a serious practical drawback in that frequency distribution curves for the two phases overlap to a considerable extent. Therefore, these five ratios, while suitable for detailed analysis of populations, cannot be used in practice for determining the phase of an individual, or even of a small series.

On the other hand, the ratios F/V and F/C show no overlap of frequency distribution (Figs. 29 and 31) and can be regarded as most suitable for phase differentiation.

When it comes to a choice between F/V and F/C ratios, an important practical consideration is that V (width of vertex between eyes) can be accurately measured only by using a binocular with a micrometer eye-piece, which is seldom possible under field conditions. On the other hand, C (maximum width of head) can be measured by callipers, which are also used for measuring F (length of hind femur). It follows that the F/C ratio can be recommended for general use as a reliable and convenient practical index of the phase (Dirsh, 1951).

We have to consider now the ratio which has been most commonly used for distinguishing the phases, namely E/F (length of elytron to length of hind femur). This ratio would appear satisfactory, since the difference between means of the two phases (Table IV) is highly significant in both sexes. However, as has already been shown (Dirsh, 1951), the length of the elytron is greater in ph. *gregaria*, as compared with ph. *solitaria*, only in males, while the female elytron is longer in ph. *solitaria*, and the length of the hind femur is greater in both sexes in ph. *solitaria* than in ph. *gregaria*. Since the phase variation in E occurs in different directions and variation in F in the same direction in the two sexes, the E/F ratio is clearly less suitable for phase differentiation than the F/C ratio, the components of which vary in the same direction in both sexes. Moreover, the frequency distribution for E/F in two phases shows some overlap (Fig. 30), and therefore, the use of this ratio may often lead to unreliable conclusions.

6. PHASE *TRANSIENS* AND MORPHOLOGICAL GREGARISATION

While the use of statistical methods permits one to characterise the two extreme morphological phases, *gregaria* and *solitaria*, this is not possible in the case of ph. *transiens*, which, by definition, comprises the whole series of transitions between the extreme forms. Since even the extreme phases, as we have seen, are subject to considerable variation with regard to the chosen criteria, it would be of practical advantage to adopt conventional limits of the criteria, *i.e.*, to decide at what points on the frequency distribution curve the " pure " phases *gregaria* and *solitaria* end and ph. *transiens* may be assumed to begin. It might be logical to accept the mean value of the chosen criterion as such a point, but it appears more suitable to use the modal value, which corresponds to the greatest number of specimens in a sample.

Since the modal value of F/C (see Fig. 31) in G males is 3·15, all individuals showing that, and lower, values may be considered as morphologically " pure " *gregaria* ; those with the value 3·75 and above as " pure " *solitaria* ; and those with the values falling between 3·15 and 3·75 as *transiens*. In the case of females, the limiting (modal) values are 3·15 for *gregaria*, 3·15–3·85 for *transiens* and 3·85 and above for *solitaria*.

If this method is adopted, it becomes possible to evaluate numerically the *degree of morphological gregarisation*, *i.e.*, of the divergence of a *transiens* population, or even an individual, from *solitaria*. This can be done by dividing the difference between the modal values for G and S by 100, and by calculating the *percentage of gregarisation* (PG).

Table VIII gives calculated percentages of morphological gregarisation for the observed values of the F/C ratio and Table IX does the same for the E/F ratio.

This method of calculating PG can be used to obtain objective information on the morphological phase status of a population. Should future, more extensive studies result in modification of the present values for the extreme phases, the tables will have to be recalculated, but it is hoped that the PG method will prove of value.

It hardly needs to be emphasised that the PG method can only be applied to homogeneous populations, since it is based on the modal value, which would be misleading in the case of a mixed population. It is essential, therefore, to prepare a frequency distribution graph for the ratio adopted as a phase index, or to apply a statistical test for the normality of distribution.

Other suggestions for morphometric assessment of the phase status of locust populations have been made by Rao (1942) and Roonwal (1949, 1949a). Both authors have based the assessment on the E/F ratio, which, as shown above, is not the most reliable phase index ; moreover, they calculated the mean ratio regardless of the sex. Rao suggested that, for the assessment of a population, the percentages in it of individuals referable to the three phases should be calculated ; the limits of E/F ratios for the phases accepted by him were : *solitaria* 2·05 and below ; *transiens* 2·06–2·15 ; *gregaria* 2·16 and above. As can be seen from Table IX, Rao's value for *solitaria* is slightly below the modal value for males and slightly above that for females, while his lowest *gregaria* value (2·16) corresponds to 67·5% gregarisation in the case of males, and only 42·5% in the case of females. This suggests that Rao's values are liable to produce misleading information.

Roonwal (1949a) has suggested that, since the *transiens* phase " is impossible to distinguish satisfactorily," it should be ignored, and only two categories, *solitaria* and *gregaria* recognised, the dividing E/F value being 2·105. According to Table IX this value corresponds to 40% gregarisation in males and to only 15% in females. Assessment of a population, according to Roonwal, should be made by calculating the percentage in it of " *gregaria* " ; this percentage he calls " population shift figure," but it is clear from the above that his conception of the phase *gregaria* is too wide, while the neglect of sexual differences in the E/F ratio makes it still wider. Roonwal's (1949a ; Roonwal and Nag, 1951 ; Misra, Nair and Roonwal, 1952) additional suggestion to use the number of eye-stripes as a phase index cannot be discussed here, as it is based on a very different aspect of variation within the phases which is still insufficiently explored.

It remains to be seen to what extent the percentage of morphological gregarisation corresponds to the degree of biological phase transformation. Extensive investigations on populations with exactly known biological history are required, since only such tests will make it possible to judge whether the PG method can be used to assess phase transformation trends in a population.

TABLE I

Means, standard errors and standard deviations of ph. *gregaria* and *solitaria*.

MALES

No.	Indices	Symbols	Mean and standard error		Standard deviation	
			G	S	G	S
1	Length of body	L	52·37 ± 0·22	49·37 ± 0·43	2·22	3·03
2	Length of elytron	E	52·79 ± 1·99	50·20 ± 0·16	1·99	2·01
3	Length of pronotum... ...	P	9·50 ± 0·04	9·46 ± 0·07	0·43	0·49
4	Length of prozona of pronotum	Pz	4·21 ± 0·02	4·14 ± 0·03	0·21	0·22
5	Length of metazona of pronotum	Mz	5·31 ± 0·03	5·40 ± 0·05	0·28	0·34
6	Height of pronotum	H	7·78 ± 0·03	7·99 ± 0·06	0·34	0·43
7	Minimum width of pronotum	M	5·83 ± 0·03	5·81 ± 0·04	0·31	0·26
8	Maximum width of pronotum	Mx	8·52 ± 0·05	8·65 ± 0·07	0·48	0·49
9	Length of " sternum " ...	St	12·37 ± 0·05	12·54 ± 0·08	0·52	0·56
10	Width of mesosternum ...	W	5·83 ± 0·03	5·63 ± 0·04	0·32	0·27
11	Minimum width of mesosternal interspace	mS	1·53 ± 0·01	1·07 ± 0·02	0·14	0·14
12	Maximum width of mesosternal interspace	mxS	1·97 ± 0·01	2·00 ± 0·02	0·10	0·13
13	Minimum width of metasternal interspace	mT	0·65 ± 0·01	0·41 ± 0·01	0·08	0·08
14	Length of anterior femur ...	AF	6·96 ± 0·03	6·61 ± 0·04	0·35	0·31
15	Length of middle femur ...	MF	8·09 ± 0·04	7·81 ± 0·08	0·37	0·57
16	Length of posterior femur ...	F	23·68 ± 0·10	24·54 ± 0·11	1·00	1·38
17	Width of vertex between eyes	V	1·82 ± 0·01	1·36 ± 0·01	0·13	0·11
18	Vertical diameter of eye ...	O	3·63 ± 0·01	3·77 ± 0·03	0·13	0·18
19	Horizontal diameter of eye ...	Oh	2·33 ± 0·01	2·41 ± 0·02	0·09	0·14
20	Maximum width of head ...	C	7·59 ± 0·03	6·34 ± 0·03	0·25	0·33

TABLE II

Means, standard errors and standard deviations of ph. *gregaria* and *solitaria*.

FEMALES

No.	Indices	Symbols	Mean and standard error		Standard deviation	
			G	S	G	S
1	Length of body	L	57·83 ± 0·68	59·27 ± 0·45	3·66	3·15
2	Length of elytron	E	59·25 ± 0·23	61·07 ± 0·25	2·34	2·75
3	Length of pronotum	P	10·48 ± 0·05	11·38 ± 0·08	0·46	0·59
4	Length of prozona of pronotum	Pz	4·66 ± 0·03	5·05 ± 0·03	0·26	0·22
5	Length of metazona of pronotum	Mz	5·85 ± 0·03	6·41 ± 0·07	0·28	0·49
6	Height of pronotum	H	8·36 ± 0·04	9·52 ± 0·06	0·41	0·43
7	Minimum width of pronotum	M	6·43 ± 0·03	6·96 ± 0·03	0·26	0·24
8	Maximum width of pronotum	Mx	9·55 ± 0·05	10·37 ± 0·07	0·47	0·48
9	Length of " sternum " ...	St	13·67 ± 0·06	15·04 ± 0·09	0·58	0·63
10	Width of mesosternum ...	W	6·77 ± 0·02	7·26 ± 0·05	0·23	0·34
11	Minimum width of mesosternal interspace	mS	1·84 ± 0·02	1·53 ± 0·02	0·17	0·14
12	Maximum width of mesosternal interspace	mxS	2·29 ± 0·01	2·57 ± 0·02	0·11	0·15
13	Minimum width of metasternal interspace	mT	1·16 ± 0·01	0·96 ± 0·02	0·11	0·16
14	Length of anterior femur ...	AF	7·50 ± 0·04	7·68 ± 0·06	0·39	0·42
15	Length of middle femur ...	MF	9·14 ± 0·03	9·38 ± 0·05	0·35	0·39
16	Length of posterior femur ...	F	25·73 ± 0·11	29·65 ± 0·13	1·06	1·42
17	Width of vertex between eyes	V	2·04 ± 0·01	1·67 ± 0·01	0·13	0·11
18	Vertical diameter of eye ...	O	3·85 ± 0·01	4·23 ± 0·02	0·13	0·16
19	Horizontal diameter of eye ...	Oh	2·43 ± 0·01	2·63 ± 0·01	0·09	0·10
20	Maximum width of head ...	C	8·16 ± 0·03	7·49 ± 0·03	0·31	0·32

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