Regulation of Morphogenesis in an Oleaceous Tree, *Nyctanthes arbor-tristis*

THE pioneers of biometry published many figures on the variation in flowers of numbers of petals, sepals, stigmatic bands, and so on. As they worked on herbs, they counted small numbers, and though they found differences in the means of different plants, were unable to compare the variances, either between plants or between the same plant at different times. *Nyctanthes arbor-tristis* Linn. (Oleaceae) sheds up to 1,492 flowers nightly, and up to 32,790 in a season, normally from September to early January in Calcutta.

Three trees of this species were observed throughout the season 1955–56 (ref. 1), and seventeen for seven weeks in 1957. Table 1 gives the grand total.

Table 1. OVERALL FREQUENCY DISTRIBUTION OF FLOWERS (FOR THREE TREES IN 1955–56 AND SEVENTEEN TREES IN 1957) ACCORDING TO NUMBER OF PETALS

No. of petals	4	5	6	7	8	9	15	Total
No. of flowers	451	29,147	109,345	18,956	1,012	14	1	158,926

It will be seen that most flowers (68·8 per cent) had six petals. In 1957 the means for the seventeen trees ranged from $5{\cdot}50 \pm 0{\cdot}0081$ to $6{\cdot}27 \pm 0{\cdot}0088$. Most means differed significantly from all others. The means for three trees measured in successive years were 5·92, 5·89; 6·05, 6·09; and 5·98, 6·01. The differences were significant but small.

Fig. 1 shows the changes in the means for three trees during a season. In order to obtain a moderately smooth graph I took moving means over five consecutive days. It will be seen that for each tree the mean fell and then rose again.

The standard deviations also differed in the different trees, ranging from $0{\cdot}5108 \pm 0{\cdot}0052$ to $0{\cdot}6605 \pm 0{\cdot}0069$. Again many differences were highly significant. As, however, the usual test of significance for the difference of two variances is only valid when the distributions are normal, and the fourth moments are not very well determined, I tested the percentages of abnormality, that is to say, the percentages of flowers with a number of petals other than six. These often differed very significantly even when the means did not. The standard deviations increased systematically through a season as shown in Fig. 2, though for one of the trees they dropped on two occasions. The changes in means and standard

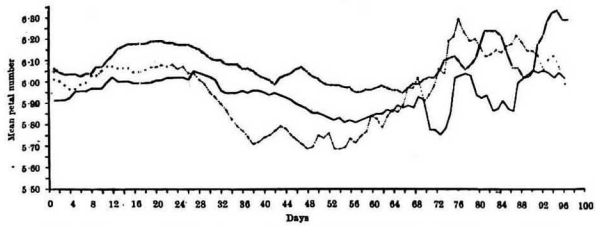

Fig. 1. Moving means of petal numbers over five consecutive days for three trees during the season 1955–56. ——, Tree No. 1; — — —, tree No. 2; .....,, tree No. 3

deviations alike are about 0·1–0·2. The point is that the means changed by about 2–4 per cent, and the standard deviations by 20–40 per cent or so.

If a craftsman produced articles with much the same mean dimensions in the course of a day's work, but their variance around this mean increased progressively, we should say that he was getting fatigued. It might be possible to trace this fatigue to a decline in the efficiency of 'negative feedback'. It is not so easy to apply this notion to a plant. The weather became progressively cooler during the flowering season, and the increased variance might be ascribed to this. However, I have observed the same increase in variance of petal number during the flowering season in two plants of each of *Jasminum pubescens* var. *alba* and *Jasminum pubescens* var. *rubescens*, although in these cases the temperature was rising. The closest analogy known to me is the case of pernicious anaemia in man. Here Price-Jones[2] showed that the mean diameters of red blood corpuscle increased moderately, but the standard deviation increased much more. Such words as regulation and homeostasis are applied to the processes by which such variables as body-temperature and blood glucose-level are kept relatively steady. Here we can measure the efficiency of regulation by the reciprocal of the variance in a set of successive values, and the regulation can be shown to depend on a negative feedback system. It may not be so easy to apply this notion to the standardization of a set of simultaneous performances.

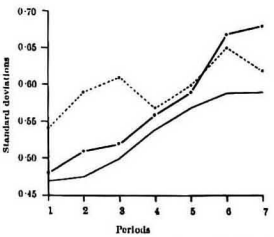

Fig. 2. Standard deviations for seven consecutive periods of sixteen days each for three trees during the season 1955–56 ——, Tree No. 1; — — —, tree No. 2; - - - - -, tree No. 3

Whatever the nature of the regulatory process, its efficiency can be measured. I suggest that the variance of a metrical character may be as important a property of an organism as its mean, and should be measured on a number of species. This is being done at this Institute, but I hope that similar work may be undertaken outside India. A detailed account of the work described here will be published elsewhere.

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[1] Roy, S. K., *Curr. Sci.*, **27**, 134 1958).
[2] Price-Jones, C., *J. Path. Bact.*, **32**, 470 (1929).