THE USE OF ASSORTATIVE MATING FOR HERITABILITY ESTIMATION

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Received February 12, 1964

REEVE (1953, 1955, 1961) has suggested that assortative mating of parents be used to obtain data for estimation of heritability by parent-offspring regression. The advantage of this technique over the standard random mating procedure is that the variance of midparent values is increased, thereby providing greater accuracy in the estimation of the regression coefficient. Possible bias introduced as the result of phenotypic correlations between parents, given certain assumptions, was shown by REEVE to be negligible or to involve only second-order effects.

Before this method is generally adopted, one further problem should be pointed out. Many quantitative characters for which heritability estimates are desired involve maternal effects. With a random mating design it is possible to obtain an estimate of heritability free from maternal effects by the use of regressions of offspring on sires. Thus, ignoring higher order $(\text{additive})^n$ epistatic terms, the sire estimate contains only variation due to the additive effects of genes ($b = 1/2\ h^2$), whereas the regression of offspring on dams yields an estimate which includes maternal effects ($b = 1/2\ h^2 + \text{M}$).

On the other hand, a completely assortative mating scheme does not allow the detection of maternal effects, since with such a procedure the regression of offspring on sire and on dam will be exactly the same. Thus the heritability of a character for which maternal effects are important will be overestimated by the use of assortative mating of parents.

To demonstrate this point, data on heritability of developmental time collected in both ways in the flour beetle, *Tribolium castaneum*, may be of interest. From more detailed studies to be reported elsewhere maternal effects are known to be important for this character.

METHODS

For both mating designs, 120 single-pair matings of individuals from the University of California synthetic stock (see LERNER and Ho 1961) were used. Parents and offspring were reared under the same conditions. The 120 matings for each design were carried out at three separate times with 40 matings per experiment.

Ten eggs were collected per mating pair within 24 hours after oviposition and placed in small shell vials with about 1.5 grams of flour. Stone ground whole-wheat flour enriched with 5 percent brewer's yeast was used. All cultures were maintained in an incubator kept at 29°C and 70 percent relative humidity. Within each set of crosses, the mating pairs were assigned to vials at random. When pupae started to appear, the vials were removed daily from the incubator, the contents sifted and the pupae removed, recorded and discarded.

The trait measured in these studies was the number of days from egg-laying to pupation. Only those vials from which a minimum of five pupae were obtained were used in the regression analyses. This restriction, which was imposed prior to conducting the experiments, resulted in 91 and 99 suitable parent-offspring combinations for the assortative and random designs respectively.

RESULTS AND DISCUSSION

Relevant data are presented in Tables 1 and 2 and Figure 1. In spite of large standard errors of the heritability estimates given in Table 1 the three experiments are quite consistent for both mating designs. Combined estimates and 95 percent confidence limits (SNEDECOR 1956) are listed in Table 2. Examination of the confidence limits obtained from regression of offspring on midparent clearly demonstrates, as REEVE has shown, that the assortative mating scheme provides a more precise estimate.

However, when regressions of offspring on sire and dam are computed separately for the random mating scheme, it is seen that the presence of maternal effects acts to inflate the midparent estimate. In the present material the confidence limits are so wide that it is not possible to measure the extent of the maternal effects. Heritability and maternal effects have been estimated by other methods and found to be about 0.15 and 0.07 respectively (DAWSON, unpublished). These estimates are in close agreement with the ones reported here; maternal effects estimated by one half of the difference between the dam and

TABLE 1

Heritabilities and standard errors from regression of offspring on parents using two different mating schemes. Each mating scheme replicated three separate times with 40 matings per experiment

Mating scheme	Experiment I	Experiment II	Experiment III
Assortative	0.30 ± 0.12 (36)*	0.38 ± 0.10 (24)	0.26 ± 0.14 (31)
Random			
Sire	0.12 ± 0.32	0.07 ± 0.35	0.16 ± 0.34
Dam	0.26 ± 0.21	0.26 ± 0.21	0.42 ± 0.33
Midparent	0.24 ± 0.19 (36)	0.33 ± 0.22 (29)	0.27 ± 0.23 (34)

* Numbers in parentheses refer to the number of matings out of 40 from which at least five offspring were obtained.

TABLE 2

Heritability estimates and 95 percent confidence limits from regression of offspring on parents using two different mating schemes

Mating scheme	Number of matings	Regression on	Heritability	Confidence limits
Assortative	91	Midparent	0.26	0.13,0.39
Random	99	Midparent	0.27	0.03,0.50
		Sire	0.12	−0.26,0.50
		Dam	0.30	0.02,0.57

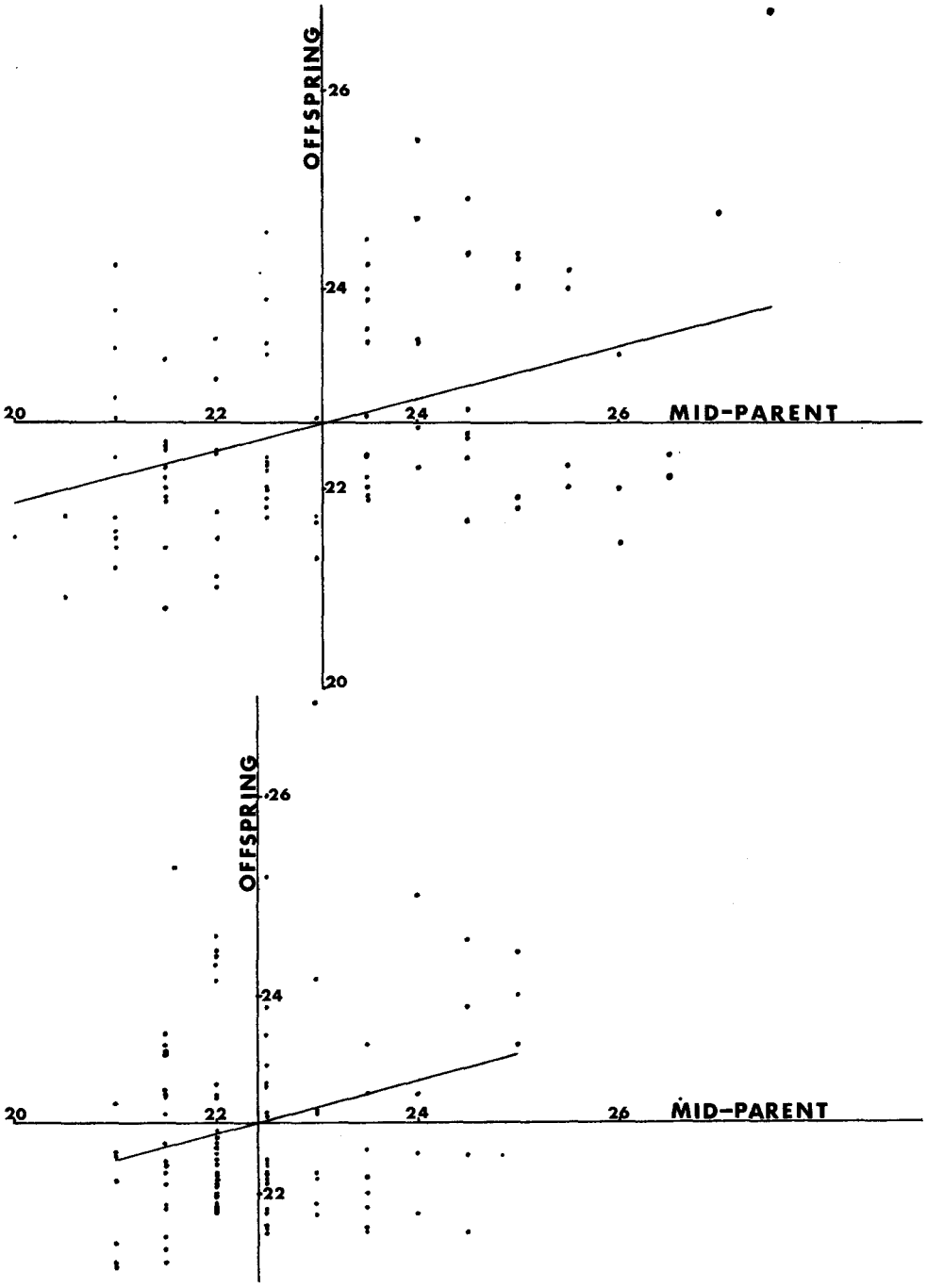

FIGURE 1.—Regression of offspring on midparent for developmental time (days from egg to pupa) from assortative (top) and random mating designs. Axes are drawn so as to intersect at the mean of the midparent values and the mean of offspring averages.

sire heritabilities from the random mating scheme turn out to be 0.09. Some indication of the variability in midparent and offspring averages is given by Figure 1.

Thus, when working with characters where maternal effects are known or suspected to be present, the less exact method of random mating of parents may be more valuable, even though it will in general necessitate a larger number of matings to attain precision equal to that obtained under the assortative mating scheme.

This study was supported in part by Public Health Service Grant RG-8942 to DR. I. M. LERNER. I am grateful to PROFESSOR LERNER for reading and improving the manuscript. MR. NOBUO INOUYE assisted in the collection of some of the data.

SUMMARY

A drawback to the use of assortative mating of parents for estimation of heritability, namely the presence of maternal effect, is discussed and illustrated with data collected on developmental rate of the flour beetle, *Tribolium castaneum*. When maternal effects are important, heritability from regression of offspring on midparent is overestimated. It is suggested that in such cases the less precise method of random mating of parents may be more valuable.

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