The heritability of response to T.M.V. was measured by a mid-parent offspring regression; 213 animals, comprising 32 litters, were measured. This regression, shown in Figure 3, gave a heritability $h^2 = 0.876$, S.E. 0.09.

In spite of the relatively low number of points making up the regression, these data clearly demonstrate the secondary response to T.M.V. to be highly heritable.

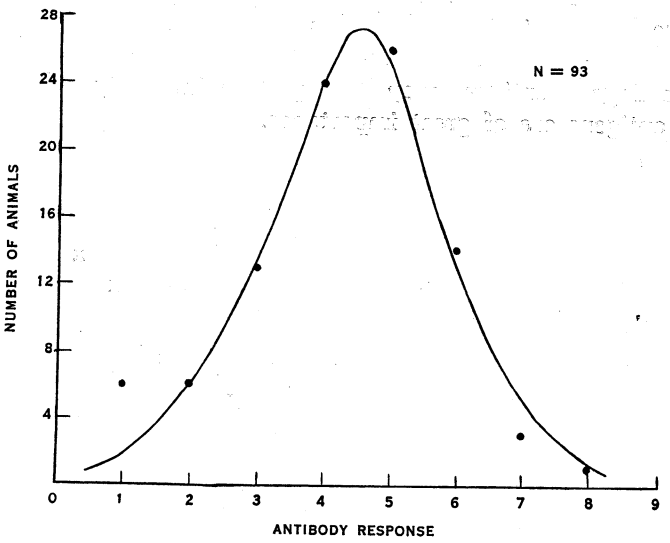

Fig. 2.—Frequency distribution from the combined data in Figure 1. $\bar{x} = 4.43$, $s\bar{x} = 0.14$, $s = 1.44$. Coefficient of variation = 32.5 per cent.

IV. Discussion

These results indicate that ability to produce antibodies to T.M.V. is highly heritable and it would be a relatively simple matter to select lines of animals with a high or low secondary response to this antigen. It was shown by Sobey (1953) and Sang and Sobey (1953), using a double diffusion technique in agar, that under the conditions prevailing in the present work, T.M.V. was apparently acting as a single antigenic fraction and producing a single specific antibody response. It was further shown that with a more prolonged antigenic stimulus T.M.V. elicited more than one antibody response; these could not be individually distinguished by the routine equivalence zone method used but only by the more delicate technique of agar diffusion. Thus had a greater antigenic stimulus been employed as a routine, the method of estimating antibody response would still have given a single measurement of what was in fact more than one antibody response. There are no grounds for assuming that these responses would be correlated, and if they were not, the resulting confusion in measurement would be likely to give a low or non-significant measure of heritability. Nevertheless, the individual antibody responses could be

as completely under genetical control as that found to the single antigenic T.M.V. fraction in this study.

These arguments raise fundamental issues regarding any study of the significance of antibodies in disease resistance. Pathogens generally are antigenically complex and may be expected to stimulate more than one specific antibody response. Of these antibodies it is often only one which plays a major part in immunity; in pneumococcal infection antibodies to the specific polysacchonides afford a high degree of specific immunity, whereas those to the nucleoprotein antigens have little protective value (Topley 1929; Topley and Wilson 1948; Bailley 1950). The evidence of Felix (1924) indicates that in motile bacilli the antibodies to flagella antigens play little part in immunity, whereas those to the somatic antigens are of great importance.

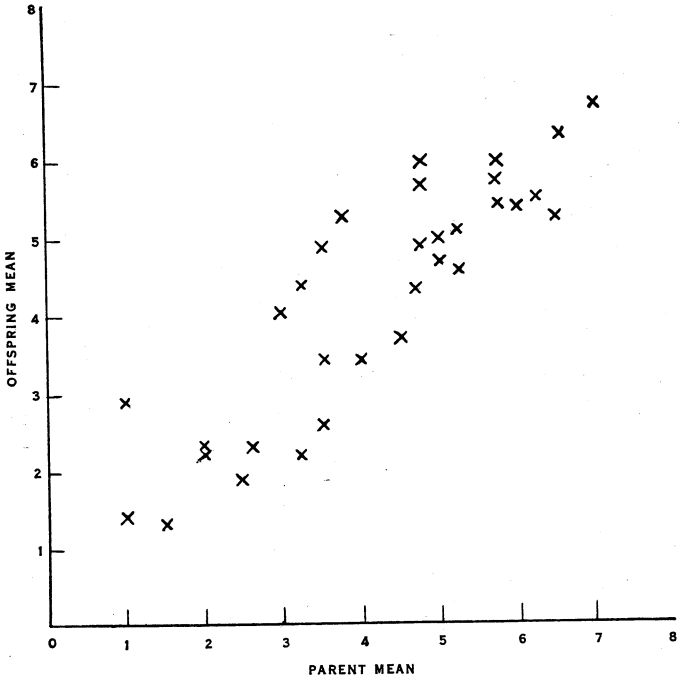

Fig. 3.—The regression of mean secondary response of offspring on mean secondary response of parents to routine injection of T.M.V. 213 Animals, comprising 32 litters, were measured. The estimated heritability was $h^2 = 0.876$, S.E. 0.09.

The relationship between the quantitative antibody response to the specific antigens concerned in resistance and the degree of resistance is not yet fully understood. There is evidence of a positive correlation (Smith 1932; Carlinfanti and Cavalli 1945; Bailley 1950), but this does not always justify the acceptance of a causal relation (Gorer and Schutze 1938; Weir, Cooper, and Clark 1953). Another factor concerning the individual antibody responses which has received little attention is the variability of their time responses, and whether or not speed of reaction is concerned in resistance.

To ensure a clear understanding of the inheritance of antibody response and of the relation of antibodies in resistance, it would appear necessary to study in detail the individual antibody responses involved. Measurements failing to differentiate the individual antibody responses are likely to be misleading in any quantitative study involving complex antigens.

If specific antibody responses are generally as highly heritable as that demonstrated with T.M.V., it might be possible to select lines of animals with a high or low antibody response to each of the individual antigenic fractions of a pathogen, provided these could be measured. Such lines of animals would afford useful material for the study of the problems raised.

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