REPRODUCTIVE FITNESS AND ARTIFICIAL SELECTION

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SUMMARY

Heritabilities for reproductive fitness are hypothesised to be non-linear as a consequence of prior directional natural selection. Three predictions of this hypothesis have been validated, namely that culling on fitness will be effective in alleviating fitness declines in lines selected for another trait, that selection on fitness during inbreeding will reduce inbreeding depression and that responses to selection for fitness traits will be consistently asymmetrical, with greater response in the direction of lowered fitness. These results have important implications for the improvement of reproductive fitness traits in plant and animal breeding.

INTRODUCTION

Reproductive fitness traits represent the most difficult and least understood traits in quantitative genetics and animal breeding, yet they are among the most important in animal production.

It is widely assumed that offspring-parent regressions are linear for quantitative characters. However, reproductive fitness has been subjected to directional selection that it expected to result in low levels of genetic variation, high frequencies of favourable alleles and primarily non-additive genetic variation remaining. Non-linear offspring-parent regressions and heritabilities are expected for characters showing directional dominance and/or directional gene frequencies (Robertson, 1977; Maki-Tanila, 1982). Since reproductive fitness characters exhibit these characteristics, it is predicted that they will exhibit consistently non-linear heritabilities (with greater heritabilities in the low direction). This leads to three predictions, namely (i) that culling on reproductive traits in artificial selection lines will be more effective in preventing the usual declines in fitness than expected from selection theory, (ii) that selection on fitness during inbreeding will reduce inbreeding depression, and (iii) that responses to bi-directional selection for fitness traits will be consistently asymmetrical with more response in the direction of lowered fitness. We have tested each of these predictions.

METHODS AND RESULTS

Full-sib inbreeding was carried out over seven generations in 20 replicate lines each of treatments with and without selection on reproductive fitness. Fitnesses of all lines and samples of the outbred base population were measured using the competitive index. Fitness reductions were significantly less in the lines inbred with selection on fitness than in those inbred without selection. The major effect was due to the lower loss of

lines in the treatment where selection on fitness was practiced.

The third prediction was tested by analysing published bi-directional selection experiments for reproductive fitness traits in several species of *Drosophila*, mice, rats, Japanese quail, chickens and *Tribolium* (see Frankham, 1990 for full details).Significant asymmetry of responses (24 of 30 studies) in the direction of lowered fitness was found. For studies reporting realised heritabilities, the means were 0.173 and 0.259 for lines selected for higher or lower reproductive fitness, respectively, the high lines being 33% less than the low lines.

DISCUSSION

It has been hypothesised that heritabilities for reproductive fitness traits are non-linear. This leads to three predictions namely that culling on fitness will be effective in alleviating fitness declines in lines selected for another trait, that selection on fitness during inbreeding will reduce inbreeding depression and that responses to selection for fitness traits will be consistently asymmetrical, with greater response in the direction of lowered fitness.

A systematic evaluation of the first prediction was done by selecting for a trait with and without culling on reproductive fitness. Frankham, Yoo and Sheldon (1988) showed that culling against low fitness was effective in preventing the usual declines in fitness in lines selected for another character.

The second prediction has been validated by showing that selection on fitness in lines under inbreeding reduces the inbreeding depression. Evidence in the literature on this point is somewhat conflicting.

The third prediction has been validated by showing that responses to bi-selection for reproductive fitness characters is significantly asymmetrical, with response being greater in the direction of reduced fitness. The magnitude of the differences in realized heritabilities was substantial (33%). Since asymmetry was evident for studies reporting realized heritabilities and for those with random mating controls of the same size as the selection lines, it is argued that the asymmetry results from genetic asymmetries.

Comsequently, all three prediction of the hypothesis have been validated. It can no longer be assumed that offspring-parent regressions and heritabilites for reproductive fitness characters are linear. These considerations have important implications in the improvement of reproductive fitness traits in plant and animal breeding.

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