

COMPARISON OF MATING SYSTEMS IN A FISH POPULATION - A SIMULATION STUDY

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SUMMARY

Computer simulation was used to compare two mating systems in a fish population for a trait controlled by different number of loci and different levels of dominance. The factorial mating system produced the highest genetic response for all traits. The difference was most pronounced for traits with complete dominance and controlled by a large number of loci.

INTRODUCTION

The increasing importance of the intensive management of small populations in animal breeding has resulted in increased interest in problems associated with selective breeding in small populations and the generally unfavourable effects of inbreeding have long been recognized. Significant inbreeding occurs when the number of individuals selected as parents for the next generation is low, which is often the case in different fish species with a high reproductive capacity.

There are some reports on the effect of inbreeding on different traits in fish (e.g. Gjerde et al., 1983). The effect of mating systems on inbreeding levels and selection response in a fish population was simulated by McKay et al. (1990). They found that factorial mating systems produce lower levels of inbreeding and higher selection response than single pair matings with the same numbers of individuals selected. However, the trait simulated in this study was controlled only by additive genetic effects and no inbreeding depression was considered. Johansson et al. (1993), among other things, compared two different mating systems in a small pig population. They found that an incomplete factorial mating system produced less inbreeding depression than a hierarchical system, with dams nested within sires. However, the amount of inbreeding was equal for all alternatives.

METHODS

The different traits modelled, using computer simulation, were controlled by either 75 or 150 unlinked loci with equal gene effects. There was no interaction between loci and two alleles at each locus were modelled with the initial frequency of 0.5. The additive effect (a , $-a$) was adjusted to give an initial additive genetic variance of 0.5 for traits controlled by both 75 and 150 loci to facilitate the comparison of the outcome for traits controlled by different number of loci. The dominance effect was set equal to the effect of the favourable allele ($d=a$) or to the half of this value ($d=1/2 a$). The initial dominance variance was 0.25 and 0.0625 for the two dominance alternatives respectively. The genetic value of an individual was calculated as the sum of additive and dominance effects over all loci. The phenotypic value was calculated as the sum of the genetic value and a random environmental deviate with mean zero and variance 0.5. The setup of genetic and environmental effects described gave heritabilities in the narrow sense of 0.40 and 0.47 for the two dominance alternatives respectively.

Individual phenotypic selection on one trait was performed and the selected individuals were mated according to single pair mating or factorial mating systems for 5 generations. For each generation, 10 individuals were selected out of 2000. Each parameter combination was replicated 20 times. The genetic mean of a generation was calculated as the mean of all individual genetic values. The coefficient of inbreeding for each individual was calculated from its pedigree and the level of inbreeding for a specific generation was calculated as the mean of the individual inbreeding coefficients. The additive and dominance variances for a generation were calculated as the variances of the individual additive and dominance values, respectively.

RESULTS

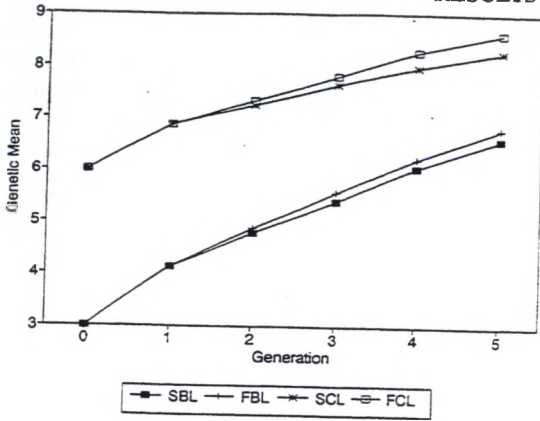


Fig 1. The parameter combinations are
 SBL=single pair mating, $d=1/2a$, 150 loci
 FBL=factorial mating, $d=1/2a$, 150 loci
 SCL=single pair mating, $d=a$, 150 loci
 FCL=factorial mating, $d=a$, 150 loci
 SE approximately 0.04

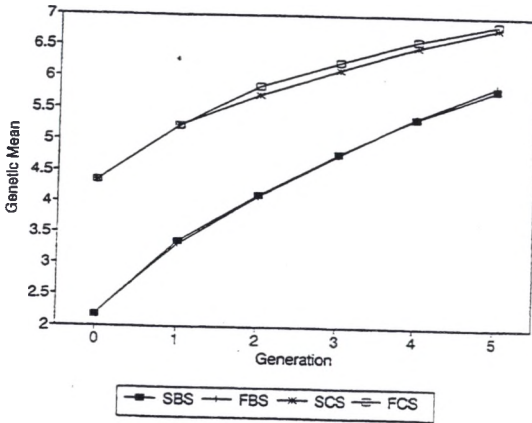


Fig 2. The parameter combinations are
 SBS=single pair mating, $d=1/2a$, 75 loci
 FBS=factorial mating, $d=1/2a$, 75 loci
 SCS=single pair mating, $d=a$, 75 loci
 FCS=factorial mating, $d=a$, 75 loci
 SE approximately 0.04

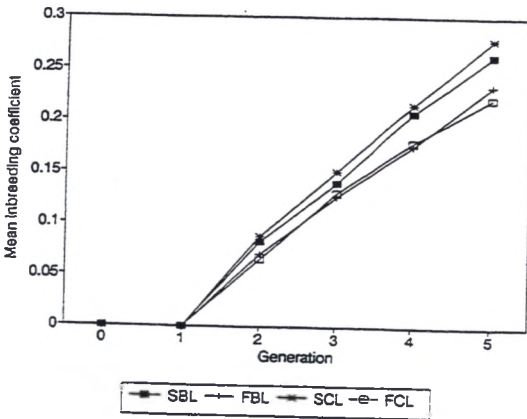


Fig 3. The parameter combinations are
 SBL=single pair mating, $d=1/2a$, 150 loci
 FBL=factorial mating, $d=1/2a$, 150 loci
 SCL=single pair mating, $d=a$, 150 loci
 FCL=factorial mating, $d=a$, 150 loci
 SE approximately 0.009

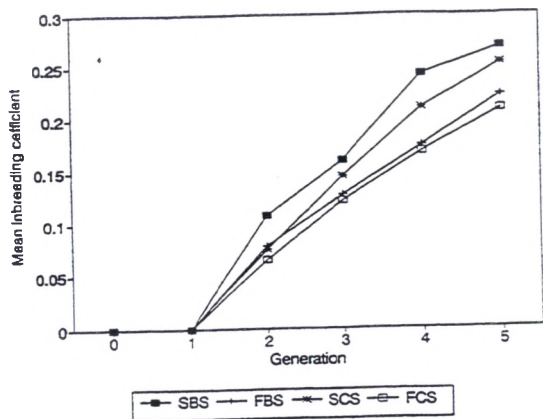


Fig 4. The parameter combinations are
 SBS=single pair mating, $d=1/2a$, 75 loci
 FBS=factorial mating, $d=1/2a$, 75 loci
 SCS=single pair mating, $d=a$, 75 loci
 FCS=factorial mating, $d=a$, 75 loci
 SE approximately 0.01

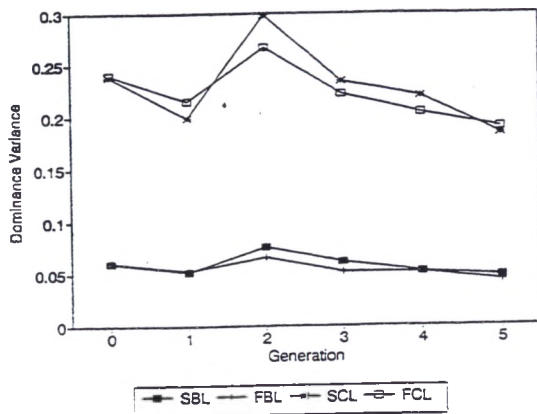


Fig 5. The parameter combinations are
 SBL=single pair mating, $d=1/2a$, 150 loci
 FBL=factorial mating, $d=1/2a$, 150 loci
 SCL=single pair mating, $d=a$, 150 loci
 FCL=factorial mating, $d=a$, 150 loci
 SE approximately 0.006

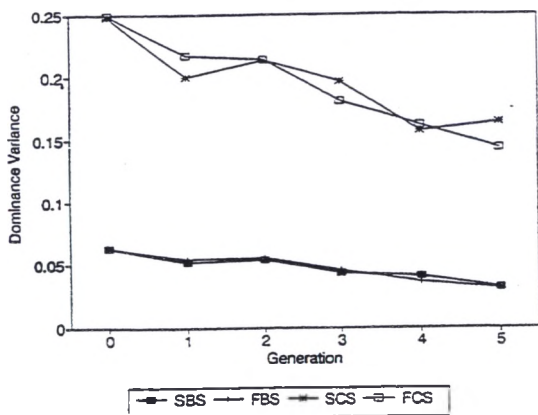


Fig 6. The parameter combinations are
 SBS=single pair mating, $d=1/2a$, 75 loci
 FBS=factorial mating, $d=1/2a$, 75 loci
 SCS=single pair mating, $d=a$, 75 loci
 FCS=factorial mating, $d=a$, 75 loci
 SE approximately 0.004

DISCUSSION

The high dominance variance in generation two (Fig. 5 and Fig. 6) may seem a bit surprising but, the phenomenon was described by Cockerham and Weir (1984). The increase in dominance variance was due to a positive correlation between genotypes within animals on different loci building up as a result of inbreeding (Fig. 3 and Fig. 4). The covariance will contribute to the dominance variance if the inbreeding coefficients between animals are different. In generation two the inbreeding coefficients only take a few values because all individuals are progeny from fullsib matings, halfsib matings or unrelated parents. A peak in dominance variance was also found by Johansson et al. (1993). They pointed out that the increase in dominance variance should be lower with fewer loci. This was in fact found in this study,

The factorial mating system produced a higher genetic response than the single pair mating system for all alternatives simulated (Fig. 1 and Fig. 2). The largest difference appearing for the trait with complete dominance, controlled by a large number of loci. However, this study shows results from short term selection, long term selection may show a different pattern of inbreeding depression when the two mating systems are compared.

Single pair mating and factorial-like mating systems are used in fish breeding. However, a true full factorial mating system may be difficult to perform for several reasons. The females and males selected may have different spawning seasons, but this problem could be overcome by gamete preservation techniques. If milt, for technical reasons, is pooled to produce factorial mating, competition between milt from different males can be a substantial problem (McKay and McMillan, 1991). On the other hand there are no reports of serious competition between eggs from different females.

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