Concerned About Inbreeding?
A Computerized Mating Program might be the Answer!

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Each year, service sires are selected for hundreds of thousands of US dairy cows using computerized mating programs. Generally speaking, sires are chosen that will genetically repair faults in the physical appearance of the cows – hence the term "corrective mating". In recent years, an important new role has emerged for mating programs: controlling inbreeding.

Inbreeding occurs whenever the sire and dam are genetically related to each other. If they are close relatives, like siblings or first cousins, the herdsman or AI technician will often recognize this relationship and choose a different sire. But trying to avoid inbreeding by examining pedigrees is becoming more and more difficult. After forty years of AI use, today's dairy sires and cows have complex pedigrees with numerous common ancestors spanning many generations. A particular sire and cow may initially appear to be unrelated, but if they share several common ancestors three or four generations back, their offspring might suffer from inbreeding.

We occasionally hear that inbreeding is increasing in the US dairy cattle population, but why should farmers be worried about inbreeding? The reason is that every cow and bull carries many undesirable genes (often called "genetic recessives") that can reduce health and productivity, and inbred animals have a better than average chance of inheriting the bad genes from both parents. For this reason, animals with high levels of inbreeding typically have lower milk production, more health problems, poorer reproduction, and shorter productive life. A recent study at Virginia Tech showed that a 1% increase in inbreeding costs the dairy producer about $23 in lifetime net income per cow. So there's no question that inbreeding can cost the commercial producer big money. Management of inbreeding in herd replacements is possible, but it requires analysis of large pedigrees for every cow and each of her potential mates. This is where the computer comes into play.

In a recent study at the University of Wisconsin – Madison, we looked at the opportunity for managing inbreeding in a sample of 50 large registered Holstein and Jersey herds. The average inbreeding coefficient for all pregnancies currently carried by cows in these herds was 4.9% for Holsteins and 6.5% for Jerseys (pedigrees were traced back to 1960 for both breeds).

Our mission was to determine the role that computerized mating programs might play in controlling inbreeding in the next generation of replacement heifers. For each of the 50 herds, we chose a sample of potential service sires from the top half of the active AI list. Sample size was 40 bulls for Holsteins and 20 for Jerseys, and no single bull was allowed to mate more than 15% of the herd.

Next we selected the best service sire for every cow in each of these fifty herds, using three different computerized mating programs to do the job. The first mating program simply selected the service sire with highest Net Merit, without considering inbreeding of the calf. This is what a typical producer might do if he simply picked the best sires available and didn't worry about individually mating each cow. The second mating program again selected the service sire with highest Net Merit, but this time we specified the maximum level of inbreeding that would be allowed in the recommended mating. Inbreeding levels were set at 5%, 6%, or 7% for Holsteins and 8%, 9%, or 10% for Jerseys; any prospective mating with inbreeding higher than these levels was rejected. This is how most currently available mating programs work. The third mating program selected the service sire with highest Net Merit, after adjusting for expected inbreeding depression in the calf. We used the value of $23 depression in lifetime income per 1% inbreeding that was discussed earlier. The three different mating programs were evaluated based on their ability to produce low levels of inbreeding in the calves, high Net Merit of the service sires, and high lifetime profitability of the female offspring.

Results are shown in Table 1 for Holsteins and Table 2 for Jerseys. Keep in mind that you can't compare Net Merit and expected lifetime profit across breeds, because each breed has a different genetic base. The first important point is that **computerized mating programs can effectively reduce**

inbreeding in the next generation of replacement heifers. Average inbreeding of calves from recommended matings was up to 40% lower when inbreeding was considered in the mating program. Interestingly, applying a maximum level of inbreeding for potential matings was a less effective way to reduce inbreeding than was selection for Net Merit adjusted for inbreeding depression. The reason is that the first type of program does not actually minimize inbreeding, it simply looks for any mating that gives less inbreeding than the user-specified value. For example, if you choose a maximum inbreeding level of 6%, then a mating that gives 5.9% inbreeding is fair game, even though different mating might give only 2% inbreeding. The second important point is that **allowing a little more inbreeding doesn't necessarily mean you'll end up with sires that have higher genetic merit**. Increasing the allowable inbreeding level from 5% to 7% in Holsteins or from 8% to 10% in Jerseys didn't increase the average Net Merit of selected sires, it just allowed more inbreeding (and less profit). Why? All bulls on the active AI list are highly selected, with many generations of popular sires in their pedigrees. Therefore, these bulls (as a group) have a high genetic relationship to the national dairy cow population. However, the average dairy cow is no more closely related to the top bull on the list than to an average bull from this group. The third important point is that **the best way to maximize profitability of the next generation of replacement heifers is to select for genetic merit adjusted for expected inbreeding depression**. Expected lifetime profit per heifer calf increased by $9-$37 in Holsteins and $20-$59 in Jerseys when a mating program that considered inbreeding was used. But lifetime profit was substantially higher when selection was based on Net Merit adjusted for inbreeding depression than when a user-specified inbreeding level was applied.

In summary, computerized mating programs are inexpensive and widely used. These programs are generally based on correcting faults in the physical appearance of the cow, but many programs now also consider the expected inbreeding of the calf. The potential economic benefits associated with controlling inbreeding using computerized mating programs are substantial. Although issues regarding long-term maintenance of genetic diversity in our dairy breeds can't be solved simply by using mating programs, today's dairy producer can effectively use mating programs to decrease inbreeding and increase profitability in his next generation of replacement heifers.

Table 1. Average inbreeding coefficient, Net Merit, and expected lifetime profit for a sample of 25 large registered Holstein herds mated to a sample of 40 active AI sires.

Goal of the Mating Program	Inbreeding	Net Merit	Lifetime Profit
Maximize Net Merit regardless of inbreeding	4.7%	$225	$384
Maximize Net Merit with less than 5% inbreeding	3.8%	$225	$405
Maximize Net Merit with less than 6% inbreeding	4.1%	$225	$398
Maximize Net Merit with less than 7% inbreeding	4.3%	$225	$393
Maximize Net Merit adjusted for inbreeding depression	2.9%	$222	$421

Table 2. Average inbreeding coefficient, Net Merit, and expected lifetime profit for a sample of 25 large registered Jersey herds mated to a sample of 20 active AI sires.

Goal of the Mating Program	Inbreeding	Net Merit	Lifetime Profit
Maximize Net Merit regardless of inbreeding	7.2%	$186	$328
Maximize Net Merit with less than 8% inbreeding	5.8%	$186	$360
Maximize Net Merit with less than 9% inbreeding	6.1%	$186	$354
Maximize Net Merit with less than 10% inbreeding	6.4%	$186	$348
Maximize Net Merit adjusted for inbreeding depression	4.4%	$182	$387