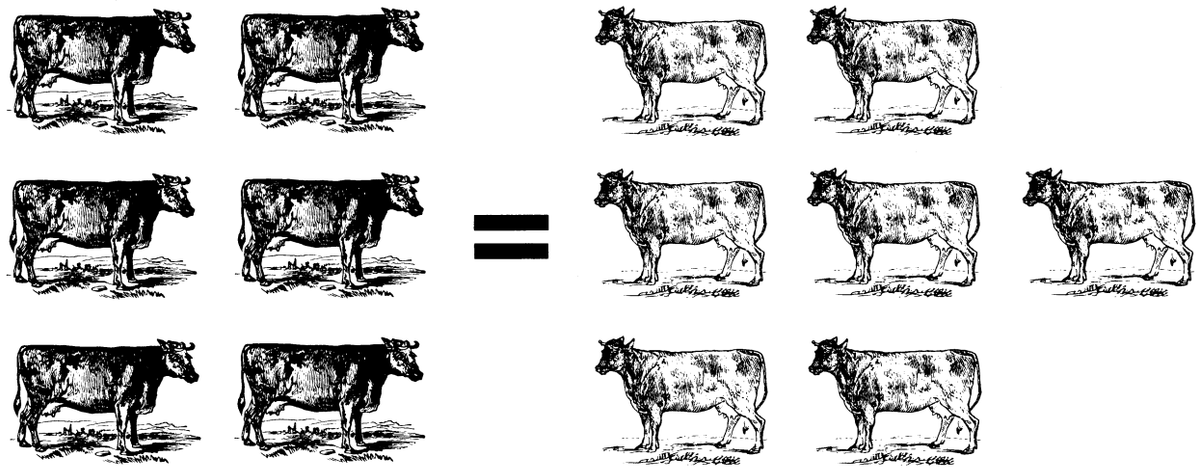


UDDER MAGIC

Opinions vary on how best to milk Bossie for all she's worth

By JANET RALOFF

Farmers who milk their cows three times a day, instead of just twice, practice a form of economic legerdemain: They turn six cows into seven. Henry Amos, who has not only practiced but also quantified this magic, says he still doesn't fully understand it. But the Athens, Ga., scientist is among researchers who aim to try. Meanwhile, a colleague in Michigan is attempting to divine why his cows produce more milk on long days.

The two programs epitomize the diversity of research paths exploring how best to "fool," comfort or otherwise manipulate the physiology of dairy cows so that they produce more milk.

Farmers have known that one way to increase a cow's productivity is to milk her more often. "However," Amos says, "with the high-producing cow, one giving 100 to 120 pounds of milk per day, it is virtually impossible to get her rebred." Re-breeding is a requirement for continued milk production. By contrast, he says, a cow whose peak production is closer to 60 pounds (lbs) per day will go into heat (estrus) and conceive as expected. "Our concern," the University of Georgia scientist explains, "Was that by making it produce more milk we might be putting additional stress on the cow that alters reproductive performance." To test production's effect on breeding, he compared Holsteins milked two and three times a day. He also compared the economics.

Amos found that by milking cows a third time, mature cows (those who have had more than one calf) produced an average 17.1 percent more milk and that cows with only one calf produced about 22 percent more. Because feed can account for up to half a dairy farmer's expenses, it was significant that the thrice-milked cows consumed only 202 lbs more food during 301 days of lactation, an increase of only about 1.5 percent.

What about the total costs associated with a third milking? "We made a stab at estimating that," Amos says, "and thought that we were getting $2.60 [worth of milk] back for each $1 more we spent."

Less clear is how with just 1.5 percent more fuel the thrice-milked cows generated 17 to 22 percent more milk. "One thing we could relate it to was body weight," Amos says. Mature cows gained 62 lbs less over the lactation cycle; cows with only one calf gained 11 lbs less than their counterparts milked just twice daily.

Amos also found that thrice-milked cows took an average 20 days longer, after calving, to go into heat. That can be important because for optimal milk production, a cow should calve once every 365 days. After each calving she would be milked for 305 days, then "dried off" for the 60 days preceding her next calving. By extending the reproductive cycle 20 days, one must either extend the cow's dry period — bringing in no income — or milk her longer, even though she may be producing no more than a third the milk she did at the peak of her cycle, six to seven weeks into lactation. Amos says his team has opted for the longer milking because even after 300 days his cows are "still producing economically."

H. Allen Tucker at Michigan State University in East Lansing finds he can increase milk production between 6 and 10 percent from October to May in Holsteins by keeping herds on a daily cycle of 16 hours (hr) of light, 8 hr of darkness. This light-dark regimen simulates with artificial lighting in the cow barns the natural day-night cycle that outdoor bovines experience in the height of summer, when their secretion of the hormone prolactin is highest. At least in humans, rats and rabbits, prolactin secretion is related to milk production.

This light-mediated productivity gain has proven economical. After accounting for increased feed, electricity and lighting, farmers could reap a net 21 cents per cow per day, Tucker calculates, meaning that "the cost of lighting could be paid off in about four months." The technique is obviously limited to where cows winter indoors.

Identifying the relationship between day length and hormone levels has been

Tucker's focus since 1973. In his studies, temperature has to be maintained precisely, he points out, because "as temperature goes up, feed intake goes down. And when feed intake goes down, milk production will also go down."

He found a correlation between day length and prolactin; longer daylight increased the hormone's secretion. In fact, after six weeks on a 16 hr daylight schedule, his cows' prolactin levels increased between two and 10 fold over the levels measured when cows were on an 8 hr daylight regime.

In contrast to the situation with women and several animal species tested, however, the cows' prolactin secretion peaks just when their milk production is at its nadir — in summer. "I've often told my students," Tucker jokes, "that prolactin is a hormone in search of a function — for the cow." He notes that blocking the hormone's secretion during the lactation of rats or even women will cause milk production to plummet. In fact, a prolactin-blocking drug is used to dry up women who either cannot or choose not to nurse. "But do the same thing to a cow with established lactation and she couldn't care less," Tucker says. "It has no effect whatever on her milk production." There seems to be one exception: "There's another release of prolactin in the cow at the time her calf is born," Tucker notes. "If we block that release — and we've done that — then her milk will be reduced about 25 percent."

Heat stress, the most serious milk-productivity problem, plagues dairy cattle throughout the South. Explains Frank Wiersma of the University of Arizona, "Any time a cow's environment gets above 85°F for an extended period, the cow loses its comfort zone." Unable to fully dissipate the heat that its metabolism generates, he says a cow will actually run a fever. Holsteins, which make up 90 percent of the dairy cows in the United States, are high milk producers, and as such are especially afflicted by this inability to fully dissipate heat, Wiersma says. Overheating can precipitate a falloff of between 10 and 15 lbs of milk per day in animals that normally produce 60 lbs.

By installing an evaporative-cooling system in the pre-milking holding pen at the university's dairy-experiment station in Tucson, Wiersma has been able to retrieve about 1.75 pints from the loss in production that is normally brought about by heat stress in his Holsteins. "Now that doesn't sound like much, I know, but we're talking about getting about 10 percent of our losses back [a pint weighs roughly a pound] and it's a really low-cost system," he says.

Overhead sprinklers intermittently spray the cows during the hour the animals are in from the fields waiting to be milked. Explains Wiersma, "We don't try to cool the cows by wetting, we simply dampen them and then blow air over their bodies."

In addition to the evaporative cooling system, the Arizona cows have access to a shade structure in part of their corral. That in itself can play a major role in relieving some of the heat stress and its affect on milk.

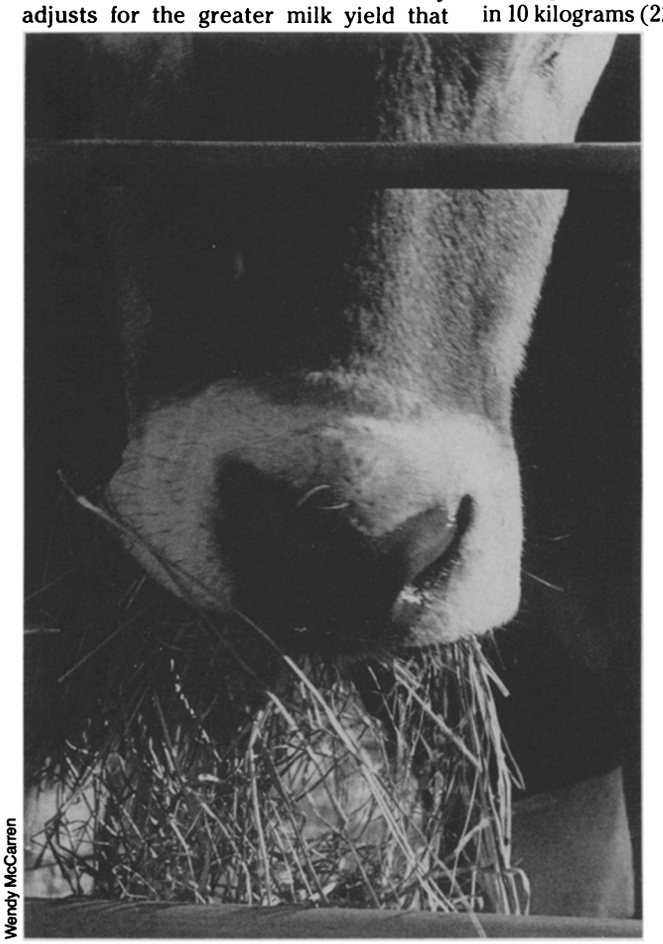
Studies at the University of Florida dairy-research center near Gainesville, for example, have shown that heat-stressed cows will give more milk when provided free access to a gable-roofed shade structure. In one Florida experiment, cows offered shade produced 10.9 percent more milk over the summer than their unshaded counterparts — an increase amounting to between 375 and 450 lbs per cow.

Shade also provides several reproductive benefits to heat-stressed animals. And this is important, notes William Thatcher, "because a cow doesn't produce milk unless she calves." A cow's normal conception rate of 50 percent can fall dramatically over the hot summers endemic throughout the South. In one experiment Thatcher conducted at the Florida facility, 44.4 percent of the animals with access to shade conceived the first time they were artificially inseminated, while among their unshaded counterparts only 25.3 percent became pregnant.

Florida research has also shown that "the greater the birth weight of the calf, the greater the dam's subsequent milk yield," notes animal physiologist Robert Collier. It's believed that somehow the cow's body adjusts for the greater milk yield that would be demanded by a larger calf. And here again shade can help. In a test where cows were either offered or denied shade from day 199 of their pregnancy through calving (gestation runs nine months) — and then managed identically as a herd after calving — calves from the shaded cows averaged 7.2 lbs more.

Those same cows that had received some shade protection during pregnancy went on to provide an average 1,030 lbs. — or almost 8 percent more milk — during their 305-day lactation cycle, even though they were managed identically to the other cows after calving. (The figure includes adjustments that account for cow's body weight, sire of the calf and the cow's estimated relative producing ability.)

Diet can also temper heat's effects. In particular, the Florida researchers have found heat-stressed animals seem to need more potassium. Not only are cows normally fed a diet low in the mineral, but also they secrete between 20 and 40 percent of the daily intake into the milk. Explains nutritional physiologist David Beede, "Unlike humans and horses, which sweat primarily sodium through their skin, the cow loses predominantly potassium. We have shown that during heat stress in the middle of the day, an unshaded cow will lose about five times as much potassium in sweat as a non-heat-stressed cow. And the potassium lost through sweating adds up to about an equivalent to that lost in 10 kilograms (22 lbs) of milk." By nearly



Wendy McCarren

Here, cow noshes on hay. Cows given "isoacids," a new dietary supplement, in addition to their normal ration of feed, will produce up to 10 percent more milk. A mix of four acids naturally produced in mammalian cells, this supplement enhances the bacterial breakdown of food in a cow's rumen (the first compartment of its stomach) so that more of what's eaten is digested and used. Developed by Michigan State University's Robert Cook, the supplement will be marketed later this year by Eastman Chemical Co. At perhaps 15¢ per cow daily, the supplement could net farmers a 5 to 1 return on investment through increased milk output per unit of feed, Cook says.

Why the drive for more milk?

"No one sees that there's likely to be a shortage of milk," notes Ben Coplan of the Brattleboro, Vt.-based Holstein Association, "so I guess there's a certain amount of irony to all this [effort]." After all, he admits, it isn't immediately obvious why farmers want to get more milk per cow when 10 percent of the U.S. milk production last year was surplus and estimates project this year's surplus to total 12 percent of production. In fact, he points out, the term "surplus" is a bit of a misnomer because what the farmer can't sell on the open market will be bought up by the federal government under its price-support program (and kept in the form of cheese and nonfat dry-milk powder). Recent estimates indicate this price-support program costs the government about $2.3 billion per year, he says.

So if there's so much milk, why don't farmers produce less? According to University of Wisconsin agricultural economist Truman Graf, they simply can't afford to.

"We haven't had an increase in milk prices since October 1980," the Madison-based analyst points out. Meanwhile, he adds, "Inflation has been shoving up everybody's costs to the tune of six or seven percent per year. Just from October 1980 to December 1983 the farmer must have incurred 20 percent higher costs."

It's gotten so bad, he says, that "almost half of all farm income is from nonfarm earnings." That means a farmer's wife who teaches school may earn half of the profit reported at tax time, he says. There are also some data to suggest that many of the people laid off from city jobs during the recent bout of high national unemployment went back to work on the family farm, he says. Finally, he notes that relative to other forms of farming, dairying has remained somewhat less sensitive to the slings and arrows of outrageous fortune. As a result, people have been less likely to give up marginally economic dairying in recent years, especially as there were fewer alternative avenues of employment open during the recession. And because investment capital has been so difficult to garner, these farmers have been pressed to extract every last penny out of their existing investments — that is, their cows — even as the price per gallon of their milk fell.

"I grew up on a dairy farm," says Lew Mix, director of farm-management research and development for Agway, Inc., a farm cooperative that involves 40,000 dairy farmers. "In the past it was a way of life. Today it's a business," and not a particularly lucrative one for many of its practitioners, he says. "Return on assets employed in dairy farming last year was four percent here in the Northeast [Agway is headquartered in Syracuse, N.Y.], which is very low, of course.

"In the next two years it's going to be even less profitable," he predicts, "because of the huge [milk] surpluses that we have." And that's significant because the value of the assets a dairy farmer has invested can be high. "In New York state, capital investment today is about $6,000 per cow," Mix says. "So if the dairyman has 100 cows, he has $600,000 invested" at a very low rate of yield.

Quoting data on New York dairy farms, he points out that annual net-cash income for farms with 50 cows — the New York average — "would be about $15,000." Moreover, because that figure was calculated on the basis of statistics from a 1981 study, "I would say that this last year, under the same assumptions, that farmer would have earned about 20 percent less," Mix says, due to federal assessments of up to $1 per 100 lbs of milk produced. The levy, instituted last year, is charged to all dairy farmers to help cover the government's cost of purchasing surplus milk.

"Right now we're in a real tight cost squeeze," he concludes, so it's in every dairy farmer's interest to improve the eroding economics of this enterprise by increasing the productivity of his or her biggest investment — Bossie. —*J. Raloff*

doubling the normal dietary levels to 1.5 percent during periods of heat stress, Beede has been able to increase milk production from unshaded cows 12 percent, and half that among shaded cows.

Dale Bauman at Cornell University in Ithaca, N.Y., is also exploring how the cow uses nutrients. In particular, he's focusing on what physiologically differentiates genetically superior milk producers from their less productive counterparts. "And it appears that growth hormone is one of the key controls," he told SCIENCE NEWS.

He has been able to boost the milk production of already high-producing cows another 10 to 40 percent with daily subcutaneous injections of the pituitary secretion. Exactly what the growth hormone supplement does is not precisely understood, but Bauman says "it must cause different organs to use different nutrients for energy sources so that more of certain key nutrients become available for milk synthesis."

Changes witnessed in the animals receiving the hormone treatment "are exactly the same in all respects to what one observes in genetically superior animals," Bauman says. "So you gain an efficiency of production in the same manner. Metabolism and the types of nutrients used by particular organs appear to be the same." Moreover, he notes that recent experiments in New Zealand indicate that genetically superior milk producers indeed appear to naturally secrete higher levels of growth hormone than cows producing less milk.

The hormone, which is presumed to play an important communications role, helping organs coordinate their functions, is released periodically throughout the day into the bloodstream. Peak blood levels following each release can be as high as 70 or 80 nanograms (ng) per milliliter (ml). Over time that level drops to a basal low of between 5 and 10 ng/ml. Explains Bauman, "The levels we give that get this increased milk performance really don't increase the concentration of those peak levels that occur with episodic releases; what they do is make it so the cow has a higher average daily concentration."

Though growth hormone is still very expensive, it's expected that synthetic, bioengineered growth hormone may eventually come within the economic grasp of most dairy farmers. Bauman also cautions that before growth hormone can be commercially used, research must confirm both that it's safe to the animals and that milk produced by the treated animals is safe for human consumption. In the two dozen studies or so since he began working with the hormone in 1979, Bauman says he has yet to identify a negative side effect.

Can you take an ordinary cow and turn her into a superior milk producer? Bauman says, "Although it's too soon to know, it would appear to be the answer is a qualified yes." □