Feedstuffs Reprint

Computer 3D vision estimates heifer height, weight

SOMETIMES, there are "aha" moments, and other times there are "wow" moments. I had one of the latter when I was attending a presentation from Israeli extension and research groups at the 69th European Federation of Animal Sciences (EAAP) program in late August in Dubrovnik, Croatia (Adin et al., 2018).

For those who want technical information, more details of the system are in a paper by Nir et al. (2018).

First, here's a bit of information about Israel's dairy industry: Israel has 135,000 Holstein cows, 120,000 heifers, 776 dairy farms, 100% artificial insemination, zero grazing and average annual milk yield per cow of 26,358 lb., with 3.75% fat and 3.45% protein, and 33% of herds are first lactation, with annual milk yield of 23,892 lb.

Further data presented were that the cost of a heifer until first calving in Israel is about $3,250, or 17% of a cow's total expenses.

It is known that there are high correlations among rate of growth, bodyweight, height and other skeletal measurements, calving difficulty and first-lactation performance as long as excess fattening does not occur.

In a previous column (*Feedstuffs*, Jan. 14, 2019), I discussed and recommended minimal bodyweight measurements at birth, two months, six months, 12 months and right before first calving. Ideally, height measurements would also be taken at those same time points. These data would enable decisions to be made about how heifers were progressing between periods, and changes or adjustments could then be made in feeding and management programs if results were not satisfactory.

The challenge is how to secure these measurements. If they are secured, it is currently expensive, time consuming and stressful for both the animals and workers. Few operations take such measurements unless they are needed for sale or contractual purposes. Ideally, a system could be developed that minimized all of these difficult elements. That was the intent the Israeli research teams had in developing a three-dimensional (3D) system.

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Bottom Line

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A 3D camera was installed on the ceiling about 9 ft. above a two-way path between the feeding and resting areas. This design allowed heifers to voluntarily walk between these two areas below the camera several times daily. This was done at the Volcani Center's research dairy farm, which has about 400 total dairy animals, 107 of which were heifers between the ages of four and 22 months within seven mutually exclusive age groups.

Ranges of measurements were: bodyweight of 352-1,260 lb. with a mean of 782 lb., wither height of 38.6-54.3 in. with a mean of 47.3 in., hip height of 40.4-58.3 in. with a mean of 50.2 in. and chest girth of 46.1-76.0 in. with a mean of 62.3 in.

A model was developed based on image processing and the 3D camera, including an identification system with a reader, antenna and proximity sensor. The camera and processes were tested, software was developed to produce a 3D image from the raw image and noise was filtered.

Model parameters selected were wither height, bodyweight and hip height at the tail root. Main parameters processed were an estimated volume of the heifer based on a double integral from the distance data within the ellipse, cross-sectional area of the heifer (ellipse), wither height, hip height, radius of the estimated ellipse, area of the ellipse and age of the heifer.

Similar numbers of heifers (117 and 124) were measured at the research herd and at a commercial dairy farm to validate the system. At each farm, there were similar ranges and averages for age, wither height and bodyweight (Table 1).

Data from both of the dairy farms were evaluated for fit (Table 2) and found to have very high R-square, meaning variation from 92.0% to 98.5% was accounted for by the regression of actual versus 3D estimates for both height and weight. Error terms were also similar for both dairy farms.

This system was found to be stable and reliable over the age, height and weight measurements for these Holstein heifers, and with a high level of accuracy. Commercial application of this system has not yet been developed.

The ultimate measurement of a calf and heifer program is how well the animals perform as lactating cows.

Somewhat coincidentally, during a break at this same conference, an attendee introduced himself to me. He was a veterinarian in a nearby country, had some dairy farm clientele and was a veterinary college faculty member.

He told me that he had used my articles to make recommendations for his clients, and one example he cited was with a dairy farm where the calf and heif-

1. Heifer measurements at both farms

Dairy farm	Average	Maximum	Minimum	Std. dev.
Volcani (n = 117)				
Age, months	13.0	21.7	4.0	4.565
Wither height, in.	47.4	54.3	38.6	3.9
Bodyweight, lb.	782.2	1,259.5	352.3	219.3
Commercial dairy (n = 124)				
Age, months	14.4	22.7	6.9	4.465
Wither height, in.	48.8	54.1	41.7	3.0
Bodyweight, lb.	814.5	1,197.9	513.1	181.7

2. Evaluation for fit

Dairy farm	R-square	RMSE*	MRAE**
Volcani (n = 117)			
Wither height, in.	0.985	0.47	0.8
Bodyweight, lb.	0.946	49.8	5.6
Commercial dairy (n = 124)			
Wither height, in.	0.922	1.14	1.9
Bodyweight, lb.	0.97	44.9	4.9

*Root mean squared error.
**Mean relative absolute error.

er program was extensively revamped. Over the next three years, the rolling herd average increased from 8,000 liters to 11,000 liters annually — a 38% increase.

I have seen some cases where calf and heifer program changes have shown up in the rolling herd average just six months after a significant change, but in most cases, it takes the full two-year growth period and the first full lactation to show full benefits.

What has been lacking is a simple, relatively inexpensive system to estimate with a reasonable degree of accuracy the height and weight of heifers at various growth stages. With something like that, performance at these intermediate stages could be reviewed to see if heifers are on the projected path they should be.

If not, then troubleshooting should ensue to find and fix the source of problems — long before heifers begin their first lactation. Also, it can be determined if this is a large group problem or just some problems with individual heifers.

The Bottom Line

A 3D computer vision system was developed to estimate heifer height and bodyweight. It was reasonably accurate at both the research dairy and a commercial dairy farm. The value of data from such a system is that progress, or lack thereof, for the heifer-growing program can be determined at that time rather than waiting to see how these heifers perform in their first lactation.

References

Adin, G., D. Werner, B. Shaked, L. Rozenfeld, A. Antler, Y. Parmet, O. Nir and I. Halachmi. 2018. Computer vision system for heifer height and weight estimation. Proc. 69th annual meeting of the European Federation of Animal Science (EAAP), abstract, p. 362, Session 32. Aug. 27-31, Dubrovnik, Croatia.

Nir, O., Y. Parmet, D. Werner, G. Adin and I. Halachmi. 2018. 3D Computer vision system for automatically estimating heifer height and body mass. Biosystems Engineering 173:4-10. ■