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Cow Math—Using Weaning Weight to Estimate Cowherd Productivity[1]

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Records and Data Collection

The ability to measure performance is a key component in all beef cow operations, and measuring production efficiency is becoming increasingly important. Regardless of size, producers must be able to identify the current status of their operation in order to make adjustments toward improvement. Cow culling is a key management tool for herd improvement, and being able to identify the poorly producing cows within a herd is essential. The old adage, "You can't get where you're going unless you know where you are," certainly holds true in beef cattle management.

Cow size has a tremendous impact on performance and efficiency. Large cows typically wean heavier calves, but they also have higher maintenance energy requirements and require more feed. Also, milk production can impact efficiency, with higher milking cows requiring higher quality forage and feed supplements and having greater maintenance energy requirements. Thus, feed required by the cow is a function of both cow size and milk production. Identifying and culling the cows within the herd that are less efficient at producing a weaned calf in the environment and management system used on the ranch can be a powerful tool to improve the herd.

One of the growing areas of cowherd record management involves using commercial software geared specifically for beef cow/calf operations. These can vary tremendously in level of complexity. Although these software options are often very affordable, many small cattle producers have chosen other routes of record keeping. A recent USDA-APHIS survey showed that more than 50% of cattle producers with 300 cows or more used some kind of computer-assisted cow record system compared with less than 15% of producers with 100 cows or less. In the same study, nearly 90% of these smaller producers indicated that they did use some type of record system. Although considered small in terms of total cow numbers per producer, these individuals account for approximately 50% of the annual production of beef in the United States.

Producers can use multiple methods to determine cow productivity. Although some are more complicated than others, each requires a minimum amount of individual data collection and a simple understanding of "cow math." Producers must first decide whether they will evaluate productivity on an individual cow basis or on a herd basis. Using an individual identification system will allow the producer to better determine the performance of individual cows and make better culling decisions. While having total herd performance is very useful for evaluating changes in management practices that may affect cow productivity, keeping individual cow records allows culling of the less productive cows in the herd, tracking of herd performance over time, and comparing herds from different working units of the ranch. Producers cannot make these decisions with a herd-based record keeping system.

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A minimum of eight items must be recorded to accurately calculate cow productivity: (1) the number of cows exposed to bulls; (2) the number of calves weaned; (3) the birth date of the calf; (4) the birth weight of the calf; (5) the sex of the calf; (6) the weaning weight and weaning date; (7) the cow body weight; and (8) the cow body condition score.

Calf age is an important consideration when calculating weaning weight. Significant variation in weaning age or breeding season can affect the reliability of using weaning weight to measure cowherd productivity. To account for this variation, weaning weight is usually adjusted to a constant age of 205 days. However, recording the exact birth date and birth weight of each calf may not be practical for some commercial producers. An alternative would be to record the birth date as the day the calf was first seen. Check the herd once or twice a week during the calving season, and record that day as the birth date of those calves seen for the first time (i.e., saw cow 201 had calf on her side on November 15). Additionally, average birth weights of 75 and 70 pounds for bull and heifer calves, respectively, can be used in place of actual birth weights. Although this will introduce some error into the calculation, it will provide a reasonable estimate for evaluating cow productivity.

For some producers, the time required to weigh each calf at weaning would not be practical, because calves are put directly on trucks and shipped. Additionally, weighing calves the day before can cause a significant amount of shrink and reduce the pay weight of the load. Thus, in this situation, calves could be weighed a few weeks before weaning or at a vaccination time before weaning. But the average age of calves at time of weighing should be greater than 180 days.

Recording cow body weight and body condition score allows accurate calculation of the weaning weight ratio. Body condition score is an important consideration when calculating cow body weight. Significant variation in body condition score can affect the reliability of using cow body weight to measure cowherd productivity. To account for this variation, cow body weight is usually adjusted to a constant body condition score of 5. A good time to collect this data is during pregnancy check when the cows will come through the chute. Refer to UF/IFAS Extension Bookstore for “Effects of Body Condition on Productivity of Beef Cattle” (http://ifasbooks.ifas.ufl.edu/p-159-effects-of-body-condition-on-productivity-of-beef-cattle.aspx) for an explanation of body condition scoring beef cows.

Example 1: Comparing Two Cows within the Herd

The simplest measure of cow performance is to look at the weaning weight for each cow. We can see from Table 1 that the weaning weight of calf for Cow 1 is 530 lb compared with a 470 lb weaning weight of the calf for Cow 2. From this calculation, it appears that Cow 1 is the higher producing cow, but this does not take into account some important information. Using weaning weight does not account for the following:

- Cow age
- Calf age
- Calf sex
- Cow weight
- Cow milk production and the associated increased maintenance energy requirements

Let’s go through the calculations to adjust weaning weight for these factors to see if Cow 1 is still the most productive cow. First, let’s adjust the birth weight and weaning weight for age of the cow at calving by using the adjustment factors in Table 3.

Age-of-dam adjusted birth weight = actual birth weight + adjustment factor

Cow 1: 75 lb actual birth weight + 0 lb adjustment factor = 75 lb age-of-dam adjusted birth weight

Cow 2: 70 lb actual birth weight + 2 lb adjustment factor = 72 lb age-of-dam adjusted birth weight

Age-of-dam adjusted weaning weight = actual weaning weight + adjustment factor

Cow 1: 530 lb actual weaning weight + 0 lb adjustment factor = 530 lb age-of-dam adjusted weaning weight

Cow 2: 470 lb actual weaning weight + 18 lb adjustment factor = 488 lb age-of-dam adjusted weaning weight

Then, we need to adjust the weaning weight of each calf for the calf’s age by calculating the 205-day adjusted weaning weight for each cow.

205-day weaning weight = [(age-of-dam adjusted weaning weight – age-of-dam adjusted birth weight) ÷ age of calf] × 205 days + age-of-dam adjusted birth weight

Cow 1: 530 lb weaning weight – 75 lb birth weight = 455 lb weight gained

455 lb weight gained ÷ 200 days = 2.28 lb/day

2.28 lb/day × 205 days + 75 lb birth weight = 541 lb 205-d adjusted weaning weight

Cow 2: 488 lb weaning weight – 72 lb birth weight = 416 lb weight gained

416 lb weight gained ÷ 210 days = 1.98 lb/day

1.98 lb/day × 205 days + 72 lb birth weight = 478 lb 205-d adjusted weaning weight

Next, we need to adjust the weaning weight of each cow for sex of the calf by calculating the difference in average weaning weight between steers and heifers in the herd.

Calf sex adjustment factor = 530 lb herd average 205-d adjusted weaning weight of steers – 470 lb herd average 205-d adjusted weaning weight of heifers = 60 lb adjustment factor

Cow 1: 541 lb age-of-dam 205-d adjusted weaning weight of steer calf + 0 lb adjustment = 541 lb sex-adjusted weaning weight

Cow 2: 478 lb age-of-dam 205-d adjusted weaning weight of heifer calf + 60 lb adjustment = 538 lb sex-adjusted weaning weight

Now, after adjusting for age of dam, calf sex, and calf age, it seems that Cow 1 is the higher producing cow, but we have not yet accounted for differences in cow body weight. Cow body weight is our estimate of the maintenance energy requirement for each cow and a predictor of how much feed each cow will need to produce a weaned calf. Thus, by adjusting weaning weight for differences in cow body weight, we look at the amount of output (weaning weight) relative to the amount of input (feed).

First, we need to adjust cow body weight for differences in body condition score at the time body weight was measured, using the following formula:

<u>Cow body weight at body condition score 5</u> = (5 – actual body condition score) × 75 pounds + actual cow body weight.

Cow 1: (5 – 5.5 actual BCS) × 75 = -38 lb adjustment

-38 lb adjustment + 1,350 lb actual body weight = 1,313 lb BCS adjusted cow weight

Cow 2: (5 – 4.5 actual BCS) × 75 = 38 lb adjustment

38 lb adjustment + 1,050 lb actual body weight = 1,088 lb BCS adjusted cow weight

Next, we need to convert the body condition score adjusted body weight to metabolic body weight. The relationship between maintenance energy requirements and cow body weight is positive, meaning heavier cows have higher maintenance energy requirements, but the relationship is not 1:1. As cows get larger, maintenance energy requirements increase more slowly than body weight. Breed affects maintenance energy requirements and further adjustments should be made to cow metabolic body weight based on information in Table 4.

Cow metabolic body weight = cow body weight $^{0.75}$, this means raised to the 0.75 power. It is calculated, using a calculator, the same as squaring a number (x^2) except you use 0.75 rather than 2.

Cow 1: 1,313 $^{0.75}$ = 218 lb metabolic body weight

Cow 2: 1,088 $^{0.75}$ = 189 lb metabolic body weight

Now, we have to adjust metabolic body weight, which is our estimate of maintenance energy requirement, for milk production. Cows with moderate-to-high milk production have 15% greater maintenance energy requirements than cows with low milk production. Thus, cows with greater than 15 lb/d peak milk should have their metabolic body weight increased by 15% when calculating the weaning rate ratio.

To find the estimated peak milk production of each cow, look at Table 5. First, find the BCS-adjusted cow weight in the left column, then find which column most closely corresponds to the age-of-dam, calf sex, 205-d adjusted weaning weight of the calf. The milk production number at the top of the column is an estimate of peak milk production of the cow.

Milk-adjusted cow metabolic body weight = metabolic body weight × (1.15 if peak milk is equal to or greater than 15; 1.0 if peak milk is less than 15)

Cow 1: BCS adjusted cow body weight is closest to 1,320 lb and 205-d adjusted weaning weight is closest to 537 lb, so the estimated peak milk production is 12 lb/d; 218 lb metabolic body weight × 1.0 = 218 lb milk-adjusted cow metabolic body weight

Cow 2: BCS adjusted cow body weight is closest to 1,100 lb and 205-d adjusted weaning weight is closest to 526 lb, so the estimated peak milk production is 18 lb/d; 189 lb metabolic body weight × 1.15 = 212 lb milk-adjusted cow metabolic body weight

Lastly, we calculate the weaning weight ratio of age-of-dam, calf sex, 205-d adjusted weaning weight to milk-adjusted cow metabolic body weight using the following formula:

Weaning weight ratio = age-of-dam calf sex 205-d adjusted weaning weight ÷ milk-adjusted cow metabolic body weight.

Cow 1: 541 lb adjusted weaning weight ÷ 218 lb metabolic body weight = 2.48

Cow 2: 538 lb adjusted weaning weight ÷ 212 lb metabolic body weight = 2.54

The ratio of output (weaning weight) to input (maintenance energy requirement/feed) is higher for Cow 2 indicating that Cow 2 is the higher producing cow relative to the amount of feed required to maintain the cow. Cow 2 did not produce the heaviest calf, but is the more efficient cow under the current management system of the ranch.

Example 2: Comparing Two Cowherds

Similar to comparing two cows within the herd, we will calculate the calf age and sex-adjusted weaning weight of different herds. We will also calculate the pounds of calf weaned per pound of cow exposed using data from two simulated herds in Table 2. However, in this calculation, we will use the body weight of all cows exposed to a bull, so we can account for reproductive performance of the herd.

First, let's calculate the total weaning weight of two example herds using the following formula:

Total weaning weight = average weaning weight × number of calves weaned

Herd 1: (490 lb average weaning weight of steers × 11 steers) = 5,390 lb of steers weaned

(450 lb average weaning weight of heifers × 9 heifers) = 4,050 lb of heifers weaned

5,390 lb of steers + 4,050 lb of heifers = 9,440 lb of calves weaned

Herd 2: (480 lb average weaning weight of steers × 8 steers) = 3,840 lb of steers weaned

(440 lb average weaning weight of heifers × 10 heifers) = 4,400 lb of heifers weaned

3,840 lb of steers + 4,400 lb of heifers = 8,240 lb of calves weaned

From the total weaning weight it appears that Herd 1 is the more productive herd primarily due to greater number of calves, but we have not accounted for age or sex of the calf, or the weight of cows exposed to bulls. In this instance, we will not adjust birth weight and weaning weight for age of the dam, because we are supposing that the two herds are managed as two complete herds that are similar average age, with the addition of replacement heifers into the herd.

Second, we will adjust the weaning weight for age of the calves using the 205-day adjusted weaning weight formula above.

205-day adjusted weaning weight

Herd 1

Steers: 5,390 lb of steer calves ÷ 11 steer calves = 490 lb per steer calf

490 lb weaning weight – 75 lb birth weight = 415 lb weight gain

415 lb weight gain ÷ 210 days of age = 1.98 lb/day

1.98 lb/day × 205 days + 75 lb birth weight = 480 lb 205-d adjusted weaning weight

Heifers: 4,050 lb of heifer calves ÷ 9 heifer calves = 450 lb per heifer calf

450 lb weaning weight – 70 lb birth weight = 380 lb weight gain

380 lb weight gain ÷ 210 days of age = 1.81 lb/day

1.81 lb/day × 205 days + 70 lb birth weight = 441 lb 205-d adjusted weaning weight

Herd 2

Steers: 3,840 lb of steer calves ÷ 8 steer calves = 480 lb per steer calf

480 lb weaning weight – 75 lb birth weight = 405 lb weight gain

405 lb weight gain ÷ 215 days of age = 1.88 lb/day

1.88 lb/day × 205 days + 75 lb birth weight = 461 lb 205-d adjusted weaning weight

Heifers: 4,400 lb of heifer calves ÷ 10 heifer calves = 440 lb per heifer calf

440 lb weaning weight – 70 lb birth weight = 370 lb weight gain

370 lb weight gain ÷ 215 days of age = 1.72 lb/day

1.72 lb/day × 205 days + 70 lb birth weight = 423 lb 205-d adjusted weaning weight

Next, we will adjust the weaning weight for the sex of the calves using the formula from above.

Calf sex adjustment factor

Herd 1: 480 lb 205-d adjusted weaning weight per steer calf – 441 lb 205-d adjusted weaning weight per heifer calf = 39 lb additional weaning weight for heifers

Herd 2: 461 lb 205-d adjusted weaning weight per steer calf – 423 lb 205-d adjusted weaning weight per heifer calf = 38 lb additional weaning weight for heifers

Calf sex adjusted weaning weight

Herd 1: (480 lb 205-d adjusted steer weaning weight) × 11 steers

+ (441 lb 205-d adjusted heifer weaning weight + 39 lb adjustment) × 9 heifers

= 9,602 lb ÷ 20 calves = 480 lb per calf

Herd 2: (461 lb 205-d adjusted steer weaning weight) × 8 steers

+ (423 lb 205-d adjusted heifer weaning weight + 38 lb adjustment) × 10 heifers

= 8,301 lb ÷ 18 calves = 461 lb per calf

The age and sex-adjusted weaning weight differs from the basic weaning weight by +8 lb in Herd 1 and only +3 lb in Herd 2. This indicates the importance of accounting for differences in age and differences in number of steers and heifers when comparing weaning weight between herds.

Finally, we will adjust the weaning weight for the differences in the weight of cows exposed to a bull. Annual costs to maintain a cow can vary greatly. In almost all circumstances, nutritional inputs can absorb 50% to 65% of total annual costs. By calculating the calf weaning weight as a function of the weight of cows exposed to bulls, we are able to best reflect the true production efficiency of the cowherd. To perform this calculation, we use the following formula:

Pounds weaned per pound cow exposed = (Age/sex-adjusted weaning weight × number of calves) ÷ (number of cows exposed × average cow weight at body condition score 5).

Herd 1: (480 lb sex/age-adjusted weaning weight × 20 calves) ÷ (24 cows × 1,250 lb per cow exposed) = 0.32 lb of calf weaned per lb of cow exposed

Herd 2: (461 lb weaning weight × 18 calves) ÷ (22 cows × 1,100 lb per cow exposed) = 0.34 lb of calf weaned per lb of cow exposed

Therefore, even though Herd 2 had the lower basic weaning weight, Herd 2 was more productive than Herd 1 because Herd 2 weaned more pounds of calf per pound of cow exposed.

Which Cow or Cowherd Is More Productive?

This is often a tough question, which certainly relates to many factors in addition to weaning weight. At the sale barn, we often make the generic assumption that the producers marketing the heaviest calves are the most profitable. Sure, they often get the largest check, but what did it cost them to deliver those heavy calves? By taking into consideration the weight of the cow or the weight of cows exposed to a bull, we are able to calculate an accurate assessment of productivity. This calculation takes into account both an estimate of inputs (cow feed requirements) and outputs (calf growth). This reflects efficiency of individual cows or cowherds.

Larger cows have higher maintenance energy requirements and will require more feed throughout the year. For example, assuming a dry matter intake of 2.5% of body weight, the cows in Herd 1 weighing 1,250 lb would consume 145 lb more dry feed per day than the cows in Herd 2 weighing 1,100 lb. This will total approximately 25 tons of additional feed per year (dry matter basis). Larger cows are not necessarily less efficient, but the increased feed required must be offset by an increase in calf weaning weight and/or an increase in reproductive performance. Increasing weaning weight through higher milk production or reproductive performance by maintaining better body condition of these larger cows will likely require providing higher quality feed. These larger cows that have lower productivity are likely too large for the nutritive value of the forage (i.e., too large for their environment). Matching cow size with the nutritional environment is critical to maximizing productivity and efficiency of the cowherd. Evaluating the weaning weight ratio of cows can help to find those cows that best fit the ranch environment.

Things to Consider When Comparing Cows or Cowherds

When comparing productivity of individual cows or cowherds, many factors can contribute to the differences in productivity beyond the biological differences of the cows themselves. If comparing cowherds across years, differences in weather, forage nutritive value and production, herd sires, supplemental feeds used, and other management practices are some of the things that can contribute to differences in productivity. If comparing individual cows within a herd, differences in sire of the calf in multi-sire herds can also affect weaning weight. Additionally, differences in cow breed can have a significant effect on productivity of individual cows or cowherds. The calculations outlined here can be a good tool to evaluate differences in productivity of beef cows, but these other factors need to be taken into consideration. If selection of replacement heifers is to be based on these calculations, great care needs to be taken to account for as many of these factors as possible, including the age and body weight of the potential replacement heifer that affects the ability of the heifer to become pregnant during the breeding season. It would be best to evaluate cows over a few years, and keep replacement heifers from those cows that consistently rank at the top for weaning weight ratio.

Table 1. Performance summary of two cows within a Florida cowherd

Item	Cow 1	Cow 2
Data to record		
Actual cow weight, lb	1,350	1,050
Cow body condition score at weighing	5.5	4.5
Cow age, yr	7	4
Calf sex	Steer	Heifer
Estimated calf birth weight, lb	75	70
Actual calf weaning weight, lb	530	470
Calf age at weaning, days	200	210
Calculated values		
Estimated age-of-dam adjusted birth weight, lb	75	72
Age-of-dam adjusted weaning weight	530	488
Adjusted 205-d weaning weight, lb	541	478
Heifer weaning weight adjustment factor	0	60
Sex-adjusted 205-d weaning weight, lb	541	538
Body condition score-adjusted cow weight, lb	1,313	1,088
Cow metabolic body weight, lb	218	189
Estimated peak milk, lb/d	12	18
Peak milk-adjusted cow metabolic body weight, lb	218	212
Weaning weight ratio	2.48	2.54

Table 2. Performance summary of two Florida cowherds

Item	Herd 1	Herd 2
Data to record		
No. of cows exposed to bulls	24	22
Average weight of cows exposed at BCS 5, lb	1,250	1,100
Number of calves born	22	20
Number of calves weaned	20	18
Number of steers weaned	11	8
Number of heifers weaned	9	10
Average age of calves at weaning, days	210	215
Average weight of calves weaned, lb	472	458
Average weight of steers weaned, lb	490	480
Average weight of heifers weaned, lb	450	440
Calculated values		
Total weight of steers weaned, lb	5,390	3,840
Total weight of heifers weaned, lb	4,050	4,400
Total weight of calves weaned, lb	9,440	8,240
205-d adjusted weight of steers weaned, lb	480	461
205-d adjusted weight of heifers weaned, lb	441	423
205-d sex adjusted weight of calves weaned, lb	480	461
Pounds calf weaned per pound cow exposed, lb	0.32	0.34

Table 3. Cow metabolic body weight adjustment factors for different breeds

Breed type	**Maintenance energy requirement relative to *Bos taurus* cows**	**To adjust cow metabolic body weight multiply by**
Bos taurus (e.g., Angus, Charolais)	100%	1.00
Bos indicus (e.g., Brahman)	90%	0.90
Dairy breeds (e.g., Holstein, Jersey)	120%	1.20
Simmental, Braunvieh	120%	1.20
Bos taurus × *Bos indicus* cross (e.g., Brangus, Braford)	95%	0.95
Bos taurus × Dairy breed cross (e.g., Gelbvieh)	110%	1.10

Table 4. Beef Improvement Federation standard age-of-dam adjustment factors for birth and weaning weight

		Weaning weight, lb	
Age of Dam at Calving	**Birth Weight, lb**	**Steer/bull**	**Heifer**
2	+8	+60	+54
3	+5	+40	+36
4	+2	+20	+18
5–10	0	0	0
11+	+3	+20	+18

Table 5. Predicting peak milk production of cows using cow mature weight and calf weaning weight

	Peak Milk, lb/d				
Cow Mature Weight, lb	**6**	**12**	**18**	**24**	**30**
	Avg. expected 7-month male calf weight, lb				
880	398	444	477	—	—
950	416	460	493	—	—
1,030	431	475	510	546	574
1,100	449	491	526	561	590
1,170	464	506	541	576	607
1,250	477	521	557	590	623
1,320	491	537	572	605	638
1,400	504	550	587	620	656
1,470	517	565	601	634	671