Data Collection and Interpretation

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Collection of accurate performance records is critical to the success of genetic evaluation and selection programs. Throughout the life cycle of a beef animal, there are several points where data need to be recorded and reported to ensure the most complete and accurate evaluation. In this chapter, the life cycle of a heifer, steer, and bull is examined to determine the records that need to be collected, how those records can be adjusted, and how to interpret those data. First, it is important to discuss several concepts to consider when collecting and interpreting data.

Contemporary Grouping

Before beginning data collection, it is important to have a good understanding of proper contemporary grouping. The environment that a calf is exposed to can have a large effect on how well it performs for all of the economically important traits. By using contemporary grouping, we are better able to separate genetic and environmental effects. A contemporary group for a traditional, within-breed genetic evaluation is defined as a set of same-sex, same-breed calves that were born within a relatively short time interval and have been managed the same ever since. In multiple-breed genetic evaluation, calves in the same contemporary group can have different breed makeup. Regardless of what type of evaluation, every calf in the contemporary group should receive an equal opportunity to express its genetic merit. Once an animal has been separated from his contemporaries, he can never be put into that group again.

For example, a producer may decide to select one particular bull calf to put into a fall or winter sale. He pulls that calf and his mother into a separate pen, where they have access to shelter and the calf gets creep feed. When weaning weights are collected on the group of bull calves, the selected calf has the highest weight. The problem is that we do not know if that calf was genetically superior for weaning weight, or if his extra growth was due to the feed and shelter. This is an extreme example, but anything that is different in the environment or management between groups of calves may give some of them an unfair advantage and make comparisons impossible. Improper contemporary grouping can lead to biased and inaccurate EPD.

Adjusting Records

Calf age and cow age are two environment factors that are not accounted for by contemporary grouping. These effects are predictable from year to year and herd to herd, so the records can be adjusted to account for that variation. For example, all calves in the herd should not be weaned and weighed when they are exactly 205 days of age. It is important to keep contemporary groups as large as possible. If a producer weighed each calf individually when it was exactly 205 days of age, each calf would be in its own contemporary group. Single-animal contemporary groups are worthless as far as genetic evaluation goes. However, when all calves are weighed on the same day (when the average of the group is close to 205 days old), the younger calves will be at a disadvantage compared to the older calves. To get a fair comparison, the raw weights of calves weighed on the same day will be adjusted to the same age of 205 days. Basically, the adjustment figures out how much each calf is gaining per day and predicts what they will weigh (or did weigh) when they are (or were) exactly 205 days old.

The second type of adjustment is for age of dam. First-calf heifers have calves that are lighter at birth than calves from older cows, and they also produce less milk throughout lactation than older cows, leading to lower weaning weights. These are not genetic factors of the calf and should not be attributed to the calf's performance.

Beef Improvement Federation (BIF, 2002) publishes adjustment factors and procedures. These are general adjustment factors that are appropriate for commercial cattle. Unless otherwise noted, BIF factors and procedures are used for illustration in this chapter. Most breed associations have developed adjustment factors using their breed data. Purebred producers should use the adjustment factors and procedures of their association.

Ratios

One way to compare calves within the same contemporary group is to use ratios. Ratios are calculated by dividing a calf's adjusted record by the average record of its contemporary group and multiplying by 100. This means that the average performing calf in the group will have a ratio of 100, poorer calves will be below 100, and better calves will be above 100 for traits where bigger is better. For traits where smaller is better, like birth weight, better (lighter) calves will be below 100, and poorer (heavier) calves will be above 100. Ratios measure an animal's percentage deviation from the average of its contemporary group. Because of differences in management and mean genetic level between herds, ratios should not be used to compare animals across contemporary groups.

$$\text{Ratio} = \frac{\text{Individual Record}}{\text{Contemporary Group Average}} \times 100$$

Complete Reporting

Traditionally, some breeders have only reported performance data on calves that they want to register. However, this leads to biased and inaccurate EPD. Complete reporting of every animal in the herd is critical to obtain the best estimates of genetic merit. By only reporting the best calves (for whatever trait), producers are not making their herd look better; they are inadvertently penalizing their highest-performing calves. In the following example (adapted from BIF, 2002), we will use weaning weight (WW) ratios to see what happens when only the best calves are reported. (Incomplete reporting has the same effect on EPD that it does on ratios.)

Suppose we have 10 calves with an average adjusted weaning weight of 625.

Calf	BIF Adj WW	WW Ratio
1	742	119
2	694	111
3	655	105
4	643	103
5	639	102
6	606	97
7	605	97
8	578	93
9	562	90
10	524	84
AVG:	625	

Now suppose that the producer only reports the top five calves, which means the new average adjusted weaning weight is 675.

Calf	BIF Adj WW	WW Ratio
1	742	110
2	694	103
3	655	97
4	643	95
5	639	95
AVG:	675	

Those high-performing calves (calves 3, 4, and 5) receive much lower ratios, and subsequently EPD, than if they had been compared to their entire contemporary group.

Another reason to use complete reporting, sometimes referred to as whole herd reporting, is to take advantage of genetic evaluations for cow stayability and fertility. As new genetic predictions of cow efficiency, maintenance, and fertility are developed, associations are going to need lifetime performance records on those cows to make the best estimates possible.

Birth

The first records to collect in a bull or heifer's life are birth weight and calving ease. Factors to consider when assigning contemporary groups are herd, year, season, sex, breed composition, management group, and embryo transfer or natural calf.

Birth weight. Birth weight (BW) should be collected as soon after birth as possible and needs to be adjusted for age of dam before being included in a genetic evaluation. The age of dam adjustment will compare all calves on a mature cow equivalent basis. Most associations ask that breeders submit the raw data, and they will make the appropriate adjustments, using their own breed-specific adjustment factors. If those are not available, use the Beef Improvement Federation (BIF) adjustments.

Age of Dam at Birth of Calf	BIF Adj BW
2	+8
3	+5
4	+2
5-10	0
11 and older	+3

This is an additive adjustment, so:

$$\text{Adj BW} = \text{Actual BW} + \text{Age of Dam Adj}$$

Example using BIF adjustments:

Remember, for birth weight, a lower number is associated with less calving difficulty.

Calf	Sex	Actual BW	Age of Dam	BIF Adj BW	BW Ratio
1	B	78	2	86	100
2	B	85	6	85	99
3	B	76	4	78	91
4	B	90	11	93	108
AVG:				86	

Calving ease. To record calving ease, use the scale recommended by your breed association, or the BIF-recommended scale.

1. No difficulty, no assistance
2. Minor difficulty, some assistance
3. Major difficulty, usually mechanical assistance
4. Caesarean section or other surgery
5. Abnormal presentation

After breeders submit actual weights, breed associations adjust the weights and use them to calculate EPD for birth weight. Both birth weights and calving ease measurements are used to calculate calving ease direct (genetic merit of the calf) and calving ease maternal (genetic merit of the dam) EPD.

Weaning

Weaning weight. The next information to collect on a bull, heifer, or steer is weaning weight. A group of calves should be weighed when the average of the group is near 205 days of age. BIF recommends that all calves be between 160 and 250 days old, or they need to be split into two contemporary groups and weighed on two different days. However, each breed association's particular guidelines for age at weaning may be slightly different. Any calf that is outside the prescribed range when weighed will not be included in a national genetic evaluation. Contemporary group criteria typically include all those for birth weight, plus birth-to-wean management code (which includes creep versus no-creep), date weighed, and sex (some calves that were bulls at birth may be steers by weaning). Weaning weight should be adjusted for age of dam and for age of calf. Most breed associations have their own age of dam adjustments, but if those are not available, the BIF adjustments are:

Age of Dam at Birth of Calf	BIF Adj WW	
	Male Calf	Female Calf
2	+60	+54
3	+40	+36
4	+20	+18
5-10	0	0
11 and older	+20	+18

The BIF formula to adjust weaning weight is:

$$\text{Adj 205-d WW} = \frac{\text{WW} - \text{Actual BW}}{\text{Wean Age (days)}} \times 205 + \text{Actual BW} + \text{Age of Dam Adj}$$

Example using BIF adjustments:

Calf	Sex	Age of Dam	Actual BW	Actual WW	Weaning Age (Days)	BIF Adj WW	WW Ratio
1	B	2	78	515	186	620	107
2	B	6	85	580	232	522	90
3	B	4	76	520	200	551	95
4	B	11	90	560	191	614	106
AVG:						577	

Weaning weights are used by breed associations to calculate weaning weight, maternal milk, and total maternal EPD. The genetic correlation between weaning weight and other weight traits makes it possible to use weaning weights to help calculate EPD for the other weight traits.

Yearling

At a year of age, there are many records that can be collected on bulls, steers, and heifers. It is important to collect data when the average of the group is near 365 days. Check with your breed association for the acceptable range of ages to take yearling measurements. In general, BIF recommends that all animals within the group be between 320 and 410 days when yearling data are taken. If animals fall outside of the range determined by the association, the group should be split into two successive yearling dates so that all animals are within the range on the day of measurement. Contemporary grouping should include the weaning criteria, plus yearling/feeding management code, date weighed, and sex. It is beneficial to hold animals off feed and water overnight to prevent gut fill from biasing weight measurements.

Yearling weight. Yearling weight (YW) should be collected on all animals and adjusted for age and age of dam. However, using the BIF adjustments, there is no separate age of dam adjustment. It incorporates adjusted weaning weight to account for age of dam. The formula to adjust yearling weights is:

$$\text{Adj 365-d YW} = \frac{\text{Actual YW} - \text{Actual WW}}{\text{\# Days Between Weights}} \times 160 + \text{205-d Adj WW}$$

Example using BIF adjustments:

Calf	Sex	Actual WW	Adj WW	Days Between	Actual YW	BIF Adj YW	YW Ratio
1	B	515	620	168	1150	1225	111
2	B	580	522	168	1024	945	86
3	B	520	551	168	1031	1038	94
4	B	560	614	168	1175	1200	109
AVG:						1102	

Adjusted yearling weights are used to calculate yearling weight EPD. Depending on the association, yearling weight may also be used as indicator traits to help calculate other EPD, such as mature weight. Many animals that have birth and weaning records go into the feedlot and will not contribute a yearling weight record. This could lead to selection bias for yearling weight EPD. However, most associations use a multiple trait animal model that includes birth, weaning, and yearling weights. This uses genetic correlations between the trait to account for selection and avoid bias.

Hip height. Frame score is a measurement that describes skeletal size. Larger-framed cattle tend to be later maturing, and smaller-framed cattle tend to be earlier maturing. Tables are available to convert the hip height measured in inches into a frame score (BIF, 2002). Hip height can be measured at any time from 5 to 21 months, but many producers choose to do it at yearling time because of convenience. Hip height or frame score can be used by associations to calculate EPD for mature weight or height. Check with the association for acceptable age ranges for submission of data.

Scrotal circumference. Scrotal circumference (SC) is an indicator of a bull's fertility, and it has a relationship with his daughters' age at puberty. Larger scrotal circumference is associated with younger age at puberty for the bull and his daughters. The contemporary group and age of measurement requirements are the same as those for yearling weight. Scrotal circumference measurements need to be adjusted for age with a breed specific adjustment factor.

$$\text{Adj 365-d SC} = \text{Actual SC} + [(365 - \text{Days of Age}) \times \text{Age Adj Factor}]$$

Breed	Age Adj Factor
Angus	0.0374
Red Angus	0.0324
Brangus	0.0708
Charolais	0.0505
Gelbvieh	0.0505
Hereford	0.0425
Polled Hereford	0.0305
Limousin	0.0590
Salers	0.0574
Simmental	0.0543

Geske et al., 1995.

Example using BIF adjustments:

Calf	Sex	Days of Age	Actual SC	BIF Adj SC	SC Ratio
1	B	354	36.2	36.6	101
2	B	400	38.5	37.2	102
3	B	368	34.6	34.5	95
4	B	359	36.5	36.7	101
AVG:				36.3	

Many breeds have their own adjustment factors, and they should be used if available. Most associations are using scrotal circumferences to calculate EPD for scrotal circumference and may use it as an indicator trait for heifer pregnancy EPD.

Pelvic area. Pelvic area (PA) can be measured on bulls and heifers at yearling time. While most breed associations are not calculating EPD for pelvic area at this time, it can be a useful culling tool within a herd. Heifers with small pelvic areas are more likely to experience calving difficulty. It may be beneficial to measure yearling bulls as well, because bull pelvic area is moderately correlated with heifer pelvic area. As with yearling weight, pelvic measurements should be taken between 320 and 410 days and adjusted to 365 days.

Bull Adj 365-d Pelvic Area =
Actual Area (cm^2) + [0.25 x (365 – Days of Age)]

Heifer Adj 365-d Pelvic Area =
Actual Area (cm^2) + [0.27 x (365 – Days of Age)]

Example using BIF adjustments:

Calf	Sex	Days of Age	Actual PA	BIF Adj PA	PA Ratio
1	H	351	150	154	102
2	H	395	165	157	104
3	H	359	144	146	97
4	H	386	152	146	97
AVG:				151	

Reproductive score. An experienced technician can palpate a heifer to determine the maturity of her reproductive tract and to determine if she has begun cycling. This information is not used in national genetic evaluations but can be a useful management tool. Heifers with immature reproductive tracts should be culled before the breeding season.

Ultrasound data. Most breed associations are now using ultrasound data collected on bulls and heifers to calculate EPD for body composition. Each association has its own specifications for when data should be collected. In general, bulls on gain test should be measured around a year of age. Some associations will use data from forage-raised bulls that are measured later than one year of age. Developing replacement heifers are typically scanned between 12 and 15 months of age, but there is variation between associations. Contact your breed association to get its requirements for age of scanning. Different associations have different requirements for ultrasound contemporary grouping. If scanning is done the same time as other yearling measurements, contemporary grouping is often the same as for yearling weight. If done at a different time, contemporary group criteria may include weaning weight contemporary group, yearling management group, and scan date. Check with a particular association for its contemporary grouping guidelines. BIF recommends that all calves in a scanning contemporary group be within 60 days of age with each other, but some associations may allow a wider age range. Ultrasound data need to be adjusted to a common endpoint of either age or weight. Each breed has its own endpoints and adjustment factors. Some breeds may include steer ultrasound data in their genetic evaluations. Check with your breed association for specific recommendations regarding scanning steers. It is important to use a certified technician to scan cattle if these data are to be included in a national genetic evaluation. Breed associations have a list of certified technicians from whom they will accept data.

Measurements taken at scanning include scan weight, ribeye area, 12-13th rib fat thickness, rump fat thickness, and percent intramuscular fat. EPD for scan weight, ribeye area, fat thickness, and percent intramuscular fat are produced from those measurements. Ribeye area and fat are indicators of the amount of carcass red meat yield. Percentage intramuscular fat is highly correlated with the amount of marbling in the carcass. Measurements of 12-13th rib fat thickness and rump fat thickness are combined to develop an EPD for fat. Some breeds combine weight, fat, and ribeye area into an EPD for yield or percent retail product.

Post-Yearling

Carcass data. Steers and cull heifers can be used to provide carcass data. Carcass data must be collected by trained personnel in conjunction with a packing plant. Many breed associations have structured carcass tests in place that do much of the groundwork for producers. Contemporary grouping for carcass data includes weaning contemporary group, feeding management group, and slaughter date. Within a plant, the day, and even the shift, that the cattle are processed can have a large effect on the carcass data. Data should be adjusted to an age-constant or weight-constant basis. Each breed association has its own guidelines to do this.

Data collected include hot carcass weight, marbling score, 12-13th fat thickness, ribeye area, and percent kidney, pelvic, and heart fat. Marbling score measures the quality of the carcass. Depending on market conditions, highly marbled carcasses can receive significant premiums. Marbling score is related to quality grade as follows:

Quality Grade	Marbling Amount	Marbling Score
High prime	Abundant	10.0-10.9
Average prime	Moderately abundant	9.0-9.9
Low prime	Slightly abundant	8.0-8.9
High choice	Moderate	7.0-7.9
Average choice	Modest	6.0-6.9
Low choice	Small	5.0-5.9
Select	Slight	4.0-4.9
High standard	Traces	3.0-3.9
Low standard	Practically devoid	2.0-2.9

Adapted from BIF, 2002.

Most breeds report EPD for carcass weight, marbling, ribeye area, and fat. In addition, they may include an EPD for yield or percent retail product. These EPD are intended to indicate the amount of lean meat in the carcass, and they use measurements of 12-13th rib fat, kidney pelvic and heart fat, ribeye area, and hot carcass weight.

Percent Retail Product
= 65.59
– (9.93 x adj fat thickness, in.)
– (1.29 x kidney pelvic and heart fat, %)
+ (1.23 x ribeye area, $in.^2$)
– (0.013 x hot carcass weight, lb)
(Dikeman et al., 1998)

Yield Grade
= 2.50 + (2.5 x adj fat thickness, in.)
+ (0.2 x kidney pelvic and heart fat, %)
+ (0.0038 x hot carcass weight, lb)
– (0.32 x ribeye area, $in.^2$)
(BIF, 2002)

Example using steer carcass data (adjusted for age or weight):

Steer	HCW (lb)	Fat (in.)	REA ($in.^2$)	KPH %	% RP	YG
1	735	0.35	12.8	2.0	65.7	2.5
2	690	0.40	11.5	2.0	64.2	2.8
3	845	0.45	14.4	2.0	65.3	2.6
4	905	0.60	13.5	2.5	61.2	3.6

Yearly cow herd measurements. Once a female makes it into the breeding herd, there are several records that should be collected every year. All replacement heifers and cows should be checked for pregnancy after the breeding season. Besides being a management tool to cull open females, some breeds are now collecting pregnancy data on heifers to calculate a heifer pregnancy EPD. At calving, birth dates, birth weights, and calving ease score should be recorded. These are necessary to document calf performance (as discussed previously) but also to document cow performance. Stayability EPD predict how long a cow will stay in the herd. This is based on reporting whether a cow is in the herd after 6 years of age.

It is important to record AI or exposure dates on the breeding herd. Currently there are few measures of genetic merit for reproduction, but breed associations are working to provide producers with EPD for fertility traits. Having complete breeding records will allow a producer to take advantage of these EPD as soon as they are developed. At weaning, cow weight and body condition score should be collected along with calf weaning weight.

Depending on the association, cow weights can be used to calculate mature cow weight EPD. Also, cow weight and body condition are important components of the new EPD being developed for cow efficiency and cow maintenance.

Summary

A successful breeding program depends on the accurate collection of performance records and the interpretation of those data. By maintaining proper contemporary grouping, adjusting the records correctly, and collecting data on every animal, the beef producer can make more effective selection decisions and maximize genetic progress.

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Body Condition Scoring System (BCS) for Beef Cattle

BCS	Description
1	Emaciated—Cow is extremely emaciated with no palpable fat detectable over spinous processes, transverse processes, hip bones, or ribs. Tail-head and ribs project quite prominently.
2	Poor—Cow still appears somewhat emaciated, but tail-head and ribs are less prominent. Individual spinous processes are still rather sharp to the touch, but some tissue cover exists along the spine.
3	Thin—Ribs are still individually identifiable but not quite as sharp to the touch. There is obvious palpable fat along spine and over tail-head with some tissue cover over dorsal portion of ribs.
4	Borderline—Individual ribs are no longer visually obvious. The spinous processes can be identified individually on palpation but feel rounded rather than sharp. Some fat cover over ribs, transverse processes, and hip bones.
5	Moderate—Cow has generally good overall appearance. Upon palpation, fat cover over ribs feels spongy and areas on either side of tail-head now have palpable fat cover.
6	High moderate—Firm pressure now needs to be applied to feel spinous processes. A high degree of fat is palpable over ribs and around tail-head.
7	Good—Cow appears fleshy and obviously carries considerable fat. Very spongy fat cover over ribs and around tail-head. In fact, "rounds" or "pones" beginning to be obvious. Some fat around vulva and in crotch.
8	Fat—Cow very fleshy and over-conditioned. Spinous processes almost impossible to palpate. Cow has large fat deposits over ribs and around tail-head and below vulva. "Rounds" or "pones" are obvious.
9	Extremely fat—Cow obviously extremely wasty and patchy and looks blocky. Tail-head and hips buried in fatty tissue and "rounds" or "pones" of fat are protruding. Bone structure no longer visible and barely palpable. Animal's mobility may even be impaired by large fatty deposits.

Source: Richards et al., 1986.