PEER REVIEWED

Critical Control Points in Beef Heifer Development*

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Abstract

Critical control points (CCPs) are the important thresholds that provide opportunities to measure the success of a process. The appropriate application of CCP in a heifer development program will provide insight as to the success or failure of management's efforts to introduce productive females into the herd. The first CCP occurs at breeding and reflects how appropriately the heifer's growth and phenotype have satisfied the physiologic demands of reproduction. Breeding management and breeding efficiency rates are examined at the second CCP, which is measured at the first pregnancy examination. The third CCP, measured at calving, gives an indication of the success of the nutritional plan and losses associated with pregnancy and the perinatal period. The fourth CCP, measured at the second season pregnancy exam, is a critical evaluation of how the heifer has fared with the cumulative stress of reproduction and lactation.

Résumé

Les points critiques contrôles (PCC) sont des seuils importants qui permettent d'évaluer le succès d'un processus. L'application appropriée de PCC dans un programme de développement des génisses de remplacement permettra d'avoir une indication du succès ou de l'échec des efforts de gestion pour intégrer les femelles productives dans un troupeau. Le premier PCC a lieu à la reproduction et reflète le degré avec lequel la croissance et le phénotype des génisses rencontrent les demandes physiologiques de la reproduction. La gestion et le taux de succès de la reproduction sont examinés dans le second PCC qui est mesuré au premier examen de gestation. Le troisième PCC, mesuré au vêlage, donne une indication du succès du plan d'alimentation et des pertes associées à la période de gestation et périnatale. Le quatrième PCC, mesuré à l'examen de gestation de la seconde saison, est une évaluation critique du succès des génisses de remplacement suite au stress cumulatif de la reproduction et de la lactation.

Introduction

Heifer development (h/d) represents management's conscious efforts to select, grow and introduce replacement females into a cowherd. The margin between a failed or successful h/d program may be quite narrow. Without planning, targets, measurements and reassessments, the likelihood of failure is high and management should consider alternate sources of female seedstock.[18] The two vital objectives of h/d are for a heifer to calve by 24 months and to conceive early in the following breeding season. These objectives are more likely to be achieved if the process is monitored and adjusted in an organized manner.

Heifer developent includes heifer selection, growth, breeding, calving and rebreeding in the second season. It can also be classified by phases including weaning to breeding, breeding to calving and calving to rebreeding. Although either categorization scheme is appropriate, it is paramount that goals are established and followed with performance evaluations.

The objectives, control mechanisms and measurement parameters of major periods of h/d have been well reported.[10,13] Table 1 is a summary of "critical control points" (CCPs) for heifer development. It emphasizes the continuous nature of h/d and can serve as a constant reminder that targets must be **m**ade, **m**easured and **m**et. W.E. Deming, the father of Total Quality Management (TQM) said in his efforts to build defect-free products, "Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs."[2] His theory assumed that if products were evaluated quantitatively during manufacturing, then deficiencies could be identified early and the process adjusted before the product reached quality assurance inspectors and/or the market. The concept of zero defects in food production originated from a response by Pillsbury to NASA's demand for no risk foodstuff for space travel.[17] The process which resulted incorporated measures at CCPs to avoid defects. Hazard Analysis Critical Control Points (HACCP) programs developed within the meat inspec-

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Table 1. Heifer development critical control points.

	Period evaluated	Objective	Control mechanism	Measurement tool
1. Prebreeding exam	**Weaning to breeding**	65% of mature weight	Developmental nutrition program	Weight
		Reach puberty, eg., CL	Selection Nutrition	Reproductive tract scores
2. Breeding	**Breeding season**	Calve 30 days prior to cows	Breed early Synchronization	Palpation 60 days Post-breeding histograms
3. Calving	**Pregnancy exam to calving**	85% of mature weight	Post-breeding nutritional program	Weight, BCS ≥ 6
			Disease programs Dam BCS	Calving distribution Perinatal and postnatal loss rates
		Calve without dystocia	Remove heifers with small pelvic areas Low EPD birth weight bulls	Calving ease scores
4. Second season pregnancy exam	**Calving to rebreeding**	BCS of ≥ 5.5 at rebreeding	Group feeding first parity heifers Lactation nutrition plan Early weaning	Palpation 60 days BCS of ≥ 4 at palpation Post-breeding histograms
		Rebreed early	Nutrition	Relative calving date or palpation

tion and food processing industry use CCPs to avoid contaminated or adulterated meat and meat products.[4,9] The Food Code[7] specifically refers to CCPs as a point where "loss of control may result in an unacceptable health risk."

CCP Tools

Critical control points are key points in a h/d program where loss of control may result in a suboptimal product and the enterprise must then be faced with unacceptable financial risks. Essentially, they are the thresholds that determine the success of the process as it reaches its conclusion. They must be measurable and be scored as satisfactory or unsatisfactory. While this may result in a plant shutdown or a rejected product in many factory settings, preferably a defect may be corrected if it is identified early and the product allowed to continue in the manufacturing process. Simultaneously, the process itself is evaluated as data is accumulated and the subsequent remedies are implemented.

The tool required for establishing values for the first CCP is determination of heifer weights in relation to their age. Weight is required to predict (and/or manage) an individual heifer's likelihood of actually becoming an economically productive replacement. Other CCPs can be measured with the simple tools found on most mobile veterinary units including OB sleeves, pelvimeter and a means of data collection and analysis. Laboratory assistance may be required for forage analysis and nutritional planning. Since body condition impacts h/d within several production segments, body condition scores (BCS) are a very important CCP tool.

Selection

Selection should fulfill the numeric, genotypic and phenotypic objectives of management. An additional 15-

30% more heifers than needed should enter the program so that some can be culled as they fail to meet subsequent goals. Selection by size inherently favors heifers that are from dams that calve early in the season. This tendency is beneficial in that heifers from cows that calve early also tend to calve early.[12] Economically, if one assumes that a suckling calf grows at 1.8 lb (0.82 kg) per day, then each 21-day estrous cycle delay in breeding results in 37.8 lb (17.2 kg) less weaning weight. Calves born at the end of the herd's 90-day calving season will weigh 162 lb (74 kg) less at weaning than a calf born at the beginning of the calving season. Since calves are commonly marketed at weaning as a group, lost pounds result in big losses in gross income. It is unlikely, if not impossible, for a cow to advance in her rank of "calving order" because of the time required for uterine involution and reestablishing fertile reproductive cycles between pregnancies.[7]

Calf size may also select for milk production. Although large weaning size is a trait that is desirable, if the calf's size is due to the milk production of the dam, then milk production may exceed what can be supported in a nutritionally lean year, which can have a negative impact on the dam's reproductive capacity. Therefore, estimated progeny differences (EPDs) for milk in relation to the body condition of the calf should be used as a check against heifer size to assure that long term selection has not drifted towards a cow whose size and milking ability are mismatched with the environment.

Selection will not be considered a CCP in this paper, rather it will be considered a component of h/d related to management's ability to match the operational goals and environment. While measures should be established to determine the success of heifer selection, the impact of these decisions may not be revealed for some time.

Critical Control Point 1—Pre-breeding (Weaning to Breeding Phase)

Once heifers are selected to enter the program, the first opportunity to evaluate whether objectives for weaning to breeding management are met occurs when heifers are examined pre-breeding. Thus the examination becomes the first CCP. Heifers should reach 65% of their mature bodyweight by the time of breeding (15 months).[20] Assuming calves are weaned at 205 days of age (7 months), eight months (240 days) are available to attain that objective. This usually requires an ADG of 1.25 to 1.75 lb (0.57-0.80 kg) per day, which is often dependent on supplementation with concentrates or high quality forage, especially in winter. Puberty is age and weight dependent.[15] Heifers that have reached puberty can be identified by rectal palpation of the uterus and ovarian structures. Infantile reproductive tracts are an indication for immediate culling.[1] Pelvic areas should be measured and individuals with low values should be considered for removal.[22] While studies offer conflicting reports as to the actual value of pelvimetry in reducing dystocia,[19] this tool should not be overlooked as means to identify a deformity and/or an individual with an extremely compromised birth canal. Finally, the non-pregnant heifer presents an opportunity to administer a comprehensive health program, which should include a parasite control program, and vaccination against such diseases as infectious bovine rhinotracheitis, bovine viral diarrhea, leptospirosis and campylobacteriosis.[10]

Critical Control Point 2—Breeding

First calf heifers should be bred to conceive 30 days prior to the general cow herd because they predictably require an additional 30 days of sexual rest before rebreeding. Synchronizing heifers and the use of AI or low cow-to-bull ratios will intensify both breeding and calving demands on personnel, but may make the process more manageable and result in a more uniform calf crop. Palpation at 60 days post-breeding allows accurate staging of gestational age. This data can be divided into 21-day segments and summarized in a histogram for detailed evaluation of the breeding program.[5,16] First estrus conception rates by bull breeding should exceed 60%. Pregnancy rates with AI can be expected to trail that of natural service. Eighty percent of heifers should conceive within the 45-day breeding season, and those that are found open should be culled or aggressively marketed to offset accumulated expenses.[6]

Critical Control Point 3—Calving (Pregnancy Examination to Calving Phase)

Growth is a major objective in this phase as well. Pregnant heifers should reach target calving weights of 85% of the cow's mature weight.[14,21] Therefore, nutritional programs during the 283-day gestation are critical to obtaining the appropriate growth rate. Ideally, heifers should calve at BCS $\geq$ 6 (nine point scale), which provides adequate reserves for lactation and reproduction without the dystocia-related problems that can be associated with BCS 8-9.[3,7] The overall success of the nutritional program is evaluated by a combination of pre-calving BCS estimates and calving records. Pregnancy, perinatal and early calfhood losses should be recorded and potentially investigated further. The use of calving-ease scores quantitatively relates the impact of dystocia on perinatal loss and indicates the need for more or less managerial and/or veterinary intervention.

Critical Control Point 4—Second Season Pregnancy Exam (Calving to Rebreeding Phase)

Body condition is a critical factor in the post-calving phase as well. First-parity heifers are more likely to conceive if their body condition scores are adequate at the beginning of the breeding season. A Louisiana study reported conception rates were better when calving at BCS ≥ 6 as compared to BCS 5, therefore a minimum target BCS at calving should be 5.5.[3] Estimating BCS at the time of bull turn-out is an opportunity to assess the rate of depletion of body energy reserves, and the success of the nutrition scheme. Delaying body condition scoring until the time of pregnancy examination only serves as a proxy or substitute to earlier body condition scoring. Discovery of average BCS below 4.0 may provide support for a diagnosis of a failed post-partum nutrition program, but it does not provide opportunity for correction of the nutritional deficit. Considering the demands of lactation and her own growth and maintenance, first-parity heifers should be segregated and group fed so they do not have to compete. Creep feeding and/or early weaning may be necessary if dam body condition declines to critical levels.[14]

Second-parity conception rate is the most significant measure of the success of a h/d program and is measured at the time the herd is pregnancy checked. Breeding date histograms of second-parity dams should be considered independent of the general herd. Late-bred or open cows at rates in excess of the general cowherd may indicate failure to give this group the attention they require. An unproductive dam can offset the successes made within the first two years. In the event that a heifer is open, decisions must be made to cull the heifer or to retain her in the herd, resulting in lost or delayed revenue. Therefore, while the cost required to maintain the body condition of a heifer following calving is considered a secondary CCP (discussed below), special care and supplementation may actually be a key success factor.[4]

CCP and Heifer Development Costs

A detailed discussion of the costs associated with implementing or monitoring a h/d program is beyond the scope of this paper. However, Table 2 shows a h/d budget formulated by Hughes and should serve as a reference to establish economic objectives for each segment.[8] Formulating relative limits for inputs such as pasture and concentrate supplementation may be examined by calculating the cost of gain or inclusion in partial budgets. These limits should be tailored to each operation and matched to their production goals.

Costs will vary by the producer's seedstock objectives and by region since pasture and commodity prices

Table 2. Heifer development budget.[8]

Conception to weaning	Weaning price	500# x $0.95	$450	
				$450
Weaning to breeding	Pasture lease-8 months	2 acres x $15 x 8/12	$20	
	Winter hay	.85 T x $40	$34	
	Grain	4.33# x 150 days x $0.06	$39	
				$93
Breeding to rebreeding	Breeding cost		$30	
	Adjustment heifer cost based on 77% conception	($573 / .77) - $573	$171	
	Interest	(573 + 171) x 10% x 1.25 yr.	$72	
	Pasture lease-1 year	2 acres x $15	$30	
	Grain pre-calving/ post-calving	((2# x 45 d) + (4 x 60 d)) x $0.06	$21	
	Winter hay	1.1 T x $40	$44	
				$368
				$911
	Less salvage value of culls	750# x $0.75 x 23%	($130)	
Replacement heifer cost				$781

vary. According to a previously reported model, objectives that target calving at 24 months of age (vs 30 months), minimizing dystocia rates (not higher than 20% above 3 year old counterparts) and maintaining adequate weaning weights on calves from first calf heifers (not less that 10% below herd average) have a large impact on the financial success of the h/d program.[11] In most situations, the financial success of the h/d program frequently hinges on the rate of pregnancy in the second breeding season.

Summary

Heifers represent the future cowherd. Because heifer development is important to management, factors such as commodity and calf prices, the likelihood that heifers will meet established goals, the resources required to reach the goals and management's ability to give h/d the attention it requires should be considered when deciding whether to raise or buy replacements. Heifer development can easily be overlooked, so heifers must be managed to assure optimum performance.

If heifers are to be reared on-farm, then examination of key measures taken at critical control points will enable identification of candidates and/or management practices that succeed, fail or may be salvaged with corrective action. Removal of uncorrectable individual failures as early as possible minimizes their negative economic impact. Early identification of failed management practices followed by corrective action may salvage the investment. Establishment of goals as well as measures of success and failure provide a basis to communicate with clients and validate a veterinary consultant's financial impact on an enterprise.

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