Babcock Institute for International Dairy Research and Development

University of Wisconsin-Madison

Dairy Essentials

26) FACTORS AFFECTING SIZE AND PRODUCTIVITY OF THE DAIRY REPLACEMENT HERD

Michel A. Wattiaux
Babcock Institute

Doug McCullough
Dairy Science Department

Raising heifers is a financial investment. The total number of heifers and number of first-calf heifers produced per year in the dairy replacement herd strongly influence the profitability of a dairy farm.

This article presents a simple discussion of factors influencing the balance between supply and departure of heifers from the replacement herd on an annual basis (Figure 1). The number of heifers that are born in the herd depends upon:

- Calving rate (number of cows and calving interval);
- Sex ratio.

The number of heifers that leave the herd depends upon:

- Calf mortality rate;
- Heifer culling rate (voluntary and involuntary);
- Age at first calving.

The number of first-calf heifers produced (available) and the number of first-calf heifers needed are two different concepts. The following three factors influence the need for—but not the availability of—first-calf heifers:

- Cow culling rate;
- Voluntary heifer sales (sales of heifers as breeding animals);
- Rate of expansion of the cow herd.

In a closed herd (no purchased cows or heifers), the number of first-calf heifers produced per year sets the maximum cow culling rate if herd size is to remain constant. When the number of first-calf heifers produced exceeds the desirable cow culling rate, excess heifers may be used to increase herd size or sold voluntarily.

Table 1 shows how to estimate the number of heifers that will be in the replacement herd (Table 1A) and the number of first-calf heifers produced per year (Table 1B).

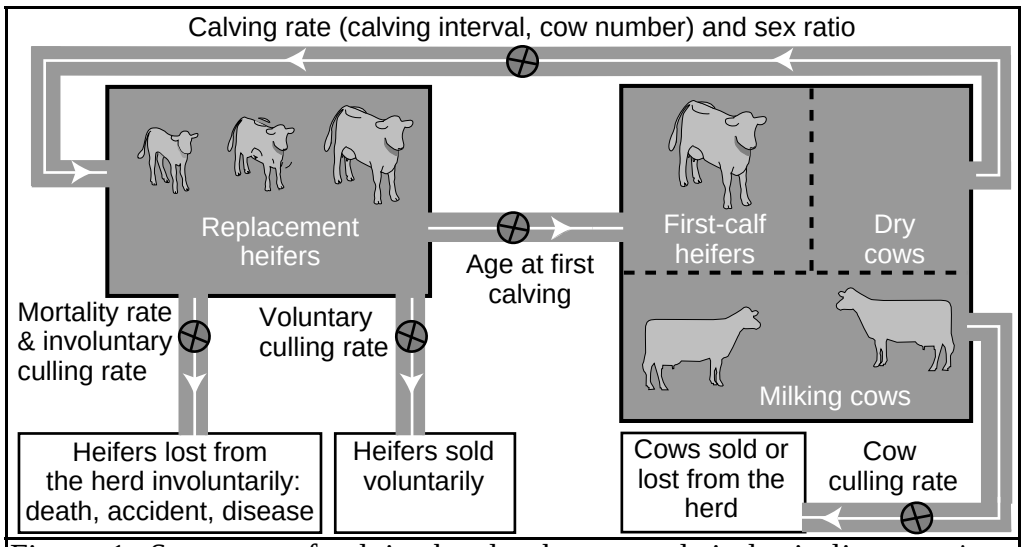

Figure 1: Structure of a dairy herd—the crossed circles indicate major management factors controlling the number of animals in each group.

Table 1: Calculating number of replacement heifers available in a 100-cow dairy herd

Factor	Example	Formula	Calculation	
A) Total number of heifers in the dairy replacement herd				
Time period[1]		2 years	2	2
Herd size	100	X No. Cows	X 100	X 100
Calving interval	13 months	X 12 / calving interval[2]	X 12 / 13	X 0.923
Sex ratio	50%	X No. of heifer / No. of calves born	X 0.5	X 0.5
Calf mortality	10%	X (1 - (percent calf mortality / 100))	X (1-0.10)	X 0.90
Age at 1st calving	25 months	X Age at calving[2] / 24	X 25 / 24	X 1.042
				= 87
B) Number of first-calf heifers available for replacement per year				
Time period[1]		1 year	1	1
Herd size	100	X No. Cows	X 100	X 100
Calving interval	13	X 12 / calving interval[2]	X 12 / 13	X 0.923
Sex ratio	50%	X No. of heifer / No. of calves born	X 0.5	X 0.5
Calf mortality	10%	X (1 - (percent calf mortality / 100))	X (1-0.10)	X 0.90
Age at 1st calving	25 months	X 24 / Age at calving[2]	X 24 / 25	X 0.96
				= 40

[1] The time period needed to calculate the total number of heifers in the herd "at any time" is two years (24 months) and the time period to calculate the number of first-calf heifers available per year is one year.

[2] Must be expressed in months.

Calving rate

The supply of heifers in the herd depends primarily on calving rate, which is calculated as:

$$\text{Number of cows} \times \left(\frac{12}{\text{Calving interval}} \right).$$

This factor measures the changes in expected number of calves when the calving interval differs from 12 months.

As the calving interval increases, the expected number of heifers born per year decreases. Under the assumptions presented in Figure 2A, an increase in calving interval from 12 to 18 months reduces the number of first-calf heifers available per year in a 100-cow herd from 43 to 29.

The numbers presented in the graphical parts of Figure 2 can also be interpreted as percentages. For example, if a 100-cow herd with an 18-month calving interval produces 29 first-calf heifers per year, then a 75-cow herd with the same calving interval will yield:

$$\frac{29 \text{ x } 75}{100} = 22 \text{ first-calf heifers.}$$

Sex ratio

Sex ratio of the newborns influences the number of heifers in the herd and is calculated as: $\frac{\text{Number of heifers}}{\text{Number of calves born}}$.

Many herds experience streaks of heifers or bulls, but over the years, there should be 51% heifers and 49% bulls. Recent research indicates that nutrition (cation-anion balance in the diet) may affect sex ratio, but the effects remain minimal. In the future, new technology will allow producers to choose the sex of future calves (semen sexing), but currently, sex ratio remains a rigid biological constraint.

Calf mortality and involuntary culling

Calf mortality and involuntary heifer culling account for heifers that are born in the herd but "disappear" before first calving because of disease or physical injury. Thus mortality rate includes calves that die and those that are culled for unforeseen reasons. The distinction between involuntary and voluntary culling rate (sale of surplus heifers as breeding

animals) is important because they have contrasting effects on herd improvement and profitability.

Typically, newborns are at higher risk of disease and death than older heifers. As heifers grow older, death loss decreases. However, involuntary culling may also occur in older heifers because of:

- Severe parasite infestations (grazing);
- Severe difficulty at first calving.

Every calf that dies or is involuntarily culled is a lost opportunity, especially when artificial insemination is used to improve the genetic potential of the herd. Under the assumptions presented in Figure 2B, an increase in mortality from 0 to 24% reduces the number of first-calf heifers available per year in a 100-cow herd from 44 to 34.

Age at first calving

When age at first calving increases beyond 24 months, the cost of raising heifers increases for the following reasons:

- Additional numbers of heifers are present in the herd;
- Additional feeding costs are incurred;
- Fewer first-calf heifers are available per year.

Long calving intervals and high mortality rates reduce the total number of heifers in the herd (Figures 2A and 2B); but a delayed age at first calving has the opposite effect (Figure 2C). A delayed calving means that heifers stay in the replacement herd for a longer period of time. For example, a 36-month-old first-calf heifer takes an additional 12 months, or 50% more time, than a 24-month old first-calf heifer before leaving the replacement herd. As a consequence, the total number of heifers in a 100-cow herd may vary from 83 to more than 120, but the number of first-calf heifers produced per year decreases from 42 to 28 (Figure 2C).

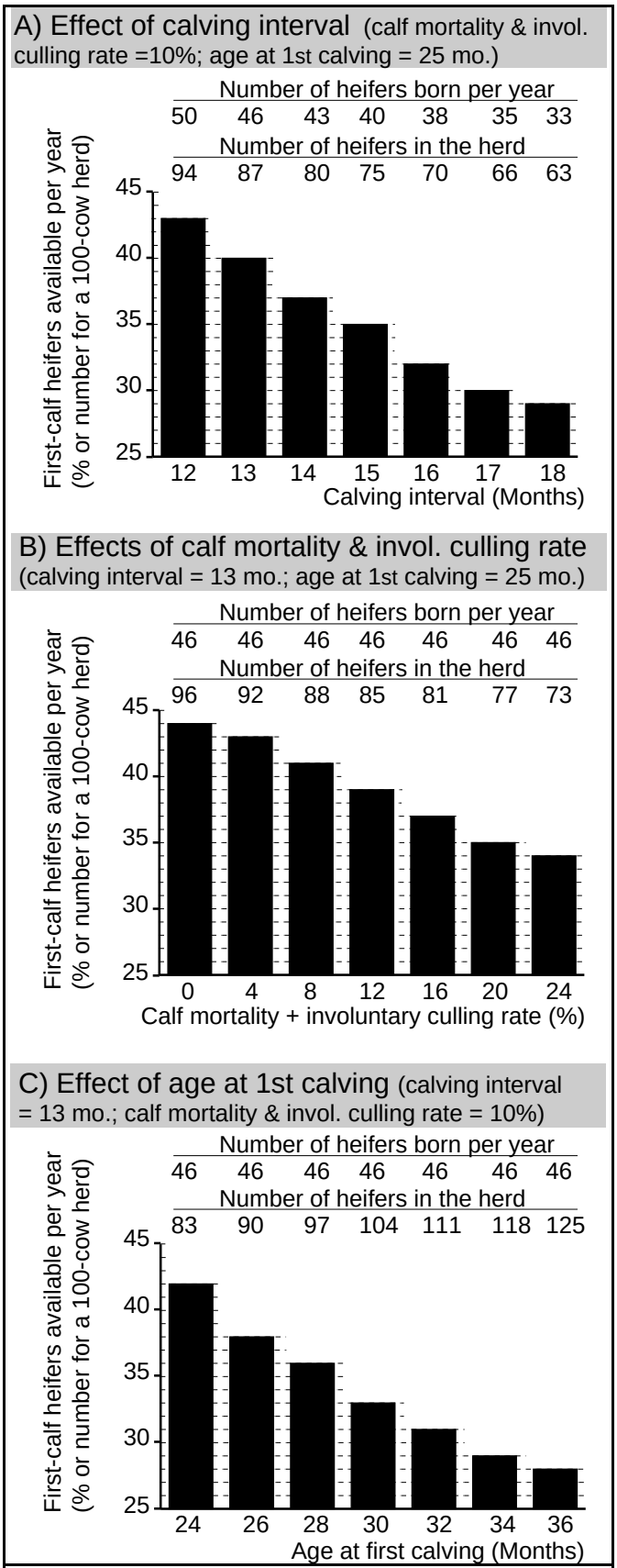

Figure 2: Major factors affecting the number of first-calf heifers available per year.

Summary

Table 2 presents the expected increase in number of first-calf heifers available per year in response to a change in calving interval, calf mortality and involuntary culling rate, and age at first calving. Table 3 presents the number of heifers in the herd and the number of first-calf heifers available per year for a 100-cow herd as a function of calving interval and age at first calving.

Table 2: Average effect of calving interval, calf mortality plus involutary culling rate and age at first calving on additional number of first-calf heifers available per year in a 100-cow herd

Factor	Range	Unit of change within the range	Additional first-calf heifers
Calving interval	12 - 18 months	minus 1 month	+ 2 to 3
Calf mortality + involuntary culling	0 - 24 %	minus 10%	+ 3 to 5
Age at first calving	24 - 36 months	minus 1 month	+ 1 to 2

Table 3: Number of heifers available as replacements in a 100-cow dairy herd, assuming a sex ratio of 50% and 10% mortality[1]

	Age at first calving (months)												
CI[2]	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Number of heifer in the replacement herd at any time													
12.0	90	94	98	101	105	109	113	116	120	124	128	131	135
13.0	83	87	90	93	97	100	104	107	111	114	118	121	125
14.0	77	80	84	87	90	93	96	100	103	106	109	113	116
15.0	72	75	78	81	84	87	90	93	96	99	102	105	108
16.0	68	70	73	76	79	82	84	87	90	93	96	98	101
17.0	64	66	69	71	74	77	79	82	85	87	90	93	95
18.0	60	63	65	68	70	73	75	78	80	83	85	88	90
Number of first-calf heifer available for replacement per year (Maximum possible cow culling rate to maintain herd size)													
12.0	45	43	42	40	39	37	36	35	34	33	32	31	30
13.0	42	40	38	37	36	34	33	32	31	30	29	28	28
14.0	39	37	36	34	33	32	31	30	29	28	27	26	26
15.0	36	35	33	32	31	30	29	28	27	26	25	25	24
16.0	34	32	31	30	29	28	27	26	25	25	24	23	23
17.0	32	30	29	28	27	26	25	25	24	23	22	22	21
18.0	30	29	28	27	26	25	24	23	23	22	21	21	20

[1] To find the number of heifers available for a mortality rate different than 10%, multiply the number found in the table by 1.111 and then multiply again by (1-mortality fraction). For example, the number of first-calf heifers available for a 14-month calving interval, 28 months of age at first calving and a mortality rate of 5% is: 32 x 1.111 x (1-0.05) = 33.8 or 34 heifers.

[2] CI = Calving interval (months)