A Five State Survey of Heifer Management Practices on Dairy Farms and Virginia Custom Dairy Heifer Growing Operations

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(ABSTRACT)

Two surveys evaluated heifer management practices in dairy herds and custom grower operations. The NC-119 Heifer Management Survey conducted through the North Central Regional Research Project 119 included 226 Holstein and 67 Jersey herds from MN, MO, PA, VA, and WA. Mean rolling herd average for milk was 8,838 and 6,251 kg for Holstein and Jersey herds, respectively. Calf mortality rates from birth to first calving were 15.3 % for Holsteins and 15.8% for Jerseys. High producing herds had more aggressive, preventive health programs, hand-fed colostrum to newborn calves, and used prepartum groups and separate postpartum groups for first calf heifers. Practices associated with low calf mortality included using maternity pens in barns separate from the dairy herd as a calving facility and vaccination for brucellosis, an indicator of the level of overall management. Larger herds weaned calves earlier, placed more importance on heifer size as a criterion for first breeding, and used prepartum groups and separate postpartum groups for first calf heifers States differed in calving facility and calf housing choices. Calf mortality rates were similar among states. The Virginia Custom Dairy Heifer Rearing Survey included 24 growers. Average herd size was 194 head. Seven growers contracted with dairy producers, nine purchased, raised, and resold heifers, and eight did both. Survey results indicated a need for increased emphasis in several management areas. Only two contract growers had written contracts. Fifty-eight percent never monitored growth and 42% did not have forages tested or rations balanced. Fifty-seven percent used AI.

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INTRODUCTION

Profitability is the key to success in the dairy industry. Progressive owners and managers of profitable herds are challenged to look for ways to increase efficiency and are not content to always do things as they have been done in the past. Change is inevitable. The dairy industry is an evolving industry. Technological advances, nutrient management requirements, labor availability, infrastructure changes, and economies of scale have impacted the VA and US dairy industries. As a result, some farms have increased in size while others have diversified, specialized, developed a niche market, or even gone out of business. Heifer rearing options have received more attention as herds reevaluated farm enterprises.

High quality, well-grown, economically raised replacement heifers are desired by dairy producers. Heifers account for 15 to 20% of the cost of milk production on the dairy farm (Heinrichs, 1993; Mourits et al., 1997). Only feed costs represent a greater percentage of costs of milk production. Producers need information about heifer management practices that will enable them to raise heifers more efficiently and to increase income producing potential of heifers. Costs, benefits, and risks associated with practices must be better defined so producers can make more informed decisions.

Cost of rearing heifers is unknown on many dairy and custom grower farms. Budgets for dairy heifer enterprises have been developed by researchers and Extension workers for different heifer rearing scenarios. Estimates of the costs of rearing heifers from birth to calving, excluding the initial cost of the calf, range from $550 to $1,325 (Bethard, 1997; Bolton, 1992; Ely and Brown, 1984; Heinrichs and Schwartz, 1990; Hoffman, 1992b; Karszes, 1994; Miller and Amos, 1986; Randle et al., 1998; Smith, 1992; Virginia Cooperative Extension, 1997; Webb, 1992; Willet et al., 1992). These budgets were developed through intensive work with individual producers, through simulations, and with best estimates based on previous work with producers. Karszes and Stanton (1994) worked closely with a small number of herds in Western NY to develop a heifer rearing budget. Bethard (1997) used simulation modeling to estimate costs of production. He defined nutrient requirements for heifers at various stages of growth. The model estimated costs of rearing based on changing inputs and costs to meet nutritional requirements. A limitation of modeling is the lack of information on costs and benefits of many practices. Knowledge of rearing costs is critical to measure enterprise profitability and to compare other heifer rearing options. Custom heifer growers must identify their costs to determine what they charge for their services if contracting or what price to ask for heifers if purchasing, raising, and reselling.

Research in dairy heifer management has largely focused on production practices that will decrease calf mortality, increase rate and/or efficiency of gain without detrimental effects on the mammary gland, and/or decrease age at weaning, first breeding, and first calving. Extension programs have delivered information about recommended practices to producers. However, it is rare to follow up with the industry to see which practices have been implemented on the farm which might be related to profit. Periodic surveys of producers provide an indication of the current status of the industry. They indicate where further research and educational programs are needed.

Two surveys were conducted to examine heifer management practices. The first was the NC-119 Heifer Management Survey. This survey was a five state effort by members of the North Central Regional Research NC-119 Committee. States participating were MN, MO, PA, VA, and WA. The purpose of the survey was to examine heifer management practices and to determine which practices were associated with high milk production and low calf mortality.

Custom heifer growers utilize the same basic dairy heifer management information as dairy producers. However, they also need business management information that is unique to their business. For example, knowledge of advantages and disadvantages of contracting versus purchasing, raising, and reselling is important to them. They also need information on what should be included in contracts and on how to determine charges for various services such as breeding or vaccination programs.

The second survey was the Virginia Custom Dairy Heifer Grower Survey. Custom heifer rearing started receiving more attention and discussion in VA and elsewhere in the mid 1990's. The First National Professional Dairy Heifer Growers Conference held in Atlanta, GA, in April 1997, led to formation of the Professional Dairy Heifer Growers Association, a national organization to serve the dairy heifer growing industry. With this attention on the topic of heifer rearing, current and prospective heifer growers as well as dairy producers began asking difficult questions about the merits and costs associated with custom heifer rearing. Their requests emphasized a need for new information. The purpose of the survey was to identify custom dairy heifer growers in VA and to characterize the industry by its nature (contract versus purchase-raise-resell), size, cattle sources and markets, and management practices. The information generated will be helpful in developing educational programs for custom heifer growers and dairy producers interested in contracting their heifers with a grower.

REVIEW OF LITERATURE

The ability to generate profit is the key to success in the dairy business. The heifer enterprise accounts for 15 to 20 percent of the cost of milk production on most dairy farms, second only to feed costs (Heinrichs, 1993; Mourits et al., 1997). An adequate supply of well-grown replacement heifers is required for herd productivity and profitability. Several options are available to meet replacement needs that include home rearing of replacements, purchasing them, contracting out heifers for all or part of their pre-productive lives, or leasing.

Smith (1993) conducted a financial survey of 200 Michigan dairy herds to determine the return on investment of the four major enterprises found on the average dairy farm. The heifer enterprise had an average return on investment of 11% as compared to 26%, -4%, and -11% for cows, grain, and forages, respectively. While the milking herd is the central focus of the dairy operation, this information underscores the economic significance of the heifer enterprise.

GOALS

Various goals have been offered for the heifer enterprise. Swanson (1967) stated that "the optimum growth pattern for dairy heifers is that regimen which will develop in the heifer her full lactation potential at a desired age and a minimum of expense." Hoffman (1992a) desired good framed heifers that calve at 24 months of age while Heinrichs (1993) suggested that the goal of the heifer rearing program should be to have high quality replacements at minimum cost. Head (1992) offered that heifers should be reared at minimum expense to develop to their full potential during productive life. Each of these goals emphasizes high quality at minimum cost.

Success of the heifer rearing program may be monitored through several performance measures including age and size at first calving and at first breeding, average daily gain, and heifer mortality. It is currently recommended that Holsteins first calve at 24 mo of age with a postcalving bodyweight of 516 to 588 kg and a wither height of 132 to 137 cm tall. In order to achieve the calving age and bodyweight goals, heifers should be bred between 13 to 15 months of age and should weigh between 340 and 363 kg. Average daily gains of 770 kg/d are recommended (Heinrichs and Schwartz, 1990). Calf mortality should not exceed 5 percent (Etgen et al., 1987).

Sound management decisions about the replacement herd positively affect the overall profitability of the dairy operation by reducing rearing costs or by improving the income generating ability of heifers once they enter the milking herd. Complete, accurate financial and production records are the key to making well-informed decisions and are needed to monitor progress of the herd.

EXPENSES

Webb (1992) outlined numerous factors affecting rearing cost which included feed price, available pasture, death loss, management decisions, disease and other losses, interest rate, and initial value of calves. Webb also estimated that feed cost was the highest and accounted for 54.8% of total costs, followed by labor (21.6%), interest (13.2%), other (5.7%), and veterinary and drugs (4.7%). Actual costs of rearing heifers from birth to calving vary widely with growing conditions and available resources. Estimates of total cost of rearing from birth to calving excluding the cost of the calf range from $500 to $1,325 per head (Bethard, 1997; Bolton, 1992; Ely and Brown, 1984; Heinrichs and Schwartz, 1990; Hoffman, 1992b; Karszes, 1994; Miller and Amos, 1986; Randle et al., 1998; Smith, 1992; Virginia Cooperative Extension, 1997; Webb, 1992; and Willet et al., 1992;). Budgets for rearing heifers from birth to calving are presented from least to most expensive in Table 1. Initial calf value was excluded from each budget. A brief description of budget conditions and assumptions follows.

The Miller and Amos (1986) budget presented in Table 1 is a budget for raising dairy heifers using a pasture system in Georgia. This budget had a total cost of rearing from birth to calving of $550 per head making it the least expensive of the budgets presented. It was assumed that growth rates would be lower in the system resulting in an average age at first calving (AFC) of 31 months. Randle et al. (1998) developed a budget for rearing heifers in Missouri utilizing a combination of confinement and pasture. Young calves were housed in calf hutches and free stalls while heifers six months and older were in a rotational pasture system. Over 50% of the budget was associated with feed cost with 19.6% allocated for labor expenses. Ely and Brown (1984) estimated the cost of rearing a heifer from birth to calving at $908. This budget was

Table 1. Dairy Heifer Budgets.

Budget	Feed	Labor	Interest	Other Variable Costs	Fixed Costs	Total Cost
Miller and Amos (1986)	$270.00	$90.00	$105.00	45.00	$40.00	$550.00
Randle et al. (1998)	416.76	158.42	34.11	114.89	83.61	807.79
Ely and Brown (1984)	555.00	112.00	137.00	49.00	55.00	908.00
Virginia Coop. Extension (1997)	623.39	229.16	NR	82.71	NR	935.26
Hoffman (1992b)	498.00	144.00	58.15	143.00	178.33	1,021.48
Karszes (1994)	645.00	138.00	62.10	115.50	83.00	1,043.60
Heinrichs and Schwartz (1990)	538.00	108.00	47.77	163.50	268.00	1,125.27
Smith (1992)	671.00	160.00	94.00	99.00	106.00	1,130.00
Willet et al. (1992)	678.03	156.00	107.74	161.00	39.19	1,141.96
Bolton (1992)	514.68	192.00	62.18	145.40	410.75	1,325.01

NR = Not reported

based on a conventional system in Georgia which relied more on stored feeds. An average AFC of 25 months was assumed for this budget.

The VA Cooperative Extension heifer budget assumed an AFC of 26 months. It was based on a confinement feeding system which utilized corn silage and orchardgrass hay as the main forages, typical of Virginia dairy farms. Cost of rearing from birth to calving was $935.26. However, the cost of rearing a heifer in this situation would be higher because interest and fixed costs for housing and equipment were not included in the budget (Virginia Cooperative Extension, 1997). The Hoffman (1992b) budget was developed for Wisconsin dairy herds utilizing a confinement rearing system. Projected cost per head for raising heifers from birth to calving at 24 months of age was $1,021.48. Eight Western New York dairy herds were surveyed by Karszes (1994) to determine the cost to raise dairy replacements. Average cost of rearing was $1,043.60 for these herds which had an average AFC of 23.3 months. Cost of rearing ranged from $943 to $1,212. Feed cost accounted for 61.8% of the total while labor accounted for 13.2%.

Heinrichs and Schwartz (1990) estimated the cost of raising replacements in Pennsylvania at $1,125.27 for heifers calving at 24 months of age. This scenario was based on a confinement rearing system which utilized a hay and grain ration post-weaning. Smith's (1992) budget presented in Table 1 resulted from data collected through the Cornell Cost Accounting Project in New York. The budget assumed an AFC of 29 months. Total cost from birth to calving was $1,130. The budget by Willet et al. (1992) was based on pasture utilization for six months when the heifer was between 13 and 24 months of age. Pasture costs were $16 per month. The budget was constructed assuming that heifers will calve at 24 months of age. Total cost of rearing in this situation was $1,141.96. Bolton's (1992) budget is the most expensive budget presented in Table 1. Cost of rearing from birth to 24 months of age totaled $1,325.01. This budget was based on a confinement rearing system in Wisconsin. One of the reasons for the excessive total cost is the high fixed costs which account for 31% of the total. A charge of $152.75 for fixed costs - livestock appeared in this budget, but was not included in others presented.

Examination of the total cost of rearing heifers from birth to calving is one way of evaluating heifer rearing economics. Table 2 represents the cost of raising dairy replacements

Table 2. Cost to raise dairy replacements per day per animal.

	18 NYCustom Growers ($/hd/d)	8 NY Dairy Herds ($/hd/d)
Feed	.87	.910
Bedding	.04	.035
Health	.02	.026
Breeding	.04	.026
Labor	.24	.195
Trucking	.01	.000
Insurance	NR	.006
Machinery operation	.04	.054
Machinery overhead	.04	.031
Building operation	.02	.011
Building overhead	.07	.086
Death loss	.00	.004
Interest on investment	.02	.088
Total	$ 1.42	$1.47

NR = Not reported.
(Karszes and Stanton, 1991a; Karszes, 1994)

on a per day per animal basis. Results of two surveys are presented, both from New York State. The first was a survey of 18 NY custom growers conducted in 1990 (Karszes and Stanton, 1991a). The second was a survey of eight Western NY dairy farms which was conducted in 1993. (Karszes, 1994). The total cost per day per animal was $1.42 and $1.47 for custom growers and dairy farms, respectively. Labor costs were higher for custom growers whereas feed costs and interest on investment were greater on dairy farms. Custom growers would be expected to spend more time working with heifers because heifers are their livelihood. Interest on investment was higher on dairy farms because of a greater investment in buildings and equipment. Knowledge of the cost per day per animal is important for dairy producers considering a custom grower for rearing heifers if the grower is charging on a per animal per day basis. Without this information, producers do not know whether or not the custom grower offers a cost savings.

The following sections will discuss major expenses associated with raising dairy replacement heifers. Feed, labor, interest, and other factors will be covered in order of importance from most to least.

Feed Cost

Feed cost accounts for 40 to 70% of the total cost and is, therefore, the largest cost associated with rearing dairy heifers (Mourits et al., 1997). Large differences exist in feed cost from farm to farm and region to region for several reasons. First, feed resources differ between regions of the country because of length of the growing season, forage species adapted to the climate, soil fertility, annual rainfall, irrigation capabilities, and land use and availability. For example, VA producers often rely on pasture, corn silage, and orchardgrass hay as home grown forages. Energy and protein supplements are usually purchased because it is more economical to buy them than to raise them. Producers in the Southwestern US often purchase 100% of the feed used on their operations. Alfalfa hay is a common forage on those farms. Another difference is that larger operations can take advantage of economies of scale by buying in bulk to reduce feed and other expenses. Third, differences exist between pasture, confinement and semi-confinement rearing systems. Miller and Amos (1986) argued that the best strategy for reducing rearing costs was to decrease feed costs while Sjersen and Purup (1997) suggested that the most effective way to reduce rearing costs is to reduce age at first calving. These approaches do not necessarily contradict each other. Feed costs can be reduced by increasing feed efficiency, by making wise purchases, and by reducing the feeding period prior to calving.

Feed cost per day fluctuates over the life of the heifer. Hoffman (Bungert, 1997) estimated the average total cost per head per day to be $1.61. Table 3 summarizes the cost per head per day by weight of the heifer. While the table accounts for all costs, the major fluctuations resulted from feeding changes.

The pre-weaning period is the most expensive time of the calf's life because the relative cost per unit of nutrient of the liquid diet is expensive compared to grain and forage diets. After weaning, feed cost drops sharply but then slowly begins to rise as the animal grows and increases her dry matter intake. Early weaning can reduce feed costs (Heinrichs, 1993). A study was conducted by Quigley (1996) to examine weaning methods and their impacts on growth and intake. Forty-three Jersey calves were divided into three treatment groups. The first group (AW) was fed milk replacer at 10% BW until abrupt weaning at 35 days of age. The second group (GW) also received milk replacer at 10% BW until 28 days of age and then 5% BW until weaning at day 35. The final group (IW) received milk replacer at 10% BW until starter intake equaled 454 g/d for 2 consecutive days. Mean age at weaning based on starter intake was 40 d. Intake and feed costs were higher for the IW group. Delayed weaning increased costs by $3.36 to $3.57 per head in this study. Quigley recommended weaning Jersey calves when calf starter DMI equals 366 to 500 g/d or 13 to 15 g/kg BW.

Another study examined the level of grain feeding as the weaning criterion. Greenwood et al. (1997) conducted a calf feeding trial examining three levels of dry feed intake as a weaning criteria - 1%, 1.5%, and 2% of initial BW. Milk was fed twice daily at 8% initial BW and abruptly stopped at weaning. Water was offered ad-libitum. When dry feed intake of 1% of initial BW for three consecutive days was used as the weaning criteria, days to weaning decreased, dry feed intake from birth to 8 weeks increased, variation in weaning age decreased, and no negative effects on growth at 20 weeks were observed. Therefore, early weaning offers a cost savings without negative effects on growth.

Heifers require sufficient growth throughout their rearing to achieve the age and size goals previously stated. Age at first calving impacts the cost of rearing. Additional months

Table 3. Daily costs of rearing by bodyweight.

Start Weight (kg)	End Weight (kg)	Cost/head/day ($)
45.4	90.7	2.54
90.7	136.1	1.07
136.1	181.4	1.15
181.4	226.8	1.17
226.8	272.2	1.30
272.2	317.5	1.34
317.5	362.9	1.44
362.9	408.2	1.82
408.2	453.6	1.86
453.6	499.0	1.79
499.0	544.3	1.81
544.3	589.7	2.01
Average		1.61

Hoffman (Bungert, 1997)

spent in a nonproductive state are costly because income from milk sales is not received while feed and other costs continue to accumulate. Bolton (1992) estimated $60.10 per month for rearing costs past 24 months of age while Willet et al. (1992) estimated the cost at $62.69 per month. Heinrichs et al. (1991) budgeted $22.20 per month for additional rearing costs beyond 24 months, but only included costs for additional hay and grain. Toro (1987) determined that the cost for each additional month ranged from $16 to $22 depending on the breeding strategy of the herd and the percent of DM obtained from pasture. The more expensive rates were for herds that seasonally bred heifers and made limited use of pasture.

Pasture

Pasture may serve as both a forage source and a housing system for dairy heifers. Pasture utilization as a forage source varies by region of the US. The Southeast relies on pasture because of a longer growing season and typically lower land values. The Upper Midwest, however, must depend more on stored feeds and confinement feeding because of shorter growing seasons and harsh winters. Southwest producers operate largely in a dry lot setting and rely on purchased feeds grown under irrigated conditions.

Four of the budgets presented in Table 1 made at least partial use of pasture as a forage source. They were the budgets by Miller and Amos (1986), Randle et al. (1998), Smith (1992), and Willet et al. (1992). The Miller and Amos (1986) budget relies most heavily on pasture. Two-thirds of the hay and silage normally required were replaced with reasonably good quality pasture. As noted earlier, this budget was the least expensive of those presented. Savings over other budgets largely came from a reduction in the amounts of grain and stored feed utilized. These researchers stated that pasture is feasible as a rearing system because slower growth, which is often associated with pasture rearing, is acceptable provided heifers are healthy and there is no impact on animal value. In addition, the relative cost of pasture does not increase as much as stored feed over time. The authors expressed concerns that pasture is not available at all times and that much variation exists in pasture quality which could result in variation of average daily gains. While it may be argued that pasture can be a source of savings, one may question whether the values presented in this budget are reasonable because they are dramatically lower than those found in other budgets from Table 1 which are based on a growing period seven months shorter than assumed in the pasture system. The savings may not be as large as anticipated on a herd basis because the number of replacements required to maintain a static herd size would increase with delayed calving. Seven months of income generation were also lost in this scenario.

In the Randle et al. (1998) budget, heifers were fed on pasture with daily supplementation from 6 to 24 mo of age. Feed costs in the budget were the second lowest overall, largely due to savings offered by pasture. In contrast, the Willet et al. (1992) and Smith (1992) budgets which made limited use of pasture, and, therefore, relied more heavily on stored feed, have the highest feed costs out of the ten budgets overall. One factor that had an impact was the price of feeds used in the budgets. Prices were different due to market conditions when the budgets were constructed.

Conventional Systems

Conventional heifer rearing systems made use of confinement feeding. Heifers were raised under more controlled conditions and were fed more stored and purchased feed as compared to heifers in a pasture system. Feed costs were typically higher as were fixed costs associated with additional heifer facilities for feeding and housing. The Bolton (1992) budget was developed for a confinement rearing system in Wisconsin and was the most expensive budget presented in Table 1. Granted that Bolton included an ownership charge of $153 for heifers in fixed costs not included in other budgets presented, the budget still has the highest fixed costs without the charge. However, only Hoffman (1992) had lower feed costs than Bolton when comparing confinement rearing budgets. The confinement rearing budgets used a variety of stored feeds including corn silage, hay crop silage, and orchardgrass hay (Bolton, 1992; Ely and Brown, 1984; Heinrichs and Schwartz, 1990; Hoffman, 1992b; and Virginia Cooperative Extension, 1997). Confinement rearing systems offer the opportunity to better control growing conditions, but this opportunity often comes at a higher price. Efficient gains are needed to offset higher feed costs and additional facility costs associated with confinement feeding.

Carboxylic ionophore antibiotics, more often referred to as ionophores, are feed additives commonly used in heifer feeding programs. Lasalocid and monensin are the most common ionophores fed to dairy heifers. The role of ionophores is to prevent coccidiosis and to enhance feed utilization and efficiency (VanAmburgh and Galton, 1993). Ionophores cause a shift in the rumen microbial population resulting in more propionic acid being produced in relation to acetic acid. Methane production is also reduced. Utilization of dietary energy increases and more dietary protein becomes available to the small intestine because of a protein-sparing effect in the rumen (Stallings et al., 1992). Benefits of utilizing ionophores in the feeding program include increased feed efficiency, improved performance, reduction of age at first breeding and first calving, and cost savings (Heinrichs et al., 1993; Meinert et al., 1992; Smith, 1993; and Stallings et al., 1992). Smith (1993) reported an improvement in heifer performance of 9 to 12% with ionophores while Stallings et al. (1992) stated that ADG's could be expected to increase by 0.045 to 0.09 kg/d. Meinert et al. (1992) conducted a monensin feeding trial with two groups. One group served as the control group and received no monensin while the other group received 200 mg of monensin per day. Age at first breeding and AFC were reduced for the monensin-fed animals by 25 days and 48 days, respectively. Smith (1993) projected a savings of $15 to $25 per head by decreasing AFC by 10 to 15 days through ionophore usage. Ionophores cost between $0.01 and $0.02 per head per day (Smith, 1993; Stallings et al., 1992). Returns are realized through increased ADG's and/or a decrease in the amount of feed required. Concerns related to ionophore feeding are less effectiveness with poorer quality forages and potential toxicity at feeding levels in excess of 1,000 mg/d (Stallings et al., 1992). In spite of these concerns, ionophores offer a practical way to increase feed efficiency and performance of growing dairy heifers.

By-pass protein, also referred to as undegradable intake protein (UIP) or rumen undegradable protein (RUP), has been recommended to increase growth rates in dairy heifers (National Research Council, 1988). While increased gains have been reported (Bethard et al., 1997; Tomlinson et al., 1997), the main benefit seems to be an increase in feed efficiency. Tomlinson et al. (1997) reported that heifers fed diets with RUP >40% of total N consumed less DM and digestible energy (DE), but had ADG's from 59 to 129 g/d higher than control animals fed at 30% RUP. Feed efficiency increased linearly as the level of RUP increased. Bethard et al. (1997) conducted a 2X2 factorial experiment using two energy and two RUP levels. The low energy diets were balanced for an ADG of 0.6 kg/d while the high energy diets were balanced for 0.9 kg/d ADG's. The low RUP diets contained RUP at 30% of CP while the high diets contained RUP at 50% of CP. Dry matter intake, ADG, BW, DM efficiencies, and CP efficiencies were higher for the high energy diets. Feed efficiency increased with increasing RUP even though BW gains were not improved.

The feeding system is a critical part of the heifer rearing program. A reduction in feed costs or an improvement in feed efficiency can have significant impacts on the profitability of the heifer rearing enterprise. Pasture and confinement rearing systems have advantages and disadvantages, but both can be successfully used to raise heifers.

Labor

Labor is the second largest expense of the heifer enterprise. Labor costs in the dairy heifer budgets presented in Table 1 ranged from $90.00 to $229.16 per head. Labor efficiency varies based on herd size and feeding, housing, and handling facilities. Labor efficiency would often be expected to be higher in herds that are larger, utilize pasture as a feeding and housing system, and/or have excellent handling facilities for routine management practices such as vaccination and artificial insemination.

Randle et al. (1998) identified three areas for labor needs in the heifer operation - feeding and management, health maintenance, and breeding. Feeding and management chores include feeding, cleaning, bedding, moving, and managing heifers. Health management tasks are vaccinating, de-worming, and de-horning. Heat detection, gathering, insemination, and pregnancy checking would be included in the breeding category. Annual labor requirements for feeding and management, health maintenance and breeding are shown in Tables 4, 5, and 6, respectively. Annual labor requirements for feeding and management were greatest at 16.6 h/hd with breeding at 1.526 h/hd and health maintenance at 0.283 h/hd. These values were based on a Missouri heifer rearing system for a 1,000 cow dairy. Smaller operations like those in Virginia would be expected to be less labor efficient. However, the percentage of total labor requirements spent in the three major areas would be expected to be similar.

Interest

Interest is the third largest expense in heifer rearing and accounts for 13.2% of the total cost according to Webb (1992). Interest rates are largely a function of the times and reflect the

Table 4. Annual Labor Requirements for Feeding and Management.

Stage of Production	Annual Production (hd)	Dairy Labor Requirement (min/hd)	Annual Labor Requirement (hr)	Annual Labor per Head (hr/hd)
0-2 months	432	8.0	3502.1	8.1
2-6 months	417	1.5	1267.7	3.0
6-12 months	404	0.6	736.9	1.8
12-24 months	384	0.6	1401.6	3.7
Total		10.7	6908.3	16.6

(Randle et al., 1998)

Table 5. Annual Labor Requirements for Health Maintenance.

Stage of Production	Annual Production (hd)	Working Rate (hd/hr)	Number of Workers	Annual Labor Requirement (hr)	Annual Labor per Head (hr/hd)
0-2 months	432	12	1	36.0	0.083
2-6 months	417	40	3	31.3	0.075
6-12 months	404	60	3	20.2	0.050
12-24 months	384	40	3	28.2	0.075
Total				116.3	0.283

(Randle et al., 1998)

Table 6. Annual Labor Requirements for Breeding.

Event	Annual Production (hd)	Working Rate (hd/hr)	Number of Workers	Annual Labor Requirement (hr)	Annual Labor per Head (hr/hd)
Heat Detection	384	N/A†	1	365	0.951
A.I. Services‡	614.4	4	2	307.2	0.500
Pregnancy Check	384	40	3	28.8	0.075
Total				701	1.526

† A total of 1 hour per day
‡ Based on 384 head inseminated an average of 1.6 times
(Randle et al., 1998)

condition of the overall economy. Interest charges for the budgets presented in Table 1 ranged from $34.11 to $137.00 per hd. Interest rates used in calculating interest charges ranged from 5 to 15%. Producers manage interest charges by managing capital purchases and by having heifers calve earlier. As interest rates increase, the importance of an early AFC increases.

Other factors that influence the cost of raising replacements include heifer mortality, number of replacements in the herd, and reproductive management. A 1978-79 survey of 140 South Carolina DHIA herds revealed a calf mortality rate of 19.1% from birth to 6 mo of age with 6.6% dead at birth, 11.2% mortality from birth to 3 mo of age and 1.3% mortality from 3 to 6 mo of age (Jenny et al., 1981). James et al. (1984) reported an overall mortality rate of 7.7% of heifer calf births in Virginia DHIA herds surveyed in 1979. Of the heifer calf births, 1.2% were born dead while 6.5% died from birth to 3 mo of age. Heinrichs et al. (1987) surveyed 329 Pennsylvania farms and determined that overall calf mortality up to one year of age was 8.7% with 5.0% born dead and 3.7% mortality from birth to one year of age.

Mortality rates generally reflect management quality barring some natural disaster. Good management usually results in mortality rates of 5% or less from birth to first calving. Low mortality rates at birth generally indicate good dry cow management, acceptable calving environment, and attention to cattle at parturition. Low mortality rates from 0 to 3 months of age result from good colostrum management, cleanliness and sanitation, attention to detail, and clean, dry, draft-free calf housing. Low mortality rates beyond three months of age result from a good feeding program, a vaccination and de-worming program, and an environment free of hazards, excess mud and manure, and ponds and lagoons. Calf mortality is costly because it delays genetic progress, reduces the number of replacements available for voluntary culling, and may result in the purchase of more replacements (James et al., 1984). When an animal dies, the costs of rearing that heifer from birth until her death must be covered by surviving animals.

Dairy producers can reduce their overall heifer rearing expenses by controlling the size of the replacement herd. The number of replacements needed to maintain herd size is often a function of age at first calving and culling rate. Table 7 shows the effect of age at first calving and culling rate on the number of replacements needed assuming a static herd size of 100 and a combined mortality and culling rate of 10%. As AFC and culling rate increase, so do the number of replacements required. If a 100 cow herd has an AFC of 26 mo and a culling rate of

Table 7. Effect of Age at First Calving and Culling Rate in Number of Replacements Needed to Maintain Static Herd Size.

Cull	Age at First Calving (mo)							
Rate	22	24	26	28	30	32	34	36
20	40	44	48	51	55	59	62	66
22	44	48	52	56	61	65	69	73
24	48	53	57	62	66	70	75	79
26	52	57	62	67	72	76	81	86
28	56	62	67	72	77	82	87	92
30	61	66	72	77	82	88	94	99
32	65	70	76	82	88	94	100	106
34	69	75	81	87	94	100	106	112

(Smith, 1993)

30%, a replacement herd of 72 heifers would be required to maintain herd size. More heifers are needed if a herd is in an expansion mode (Smith, 1993).

Reproductive management impacts heifer rearing expenses. Delays in getting animals bred are costly. A goal of the replacement breeding program may be for heifers to reach puberty at a reasonable age and to have a good heat detection efficiency (>70%), a low number of services per conception (<1.6), and a low abortion rate (<5%) so that heifers calve at 24 months of age. Puberty in dairy heifers is a function of size more than age (Swanson, 1967). The age at onset of puberty is inversely related to growth rate. Larger breeds can be expected to reach puberty at 9 to 11 months of age with an average BW of 250 to 280 kg (Sjersen and Purup, 1997).

Heat detection is an important component of the breeding program when artificially inseminating heifers. Bethard (1997) examined the effects of different levels of heat detection efficiencies in a heifer simulation model. Total rearing costs were reduced by $39.72 per head when heat detection efficiency improved from 40 to 50% and by $16.22 when improved from 50 to 60%. The results emphasized the cost of poor heat detection.

Abortion rates also impact heifer rearing costs. Bethard (1997) determined that the cost of rearing increased by $9.10 for each percent increase in abortion rate. This finding stresses the need for strong reproductive, nutrition, and vaccination programs which are important for preventing abortions.

PROFITABILITY

Dairy producers desire to raise heifers that produce high levels of milk and are profitable. It is necessary to identify characteristics of high producing, profitable heifers when examining the income side of the heifer enterprise profit/loss statement. Age and size at calving as well as growth rates have been shown to influence future profitability of heifers.

Age and Size At First Calving

Much appears in the literature about the age and size of heifers at first parturition. Both age and size are important variables to consider when evaluating the heifer rearing enterprise. Gill and Allaire (1976) used lifetime records from 933 Holstein cows to find that the optimum age at first calving (AFC) for total lifetime performance was 22.5 to 23.5 mo. Milk production, body weight, reproductive performance, herdlife, and prices for feed energy, milk, calves, salvage value, and fixed costs were used to develop a profit function. Profit per day of herdlife was maximized at a 25 mo AFC. Heinrichs (1993) recommended that heifers first calve at 24 months of age with a postcalving weight of 560 to 600 kg. Older heifers are usually less profitable because of increased labor and feed costs and due to delayed income from milk production (Pecsok and Spain, 1992).

Advantages of reduced age at first parturition include reduced feed costs, increased production per day of herd life, decreased overcrowding, increased rate of genetic progress due to a shorter generation interval, increased number of offspring per dam, and lower overhead costs (Heinrichs, 1993; Mourits et al., 1997; Simerl et al., 1991). Disadvantages may include lower conception rates, increased incidence of dystocia, reduced milk production in the first lactation, smaller body size postpartum, reduced longevity, and cost of increased planes of nutrition (Hoffman et al., 1996; Mourits et al., 1997; Simerl et al., 1992). Simerl et al. (1991) concluded that reduced AFC could be achieved without a significant increase in problems at parturition.

While age has been used as the benchmark for calving goals for many years, size is the more critical factor. Inadequate growth prior to calving places the animal at a competitive disadvantage. Undergrown heifers are likely to have limited milk production during the first and second lactations and delayed conception during the first lactation due to competition with herdmates and lack of body reserves (Van Amburgh, 1991). Van Amburgh and Galton (1994) suggested that postcalving BW at first parturition should be at least 82% of mature BW. Holstein heifers with a postcalving BW of 560 to 600 kg would be expected to have the potential to adapt well upon entering the milking herd.

Growth Rates

Maintaining adequate growth rates throughout the heifer's development is important if a heifer is going to enter the milking herd at desired weight and age. A Holstein heifer calving with a prepartum BW of 612 kg at 24 mo of age requires an ADG of 0.78 kg/d assuming a birth weight of 45 kg. This growth rate may be seen as a minimum standard. Pecsok and Spain

(1992) stated that growth rates below 0.82 kg/d are usually not justified economically. Exceptions would include when low cost forages such as pasture are being fed or when the heifer receives extra value for a reduced growth rate at equal BW because of market conditions or a more preferred timing for replacements entering the milking herd.

Rates of gain may impact mammary development. Growth of the mammary gland can be divided into an isometric phase and an allometric phase. The mammary gland undergoes isometric growth when it grows at the same rate as the rest of the body. During the allometric phase, the mammary gland may grow at 1.8 to 3.5 times faster. Allometric growth is observed in the prepubertal heifer from 3 mo of age until puberty and also during gestation. Changes in growth patterns appear to be hormone related and is associated with puberty, pregnancy, and parturition (Sjersen et al., 1982; Van Amburgh and Galton, 1994; VanAmburgh et al, 1991). Heinrichs (1993) recommended an ADG of 650 g/d prior to puberty and 850 g/d for the postpubertal heifer.

Slow growth rates (<.6 kg/d ADG) have numerous consequences. First, slow growth increases the time to breeding as puberty is dependent on size or physiological age more than chronological age. Naturally, an increase in the time to breeding also leads to an increase in the age at calving (Stelwagen and Grieve, 1990; Swanson, 1967; VanAmburgh and Galton, 1993). Slower growth also increases the number of replacements needed to maintain a static herd size and calls for additional inputs to maintain and grow heifers to an older age (Smith, 1993; VanAmburgh and Galton, 1993). For these reasons, researchers began studying accelerated growth (>.9 kg/d ADG). Accelerated growth implies feeding heifers on a high plane of nutrition to increase ADG and reduce AFC. Accelerated growth has been debated much in recent years.

Potential benefits of accelerated growth are breeding at an earlier age, reduced feed costs, and an earlier return on investment (Gardner et al., 1988). However, there are numerous concerns about accelerated growth which include detrimental effects on mammary gland development, overconditioning, and increased incidence of dystocia (Gardner et al., 1988; Sjersen and Purup, 1997; VanAmburgh and Galton, 1993).

Numerous studies have shown a negative effect of accelerated growth on future productivity. Swanson's (1960; 1967) work with pairs of identical twins showed that fattened heifers produced only 85% as much 4% fat corrected milk in the first lactation as those reared on a normal plane of nutrition. Second and third lactations were also negatively affected in the fattened heifers. Little and Kay (1979) conducted a trial using 110 heifers and compared performance of heifers reared for .74 versus 1.0 kg/d ADG from 14 weeks of age to first calving. Milk yield in the rapidly reared heifers was significantly lower in all lactations. It was also noted that udders of the rapidly reared heifers were different from control heifers in size and shape. In general, the udders on the rapidly reared heifers were smaller indicating that accelerated rearing had a detrimental effect on mammary development. Milk production was likely limited due to a reduction in secretory tissue.

Sjersen et al. (1982) examined the effect of nutrition on mammary development by conducting an experiment with prepubertal and postpubertal heifers further divided into two groups. The first group was fed a restricted diet to target a 600 g/d ADG. The second group received ad lib amounts of the same diet and was fed for a 10% weighback. Observed ADG's were 613 and 1218 g/d for the restricted and ad lib groups, respectively. Puberty was reached at 10.8 mo and 258 kg BW on average for the restricted group while the ad lib group did so at 9.7 mo and 278 kg. Heifers fed the ad lib diet during the allometric phase of mammary development showed a decrease in the amount of secretory tissue in the mammary gland at slaughter as compared to those reared at the normal rate. Parenchyma weighed 642 g in the heifers fed the restricted diet versus 495 g in the heifers fed the ad lib diet. Similar results in the postpubertal heifers were not observed indicating that the prepubertal allometric phase is a critical period.

Other studies have shown no negative effects of accelerated growth on future performance (Gardner et al., 1988; Park et al., 1987; Radcliff et al, 1997; VanAmburgh et al., 1998). Gardner et al. (1988) fed 433 Holstein heifers from 6 wk of age to breeding age in two groups. Control animals were fed according to the Beltsville growth standard (Matthews and Fohrman, 1954). Accelerated animals were fed on a higher plane of nutrition and received 3.0 mcal/kg digestive energy versus 2.7 mcal/kg (as-fed) for the control group. Average daily gains from birth to 340 kg BW were 0.78 and 0.89 kg/d for the control and accelerated groups, respectively. Age at first calving for control animals was 24.6 mo while accelerated animals calved at 22.2 mo. There were no treatment effects on milk production during first or later lactations nor differences in calving difficulty between groups.

Radcliff et al. (1997) examined the effects of diet and bovine somatotropin (bST) on growth and mammary development using 40 Holstein heifers. Administration of bST was examined because it increases growth rate, decreases carcass fat, increases mammary parenchymal tissue and decreases mammary adipose tissue (McShane et al., 1989; Moseley et al., 1992; Sjersen et al., 1986; Vestergaard et al., 1993). Bovine somatotropin use is not currently approved for dairy heifers in the US, but may be a useful management tool to improve growth of dairy heifers in the future. Heifers were assigned to one of four groups. Treatments were bST versus no bST and low plane of nutrition (0.8 kg/d ADG) versus high plane (1.2 kg/d ADG). Observed effects of the high diet were increased mean BW gain, decreased age at puberty, increased carcass weight, BW and body condition score at slaughter, and increased total amount of protein and fat in the carcass. Treatment did not effect the total amount of parenchymal DNA. The accelerated diet lowered the cost of rearing the average heifer to breeding age in this study. Although the cost per day for the accelerated heifers was higher than controls ($2.15/d versus $1.76/d), the cost of rearing from 120 d to 363 kg BW was lower ($403.17 versus $ 480.12). Similar results were observed in the accelerated plus bST versus control plus bST groups. Administration of bST had no effect on age at puberty, but increased BW and wither height at puberty. It also increased the percent of carcass protein and water but decreased the percentage of carcass fat. Total amount of parenchymal DNA increased in the bST-treated heifers. Use of bST increased rearing cost from 120 d to postpuberty by $59 for controls and $30 for heifers fed on the high plane of nutrition. Unfortunately, all heifers were slaughtered in the project so the effects on performance was unknown. The authors concluded that growth rates increased and age at puberty decreased without detrimental effects on mammary development when a high protein, high energy diet was fed to dairy heifers.

Van Amburgh et al. (1998) conducted a study with 273 Holstein heifers to examine the effects of prepubertal growth rates on first lactation performance. The prepubertal period was from 90 to 320 kg BW. Target ADG's were 0.6, 0.8, and 1.0 kg/d. Different protein sources were fed but no significant differences were observed relative to them. Observed ADG's were 0.68, 0.83, and 0.94 kg/d for heifers fed for 0.6, 0.8, and 1.0 kg/d ADG, respectively, with AFC of 24.5, 22.0, and 21.3 mo. Accelerated growth increased gains and reduced AFC in this study. The authors claimed that first lactation milk yield did not suffer because of accelerated growth during the prepubertal period. However, actual FCM and 305-d milk yields were significantly decreased by accelerated growth. Yields for the group targeted for 1.0 kg/d ADG averaged 5% less milk than those in the 0.6 kg/d ADG targeted group.

More research is needed to better define acceptable growth in prepubertal heifers. Sjersen and Purup (1997) suggested that negative effects of accelerated growth were not observed in some studies because of short treatment periods, high pretreatment growth rates, small growth rate differences between treatment groups, variation of growth within treatment groups, and/or treatment periods outside the critical period of mammary development. Economics should ultimately decide the accelerated growth debate. Dairy producers need to know if future productivity and profitability of heifers will be sacrificed if heifers are grown too fast during prepubertal development.

Compensatory Growth

Changes in the feed supply and forage quality present challenges in feeding dairy heifers. There are times, particularly when pasture is being utilized, that heifers are fed diets that do not meet the heifers' nutrient requirements for desired rates of gain. According to Park et al. (1987), compensatory growth is a phenomenon that "occurs when previously marginal or underfed heifers are re-alimented on a higher nutritional level." Compensatory growth depends on several factors including the nature of the diet when the animals were under restricted feeding, severity and duration of undernutrition, relative mature BW of the heifer and the pattern of re-alimentation. Greater BW gains, increased efficiency of energy utilization, reduction in maintenance requirements, and enhanced appetitie and feed intake capacity are often observed during compensatory growth (Choi et al., 1997).

Park et al. (1987) conducted an experiment using 20 Holstein heifers in two groups, a control and a test group. Control heifers had a target ADG of 0.45 kg/d. Test heifers were fed in a stair-step pattern of 5, 2, 5, and 2 mo alternating between maintenance and compensatory growth. The maintenance diets were formulated at 15% below NRC requirements and the compensatory diets were balanced at 40% above NRC recommendations for .45 kg/d ADG. Test heifers gained more, consumed less, had higher efficiency of growth and protein and energy utilization, and produced 10% more milk during the first lactation.

Choi et al. (1997) conducted a similar experiment using 24 heifers. A stair-step feeding pattern was used for test animals which alternated feed intake between 20% below controls and 25% above controls for 3, 2, 4, 2, 5, 2 mo. Treatment animals gained more, consumed less dry matter, consumed less concentrates, showed improved growth efficiency, and produced 9% more milk during first lactation with no effect on milk composition as compared to control animals. Treatment had no effect on reproductive parameters of first estrus, first conception, services per conception, or dystocia. Compensatory growth offers the heifer grower an opportunity to make up for lost time when growth has been depressed due to inadequate forage quality and/or quantity.

Growth Monitoring

Average daily gains in the heifer program are comparable to milk production in the milking herd. Dairy producers monitor trends in milk production to evaluate success of nutrition, reproduction, and milking management practices. Growth monitoring is important for measuring success of the heifer rearing program. Body weights and wither or hip heights provide the basic information needed to monitor growth. Hoffman (1997a) stated that BW alone may be the best indication of growth in dairy heifers because of its relationship to first lactation performance and dystocia. Balance scales, electronic scales and weight tapes are most commonly used to obtain heifer weights. It is recommended to use postpartum BW to evaluate weight of first calf heifers at calving. While postpartum BW may be influenced by milk yield, gut fill, and weight loss, prepartum BW will be high due to the fetus and fetal tissue (Hoffman, 1997a). Average daily gains may be calculated once BW data have been collected. Gains may then be compared to goals and recommendations to determine success and identify areas for improvement.

Heifer Simulation

Budgets on dairy heifer enterprises are often difficult to obtain because of a lack of financial information from dairy producers and heifer growers. Heifer simulation models can be helpful in estimating heifer rearing expenses when other information sources are insufficient. Simulation models have been constructed using data sets which estimate growth, nutrient requirements, and consequences of various management decisions (Bethard, 1997; Foster, 1988; Toro, 1987)

Toro (1987) constructed a simulation model to examine the influence of two ages at weaning (6 and 12 wk of age), three breeding strategies (AI, natural service, and seasonal AI), three growth curves (fast, average, and slow rates of gain), and three percentages of pasture utilization (0%, 20%, and 80%) on cost of heifer rearing. Fifty-four systems resulting from all possible combinations of the above factors were examined using 1,000 heifers per system. Delayed weaning resulted in an additional $45 total cost per heifer. Total costs per heifer for the three breeding strategies were $729, $722, and $781 for AI, natural service, and seasonal AI. Rates of gain for the fast, average, and slow groups were 0.65, 0.64, and 0.61 kg/d. Unfortunately, there was little difference in the growth rates used in the simulation. Feed costs per heifers reared under the fast, average, and slow rates of gain were $488, $488, and $504. Labor costs were also higher for those reared under the slower rates of gain. Total costs decreases as the percentage of DM from pasture increased. Total cost per heifer were $799, $758, and $674 for 0%, 20%, and 80% DM from pasture during six months of the year. Toro found that the least expensive system overall combined weaning at 6 wk of age, AI, fast gain, and 80% pasture. Season of birth and calving influenced heifer rearing cost. Rearing cost for heifers born in fall and calved in fall or born in winter and calved in fall was $551 as compared to $776 for heifers born in fall and calved in winter.

Foster (1988) used a microcomputer dairy herd simulation to evaluate the effects of involuntary culling, rate of heifer rearing, and sire selection against dystocia in heifers to determine impacts on net income. Involuntary cull rates used were 12% and 24%. Voluntary cull rates were based on an index of net income for the current lactation which gave some consideration to the pregnancy status of the animal. Heifer rearing resulted in heifers first calving at 26 or 32 mo of age. Sires were randomly selected or were selected for calving ease. Two approaches were taken in the simulation. First, twenty 80-cow herds were simulated for 20 years using 8 combinations of culling, heifer rearing, and sire selection. Cost of rearing heifers to 26 mo of age was $1,030. Foster found that the highest net income and earliest time to payoff of rearing expenses was achieved by calving at 26 mo of age, 12% involuntary culling, and random mating which disregarded dystocia. The second approach used 1,000 cows in a single herd for individual cow simulation using the same 8 combinations outlined above. Using this approach, Foster determined that the cost of heifer rearing was $1,141. Heifers calving at 26 mo cost more to rear by $0.07 per d but paid off more quickly than those calving at 32 mo.

Bethard (1997) used microcomputer simulation to evaluate heifer management strategies. A growth model evaluated six growth strategies: 1) normal growth from 5 wk to calving; 2) accelerated growth from 5 wk to calving; 3) slow growth from 5 wk to calving; 4) normal growth from 5 wk to 14 mo and accelerated growth from 14 mo to calving; 5) accelerated growth from 5 wk to 14 mo and control growth from 14 mo to calving; and 6) slow growth from 5 wk to 14 mo and accelerated growth from 14 mo to calving. Total rearing costs per heifer from birth to first calving for these groups ranged from $1,138 to $1,275. The least expensive rearing program was slow growth from 5 wk to 14 mo and accelerated growth from 14 mo to calving whereas the most expensive was slow growth from 5 wk to calving. The author also examined changing feed costs, heat detection efficiency, death loss, and abortion rate. As expected, increases in feed cost resulted in higher overall costs. Improvements in heat detection efficiency reduced rearing costs. Total cost of heifer rearing was reduced by $39.72 per head when heat detection efficiency improved from 40 to 50%. A decrease of $16.22 was observed when efficiency improved from 50 to 60%. Total rearing cost increased by $2.40 for each percent increase in death loss at birth through weaning. A $9.10 increase per heifer was observed for each percent increase in abortion rate.

Simulations are helpful in estimating the cost of rearing heifers. They assist in evaluating management options by projecting costs and benefits associated with practice changes. However, simulations have limitations as well. Heifer rearing is a complex issue with many factors affecting growth and performance of animals. Some factors are within the control of the producer. Others such as weather are not. A simulation model is only as good as the data upon which the model is based. As more data is incorporated into a model, the more confidence one can have in its predictions.

HEIFER MANAGEMENT SURVEYS

Surveys provide valuable information about management practices implemented in field situations. Numerous surveys have been conducted to ascertain the status of heifer management practices in the US. James et al. (1984) conducted a survey of 407 VA DHI herds in 1978-79 to examine calf mortality. Henrichs et al. (1987a; 1987b) surveyed 329 herds from 33 counties in PA in 1984-85 to investigate calf and heifer management practices and housing. Calf management practices and health management decisions on 46 large dairies in Tulare County, CA, were the foci of the survey conducted by Goodger and Theodore (1986). Karszes and Stanton (1991a; 1991b) studied heifer management practices and costs of 112 NY dairy farms with 80 or more cows and of 34 NY custom heifer growers in 1990. Perhaps the largest calf management study ever conducted was the National Dairy Heifer Evaluation Project (NDHEP). NDHEP was a joint effort of state agriculture departments, Cooperative Extension, National Agricultural Statistics Service, and Animal and Plant Health Inspection Service. This 1991-92 survey included 1,811 herds from 28 states which represented 78% of the US dairy cow population (Heinrichs et al, 1994; Heinrichs et al, 1995; Losinger and Heinrichs, 1996; National Dairy Heifer Evaluation Project, 1993). Jordan and Fourdraine (1993) characterized the management practices of the top milk producing herds in the US. The top 128 herds were identified through the dairy records processing centers and were mailed a survey of management practices. Sixty-one herds responded to the survey conducted in 1992. Highlights of these heifer management surveys follow.

Surveys examined practices associated with heifer management from birth to first calving. Calving location was identified in many of the surveys. Individual stalls and pasture were the predominant calving areas in the NDHEP (1993). The top herds in the US used maternity stalls 63.4% of the time during winter months and 45.0% of the time during the summer (Jordan and Fourdraine, 1993). California herds most frequently used close-up pens whereas PA herds tended to use a combination of pasture and maternity pens (Goodger and Theodore, 1986; Heinrichs et al., 1987a). James et al. (1984) reported that 89% of VA DHI herds surveyed used pasture as a calving area. Calving facilities varied from region to region based on climate and housing types common to the area.

Individual calf hutches were used to house pre-weaned calves by 30.5 and 32.4% of operations surveyed in the NDHEP in winter and summer months, respectively (1993). Heinrichs et al. (1987a) reported that 44.7% of PA dairy herds used calf hutches. Sixty-eight percent of VA DHI herds individually housed calves prior to weaning (James et al., 1984). In contrast, Goodger and Theodore (1986) reported that 76% of the Tulare County, CA herds group housed pre-weaned calves.

Mean weaning ages reported in the surveys ranged from 7.7 to 8.1 wk (Heinrichs et al, 1987b; Heinrichs et al, 1994; James et al., 1984; Karszes and Stanton, 1991b; NDHEP, 1993). Forty-three percent of NDHEP participants used age as a weaning criterion while 26.9% relied on grain intake (1993). PA herds relied most heavily on grain intake with 52.9% using it as a weaning criterion (Heinrichs et al., 1987b).

Water encourages dry matter intake from calf starter in pre-weaned calves. Water was offered pre-weaning to calves in 60.9% of NDHEP herds before 4 wk of age. On average, calves received water at an average age of 25.8 d. Water was available to pre-weaned calves in 75.1 and 86.1% of PA and CA herds, respectively (Goodger and Theodore, 1986; Heinrichs et al., 1987b). A majority of herds offered forage to calves prior to weaning which may hinder intake of calf starter. NDHEP found that 67.6% of operations offered forage to calves prior to 4 wk of age. On average, calves received forage at 23 d of age (Heinrichs et al., 1994; NDHEP, 1993). Forages were offered to calves prior to weaning in 78.3 and 78.7% of farms surveyed in CA and PA, respectively (Goodger and Theodore, 1986; Heinrichs et al., 1987b).

Average AFC was 25.0, 25.9, 26.1, and 26.6 for NY herds, NDHEP, top US herds, and PA herds, respectively (Heinrichs et al., 1987b; Jordan and Fourdraine, 1993; Karszes and Stanton, 1991b; NDHEP, 1993). Powel (1985) analyzed USDA data from 1960 to 1982 and found that AFC increased until 1976 when it started to decline at a rate of three days per year. Ages at first calving for Holsteins and Jerseys in 1982 were 27.31 and 25.93 mo, respectively. Age at first calving has not changed much in recent years. Age at first calving for both Holsteins and Jerseys located in the Southern region of the US was 26 months in October 1997, according to Dairy Records Management Systems in Raleigh, NC. Virginia DHIA herds averaged 28 months for AFC in December 1997. These ages are higher than the 24 mo AFC desired.

Surveys indicate where the industry stands on adoption of management practices and new technology. They allow researchers to establish benchmarks against which future progress may be compared.

CUSTOM REARING

Custom rearing of dairy replacement heifers is an alternative for dairy producers. Heifers may be contracted out to a professional heifer grower or sold to a grower with an option for repurchase at the end of the growing period. Alternative replacement options to home rearing can be risky. Introduction of disease into the herd is one concern (Smith, 1993). Biosecurity issues arise when cattle from more than one farm are co-mingled as is the case with many contract growers. The chances for introducing new disease also increase when one opens the herd by purchasing cattle. A second concern is that the opportunity for service sire selection is often lost, especially with purchased cattle (Smith, 1993). Many heifer rearing contracts allow the owner to maintain control when artificial insemination is practiced. However, some contract situations exist where the grower has complete control of the breeding program. These concerns can be addressed through better knowledge of heifer sources and through the development of a good grower-owner relationship.

Contract Heifer Rearing

Contract heifer rearing offers numerous advantages to the dairy producer. By using a professional heifer grower, the dairy operator can concentrate on milk production and the care of the milking herd. Requirements for land, facilities, labor, and capital may be reduced (Webb, 1992). The National Dairy Heifer Evaluation Project conducted in 1991 found that 1.6% of dairy producers were having their heifers contract reared. Differences among regions of the US were noted. Contract rearing in the West was the greatest at 7.8% with the Northeast, Southeast, and Midwest at 2.4%, 2.1%, and 0.5%, respectively (Heinrichs et al., 1994)

When a dairy producer considers contract rearing, pros and cons must be weighed in the decision making process. Advantages of contract rearing to the heifer owner may include a reduction in labor needs, more time available for working with the milking herd, more space for lactating cows, opportunity to expand the herd without capital investment, more feed available for milking cows, and improvement of heifer quality. Owner disadvantages may include less use for lower quality forages, less control over heifer care, potential difficulties in dealing with a heifer grower, possibly poorer heifers, and existing heifer facilities that may not be fully utilized (Hoffman, 1992a).

Professional heifer growers must weigh similar pros and cons before beginning a business venture. Contract heifer rearing offers a business opportunity, is a chance to use obsolete or unused facilities, is less demanding than milking, and provides a use for forage and grain crops. Disadvantages for the grower may include additional costs for heifer raising facilities, resolving occasional disputes with heifer owners, and demands on time that vary according to heifer needs (Hoffman, 1992a).

The contract is an important instrument to guide the relationship between owner and grower. Surprisingly, Karszes and Stanton (1991a) reported that 75 percent of respondents in their survey of 18 custom heifer growers in New York did not have a written contract. A custom grower contract should contain a list of who is responsible for what items, growth expectations, charge arrangements, length of contract, cancellation of contract, arbitration procedures, rate and method of payment, supplies and services provided, decisions on heifer management practices, identification and records requirements, and liability (Hoffman, 1992a; and Karszes and Stanton, 1991a).

Karszes and Stanton (1991a) compared the operating costs to raise boarded animals and the rates being charged to the dairy producer by 15 New York custom growers. The costs and rates are summarized in Table 8. Total cost per animal per day was $1.29. Variable costs usually represented about 86% of the total costs. Important variable costs to estimate are feed, bedding, health, breeding, trucking, and labor. Forages were largely homegrown and were sold to the heifer enterprise at market value. Feed costs were largest and accounted for 59 to 66 percent of the total with labor accounting for 11 to 22 percent. The average rate charged for boarding heifers was $1.24 per head per day. Given these costs and rates, the average grower was losing $0.05 per head per day. This information stresses the importance of having good financial records and better using those records for determining boarding rates.

Buy-Sell Operations

Some professional heifer growers purchase dairy heifers, rear them, and then resell the animals. Heifers may be sold back to the original owner or in other markets including local dairy producers, out-of-state dairy producers, consignment sales, or export. Some dairy producers enter into an agreement with the grower to sell their heifers to the grower with the first

Table 8. Operating Costs and Rates Charged for Boarding Animals.

Item	$ per day per animal
Rate per day per animal	$1.24
Feed	.79
Bedding	.04
Health	.01
Breeding	.01
Labor	.24
Trucking	.00
Machinery operation	.05
Machinery overhead	.03
Building operation	.02
Building overhead	.07
Death loss	.00
Interest on investment	.02
Total cost per day per animal	$1.29

Karszes and Stanton (1991a)

right of refusal on the repurchase when heifers mature. Buy-sell operations have a greater opportunity for profit if the animal is purchased at a low price and later sold at a high price. Disadvantages of buy-sell operations to the heifer grower include increased risk by owning the animal, larger capital requirements for starting up, price uncertainty when the animal is sold, and higher interest charges due to ownership of the animal (Karszes and Stanton, 1991a). Buy-sell operations are better suited to growers who enjoy taking greater risks and who enjoy marketing cattle.

Custom growing of dairy heifers is likely to increase in Virginia and other parts of the US as dairy producers try to specialize in milk production, increase in herd size, and make best use of limited resources. Professional heifer growers will need to provide quality service at a reasonable cost to encourage dairy producers to take advantage of their services.

CONCLUSIONS

Management of the heifer enterprise is important in the overall scheme of the dairy business. Well-grown heifers enhance a herd's potential for production efficiency and profitability. Dairy producers and professional heifer growers must be aware of production costs to be competitive. Benchmarks are needed for evaluating heifer rearing programs, both from a production and business management standpoint. While DHI and other production record systems are available for production record analysis, more is needed in the financial arena. Costs of heifer rearing can be estimated through producer surveys, projections based on historical data using current prices of inputs, and through simulation modeling. Producers need to know cost to benefit ratios of recommended production practices.

Additional research is needed in the area of heifer growth. Producers need to know what gains are acceptable and economical in all phases of a dairy heifer's development. The costs, benefits, and risks of accelerated growth need to be better defined.

Surveys of heifer management practices provide much information about the status of dairy heifer rearing. Rates of implementation of new technology and production practices can be determined. Success of the technology or practice can be measured with varying degrees of success in a field setting which can validate controlled research experiments. The custom dairy heifer growing industry is relatively new in many parts of the US. A survey of these producers could provide valuable information about business and production practices implemented in these operations.

Hoffman and Funk (1992) outlined several key concepts of replacement heifer management. Rearing cost can be reduced by reducing age at calving. A reduction in the age at calving requires increased planes of nutrition. Prepubertal mammary development and future milk production can be negatively impacted by increased planes of nutrition. Increased calving weight reduces the incidence of dystocia and has a positive effect on milk yield during the first lactation. However, increased calving weight has negative effects on feed efficiency. In short, good heifer management is often a balancing act that requires accurate and current information for decision making.

MATERIALS AND METHODS

NC-119 HEIFER MANAGEMENT SURVEY

The NC-119 Heifer Management Survey was conducted through five research stations participating in the North Central Regional Research Project 119. Participating states were MN, MO, PA, VA, and WA. Virginia served as the lead state for the heifer management survey.

Survey Development

A heifer management survey was developed and tested with 16 herds in VA. This survey was later modified by a NC-119 committee before being distributed to other states. The final version of the survey contained 50 questions (Appendix A). Questions in the survey covered topics associated with replacement management including care of the dam prior to calving, calving facilities, colostrum feeding, pre-weaned calves, replacement herd health, reproductive management, milking management and mastitis prevention, replacement culling practices, records, and nutrition.

Data Collection

Surveys were conducted between June 1992 and May 1995 with the exception of the MO survey which was conducted between November 1996 and January 1997. The method of collecting data varied by state. Surveys were mailed to selected participants in MN and MO. Investigators made farm visits and used personal interviews to collect data in VA and WA. A combination of these two approaches was used in PA. Jersey herds in PA were surveyed via mail whereas Holsteins were surveyed through personal contacts. Table 9 summarizes characteristics of the surveys.

The process for selecting participating herds varied by state. The MN herds were selected on the basis of Rolling Herd Average-Milk (RHAM). Herds were grouped into quartiles according to RHAM. Quartiles were <7,711, 7,711 to 9,071, 9,072 to 10,432, and >10,432 kg RHAM. Herds were then selected randomly from each quartile. Surveys were mailed to 462 herds. In MO surveys were mailed to the top 150 Holstein herds based on RHAM. Surveys were mailed to all PA Jersey herds on the Pennsylvania Jersey Association

Table 9. NC-119 Heifer Management Survey participation summary.

State	Breed	Herds (n)	Time Frame	Survey Method
MN	H	124	August 1994 - May 1995	Mail
MO	H	52	November 1996 - January 1997	Mail
PA	H	21	August 1994 - November 1994	Personal interviews
PA	J	67	March 1994 - April 1994	Mail
VA	H	16	June 1992 - March 1994	Personal interviews
WA	H	13	August 1994 - April 1995	Personal interviews

mailing list. Holstein herds in PA were randomly selected from herds greater than 80 cows in herd size in two counties in Northeast PA. Virginia herds were in an eleven county area from the south central part of the state and were selected on the basis of RHAM. Half of the herds surveyed were above state average RHAM and the other half below. WA herds were selected on profitability estimates from a previous study. Herds were chosen from top, middle, and bottom herds for net income to 48 mo of age. Herds were required to be enrolled in a DHIA testing plan, to rear their own dairy heifers, and to have a milking herd of 200 to 600 cows (Veldman-Edmonds, 1996).

Data Analysis

Separate analyses were conducted for Holstein and Jersey herds. Holstein herds were represented in each of the states participating in the survey whereas Jersey herds were from PA only. Sixty-seven herds were included in the Jersey data set and 226 herds were in the Holstein data set.

Differences in survey responses were examined among Holstein herds by state, calf mortality, herd size, and RHAM. Six categories were used to separate herds by calf mortality: <5.0; 5.0 to 9.9; 10.0 to 14.9; 15.0 to 19.9; 20.0 to 24.9; and 25% and above. These categories were selected because calf mortality rates were divided into meaningful management levels in 5% increments. Calf mortality levels below 5% are considered excellent. Levels below 10% are considered good. Four herd size groups were used: 1 to 50; 51 to 100; 101 to 150; and >150 cows. These groups were chosen to distribute herds into meaningful herd sizes as they related to labor requirements. Herds below 50 cows would likely rely entirely on family labor. Larger herds would require outside labor sources in most operations. Quartiles were used to categorize herds on the basis of RHAM. The quartiles were: <8,188; 8,188 to 8,822; 8,823 to 9,505; and >9,505 kg RHAM. Quartiles were used to compare management practices of the top 25% of producers based on RHAM to other production levels.

Differences in survey responses were examined among Jersey herds by calf mortality, herd size, and RHAM. Three categories were used to separate herds by calf mortality: <10; 10.0 to 19.9; and 20% and above. Three herd size groups were used: 1 to 50; 51 to 100; and >100 cows. Calf mortality groups were combined and the group for herds greater than 150 cows was dropped due to the lower number of herds available in the Jersey data set. Quartiles were used to categorize herds on the basis of RHAM. The quartiles were: <5,829; 5,829 to 6,244; 6,245 to 6,804; and >6,804 kg RHAM.

Continuous and discrete variables were present in the data. Continuous variables included items such as age at weaning and percent of heifers sold for dairy purposes. Discrete variables in the survey were yes/no questions about whether or not a practice was implemented on the farm.

Calf mortality was calculated from survey responses. Respondents were asked for the number of calves born (assuming heifers and bulls), how any were born dead or died within 24 hours, how many died less than 3 mo of age, and how many died greater than 3 mo of age in the last 12 mo. Equations used to calculate mortality values follow.

% born dead = (n calves born dead or died within 24 h)/(n calves born) * 100 (Equation 1)

% deaths <3 mo of age = ((n died <3 mo of age * 2)/(n calves born)) * 100 (Equation 2)

% deaths >3 mo of age = ((n died >3 mo of age * 2)/(n calves born)) * 100 (Equation 3)

n calves died from birth to first calving = (Equation 4)

(n calves born dead or died within 24 h) + (n died <3 mo of age) * 2 + (n died >3 mo of age) * 2

% mortality = (n calves died from birth to first calving)/(n calves born) * 100 (Equation 5)

It was assumed that the number of deaths less than 3 mo of age and greater than 3 mo of age only included heifer calves. Therefore, these variables were multiplied by 2 when calculating % deaths <3 mo of age , % deaths >3 mo of age, and overall mortality. This adjustment was made to account for all calves, assuming a 50:50 heifer to bull ratio.

SAS (SAS, 1996) General Linear Models Procedure (GLM) was used to analyze continuous variables for differences by state, calf mortality rate, herd size, and RHAM. Different models were used for Holstein and Jersey data sets. State was considered an independent variable in all Holstein models, but was not included in the Jersey models because all Jersey herds were from PA. Different mortality and herd size groupings were used for the two breeds. The null hypothesis was that there were no differences in variables by state, calf mortality rate, herd size, and RHAM.

The first model used in the Holstein data set looked for differences by state, calf mortality rate, herd size, and RHAM. The model was

$y_{ijklm} = \mu + STATE_i + MORTPCT_j + HERDSIZE_k + RHAM_l + e_{ijklm}$

where

y_{ijklm} = dependent variable;

μ = overall mean;

$STATE_i$ = effect of the i^{th} state; i = MN, MO, PA, VA, WA;

$MORTPCT_j$ = effect of the j^{th} mortality percent category; j = 1,…,6;

$HERDSIZE_k$ = effect of the k^{th} herd size category; k = 1,…,4;

$RHAM_l$ = effect of the l^{th} RHAM category; l = 1,…,4; and

e_{ijklm} = residual error.

Dependent variables examined using this model were:

- first colostrum timing (h);
- amount of colostrum fed at the first feeding (l);
- amount of colostrum fed during the first day of life (l);
- age when the calf was separated from the dam (d);
- age when grain feeding began (d);
- age when forage was offered pre-weaning (d);
- age when water was offered pre-weaning (d);
- weaning age (wk); and
- goal for age at first calving (mo).

The second Holstein model differed from the previous model because calf mortality rate was excluded. Calf mortality was excluded either because dependent variables were directly related to calf mortality or were variables for which calf mortality relationships would be not be meaningful or expected. This model was

$y_{ijkl} = \mu + STATE_i + HERDSIZE_j + RHAM_k + e_{ijkl}$

where

y_{ijkl} = dependent variable;

μ = overall mean;

$STATE_i$ = effect of the i^{th} state; i = MN, MO, PA, VA, WA;

$HERDSIZE_j$ = effect of the j^{th} herd size category; j = 1,…,4;

$RHAM_k$ = effect of the k^{th} RHAM category; k = 1,…,4; and

e_{ijkl} = residual error.

Dependent variables under this model were:

- calves born (n);
- calves born dead (%);
- calves died less than 3 mo of age (%);
- calves died greater than 3 mo of age (%);
- overall calf mortality (%);
- time in pre-calving group (d);
- additional time allowed before first breeding for first calf heifers (d);
- heifers milked pre-partum (%);
- heifers sold for extra income (%);
- heifers sold for beef (%); and
- time enrolled in the DHI Heifer Management Option (mo).

Another model was constructed to examine differences in herd size by state, calf mortality rate, and RHAM in Holstein herds. This model was

$$y_{ijkl} = \mu + STATE_i + MORTPCT_j + RHAM_k + e_{ijkl}$$

where

y_{ijkl} = herd size;

μ = overall mean;

$STATE_i$ = effect of the i^{th} state; i = MN, MO, PA, VA, WA;

$MORTPCT_j$ = effect of the j^{th} mortality percent category; j = 1,…,6;

$RHAM_k$ = effect of the k^{th} RHAM category; k = 1,…,4; and

e_{ijkl} = residual error.

The final model in the Holstein data set was designed to look for differences in RHAM by state, calf mortality rate, and herd size. This model was

$$y_{ijkl} = \mu + STATE_i + MORTPCT_j + HERDSIZE_k + e_{ijkl}$$

where

y_{ijkl} = RHAM;

μ = overall mean;

$STATE_i$ = effect of the i^th^ state; i = MN, MO, PA, VA, WA;

$MORTPCT_j$ = effect of the j^{th} mortality percent category; j = 1,…,6;

$HERDSIZE_k$ = effect of the k^{th} herd size category; k = 1,…,4;

e_{ijkl} = residual error.

A model was constructed for the Jersey data set to look for differences in dependent variable by calf mortality rate, herd size, and RHAM. The model was written

$$y_{ijkl} = \mu + MORTPCT_i + HERDSIZE_j + RHAM_k + e_{ijkl}$$

where

y_{ijkl} = dependent variable

μ = overall mean;

$MORTPCT_i$ = effect of the i^{th} mortality percent category; j = 1, 2, or 3;

$HERDSIZE_j$ = effect of the j^{th} herd size category; k = 1, 2, or 3;

$RHAM_k$ = effect of the k^{th} RHAM category; l = 1,…,4; and

e_{ijkl} = residual error.

Dependent variables examined using this model were:

- first colostrum timing (h);
- amount of colostrum fed at the first feeding (l);
- amount of colostrum fed during the first day of life (l);
- age when the calf was separated from the dam (d);
- age when grain feeding began (d);
- age when forage was offered pre-weaning (d);
- age when water was offered pre-weaning (d);
- weaning age (wk); and
- goal for age at first calving (mo).

The next Jersey model excluded calf mortality rate either because dependent variables were directly related to calf mortality or were variables for which calf mortality relationships would be not be meaningful or expected. The model used was

$$y_{ijk} = \mu + HERDSIZE_i + RHAM_j + e_{ijk}$$

where

y_{ijk} = dependent variable;

μ = overall mean;

$HERDSIZE_i$ = effect of the i^{th} herd size category; i = 1, 2,or 3;

$RHAM_j$ = effect of the j^{th} RHAM category; j = 1,…,4; and

e_{ijk} = residual error.

Dependent variables examined by this model were:

- calves born (n);
- calves born dead (%);
- calves died less than 3 mo of age (%);
- calves died greater than 3 mo of age (%);
- overall calf mortality (%);
- time in pre-calving group (d);
- additional time allowed before first breeding for first calf heifers (d);
- heifers milked pre-partum (%);
- heifers sold for extra income (%);
- heifers sold for beef (%); and
- time enrolled in the DHI Heifer Management Option (mo).

Differences in Jersey herd size by calf mortality rate and RHAM were examined using the following model:

$$y_{ijk} = \mu + MORTPCT_i + RHAM_j + e_{ijk}$$

where

y_{ijk} = herd size;

μ = overall mean;

$MORTPCT_i$ = effect of the i^{th} mortality percent category; i = 1, 2, or 3;

$RHAM_j$ = effect of the j^{th} RHAM category; j = 1,…,4; and

e_{ijk} = residual error.

The last Jersey model was designed to look for difference in RHAM by calf mortality rate and herd size. This model was

$y_{ijk} = \mu + MORTPCT_i + HERDSIZE_j + e_{ijk}$

where

y_{ijk} = RHAM;

μ = overall mean;

$MORTPCT_i$ = effect of the i^{th} mortality percent category; i = 1, 2, or 3;

$HERDSIZE_j$ = effect of the j^{th} herd size category; j = 1,…,4;

e_{ijk} = residual error.

Herds were included in the respective data sets if there were no missing values for the variables in the model. A level of P<0.05 was used to determine significance. Tukey's procedure was used to detect differences in least squares means (LSMEANS) for states. Harmonic means for n were used in the calculation of the standard error of differences between treatment means because the number of observations were different for each state. The harmonic means kept a state with a disproportionately large sample size from having too much influence in the SE calculation. Linear and quadratic contrasts were used to look for trends in dependent variables with changing levels of calf mortality, herd size, and RHAM.

SAS (SAS, 1996) procedure PROC FREQ was used to analyze discrete variables. Chi squares were used to detect significant differences among states, calf mortality rates, herd size and RHAM. A level of P<0.05 was used to determine significance.

SAS (SAS, 1996) procedure PROC REG was used to determine what management practices most affected calf mortality in Holstein herds in the NC-119 data set. Variables included in the full model were management practices that could potentially influence calf mortality. Variables included can be categorized in the following groups:

- calving facilities and bedding;
- colostrum management;
- age at separation from the dam;
- calf feeders;
- calf housing and bedding;
- calves suckling each other pre-weaning;
- weaning decision criteria;

- dam and heifer vaccinations;
- deworming;
- coccidiostat/coccidiocide usage; and
- heifer access to ponds and lagoons.

Producers reported calving facilities for the milking herd and for first calf heifers. Responses were the same on most farms. Therefore, calving facilities were combined into single variables for each facility to indicate whether or not a particular calving facility was used by either the milking herd or first calf heifers on each farm. Producers also identified calf housing types used during summer and winter seasons. Most herds were consistent in their use of calf housing across seasons, so calf housing choices were combined into single variables for each type of calf housing to indicate whether or not the type of calf housing was used in winter and/or summer seasons.

The full model contained 67 independent variables. PROC REG was run with backward and MAXR options. The purpose of the backward selection process was to eliminate nonsignificant variables from the model. Variables were allowed to stay in BACKWARD selection at $P<0.05$. Significant variables from backward selection were then used in MAXR selection to construct the best model. Models derived from backward and MAXR selection were compared on the basis of significance level, R-square, and C(p). The preferred model would be significant at $P<0.05$. R-square which indicates the amount of variation explained by the independent variables would be high. The C(p) statistic is an indicator of bias and tells whether a model is over- or underspecified. The best model would have C(p) approaching but not exceeding p where p is the number of variables in the model including the intercept.

VIRGINIA CUSTOM DAIRY HEIFER REARING SURVEY

Survey Development

The Virginia Custom Dairy Heifer Rearing Survey was developed to characterize the custom heifer grower industry in Virginia. The survey consisted of 53 questions. Most questions in the survey were applicable to both heifer growers who contract with dairy producers and those who buy and sell heifers, but special sections were also included to further characterize each group. Survey questions covered the following areas:

- general herd description;
- heifer inventory;
- records;
- labor;
- pre-weaned calves;
- replacement herd health;
- nutrition and feeding;
- monitoring heifer growth;
- reproductive management; and
- replacement herd culling practices.

A copy of the survey is attached in Appendix B.

Data Collection

Professional dairy heifer growers in Virginia were identified through contacts with dairy producers, dairy industry personnel, extension agents and specialists, and other heifer growers. Twenty-four growers were selected to complete the survey on the basis of their willingness to participate. Surveys were completed during on-farm interviews between November 1996 and March 1998.

Data Analysis

Information collected through the custom grower survey was summarized using a computer spreadsheet. Means and frequencies were calculated within the spreadsheet. More advanced statistical analyses were not used because of the small sample size and lack of performance measures such as ADG or AFC.

RESULTS AND DISCUSSION

NC-119 HEIFER MANAGEMENT SURVEY - HOLSTEIN HERDS

The NC-119 Heifer Management Survey included 226 Holstein herds from 5 states. These herds were examined for differences in management practices based on state, calf mortality rate, herd size, and rolling herd average for milk (RHAM). Number of herds with reported values for calf mortality, herd size, and RHAM were 158, 221, and 205, respectively. PA herds were excluded from calf mortality comparisons because each of the 21 herds had incomplete calf mortality data.

Table 10 contains means for herd size and RHAM for survey herds and DHI herds at the time of data collection in each state. Survey herds were larger than their state average counterparts and also had higher milk production. Average herd size was 94.5 cows and ranged from 20 to 712 cows with an average of 100.9 calves born in the past 12 mo. Mean RHAM was 8,838 kg. RHAM was not significantly different by state or herd size in the survey. However, there were differences by calf mortality rate. Herds in the lowest mortality groups had the highest RHAM. This relationship has been previously documented. James et al. (1984) reported a negative correlation of .16 between rolling herd average for milk and fat and calf mortality. Jenny et al. (1981) found that calf mortality declined from 23.0 to 12.0% as rolling herd average fat increased from less than 200 kg to greater than 264 kg. Herds with better management would be expected to have healthier calves and higher milk production.

Overall calf mortality was 15.3%. Mortality rates for calves born dead or died within 24 h, died less than 3 mo of age, and died greater than 3 mo of age were 7.5, 5.8, and 2.0%, respectively. Significant differences were not observed by state, herd size, or RHAM. Overall calf mortality was within ranges reported by others. However, percent of calves born dead or died within 24 h was higher than previously reported. James et al. (1984) reported calf mortality up to 3 mo of age at 7.7% in VA DHI herds. Calves born dead accounted for 1.2% of heifer calf births. PA herds averaged 8.7% mortality up to one year of age with 5.0% still births (Heinrichs et al., 1987). SC herds had higher calf mortality rates. Overall calf mortality was 19.1%. Calves born dead accounted for 6.6% of births (Jenny et al., 1981).

Table 10. Means for herd size and RHAM for survey herds and DHI herds at the time of the survey by state.

	Herd Size (cows)		RHAM (kg)	
State	Survey Herds	State Average	Survey Herds	State Average
MN	66	56	8,711	8,225
MO	85	81	9,018	7,441
PA	97	NA	8,399	7,489
VA	133	118	8,342	8,106
WA	344	214	10,398	9,980

NA = not available.

Regression analysis of factors associated with calf mortality revealed three factors that had a significant effect. The following equation was generated using backward and MAXR selection in the PROC REG procedure:

Overall calf mortality (%) = 23.1 - 6.0 MPSEP + 18.4 FSMH - 6.5 BRUC (EQUATION 6)

where

MPSEP = maternity pens housed separately from the milking herd used as a calving facility (0 = no; 1 = yes);

FSMH = free stalls housed with the milking herd used as a calving facility (0 = no; 1 = yes); and

BRUC = calfhood vaccination against brucellosis (0 = no; 1 = yes).

This model was significant at $P<0.0001$, but explained only 21.6% of variation in calf mortality rate. Calf mortality is complex and can be affected by many factors on the dairy farm. Individual practices that have a large impact on calf mortality are difficult to identify.

Herds using maternity pens housed separately from the milking herd for the calving area generally had lower calf mortality rates. In contrast, calf mortality increased by 18.4% if cows calved in a free stall barn with the milking herd. These results emphasize the importance of a separate facility for calving. Separation from the milking herd should reduce exposure to disease pathogens. General sanitation in a separate facility may also be better due to less cattle traffic.

Vaccination for brucellosis appeared in the model and was associated with lower calf mortality. Calves are vaccinated against brucellosis between 4 and 12 mo of age. Highest calf mortality rates are usually for calves less than 3 mo of age. Therefore, this term most likely entered the equation as an indicator of overall management, not because of a direct effect from the vaccination.

Care of the Dam

Sixty-one percent dewormed the milking herd. Only 31.3% of VA producers in the survey reported deworming, lowest among the five states. Producers in VA have been discouraged from deworming the milking herd by veterinarians in the Virginia-Maryland Regional College of Veterinary Medicine. These veterinary educators felt the practice was unnecessary. Percent of herds vaccinating against leptospirosis, IBR, and BVD were 92.4, 92.9, and 92.4%. These rates were higher than those reported by Heinrichs et al. (1987). Percent of PA herds in their study vaccinating against leptospirosis, IBR, and BVD were 60.2, 68.1, and 52.3%. Tables 11 and 12 report the percent of herds vaccinating against these diseases by herd size and RHAM, respectively. Herds less than 50 cows had lower vaccination rates than larger herds. As herd size increases, disease problems present a greater risk to cattle, particularly if facilities are overcrowded. Vaccination programs are not a cure-all but provide risk protection. Herds in the bottom RHAM quartile tended to have lower vaccination rates than higher producing herds which may have been indicative of overall management quality.

Body condition scoring of dry cows was practiced by 40.5% of the herds. The highest production group was most likely to use body condition scoring, but differences were not significant. Body condition scoring is another tool for fine-tuning feeding management.

Calving Facilities

Calving facility choices for the milking herd and heifers are shown in Table 13. Some producers used more than one type of facility for calving and may have used different facilities during different seasons. Pasture and maternity pens located either with or separate from the milking herd were the major calving facilities used for milking and replacement animals. Significant differences were observed by state and RHAM. Some state differences were due to climate and some were due to housing types more common to the region. Herds in MO and VA relied most heavily on pasture as a calving location. Herds in WA were more likely to use maternity stalls due to larger herd size and wet weather conditions. PA herds were most likely to use stanchions or tie stalls which are more common in the Northeast US, particularly in smaller herds. Calving facilities used by Holstein herds for milking and replacement animals by state are found in Table 14.

Several trends were observed concerning calving facility choices and level of milk production. As level of milk production increased, use of pasture as a calving location decreased while use of maternity pens housed separately from the milking herd increased. Higher producing herds were also less likely to use stanchions or tie stalls for calving. Table 15 contains calving facility choices based on RHAM. Pasture is considered a good calving area if

Table 11. Percent of Holstein herds vaccinating the dam against leptospirosis, IBR, and BVD by herd size.

	Herd Size (cows)			
Disease	1-50	51-100	101-150	>150
Leptospirosis[1]	85.7	94.7	100.0	96.8
IBR[1]	85.7	97.4	97.2	96.8
BVD[1]	85.7	95.1	97.2	96.8

[1] At least one pair is significantly different (P<0.05).

Table 12. Percent of Holstein herds vaccinating the dam against leptospirosis, IBR, and BVD by RHAM.

	RHAM Quartile[1]			
Disease	1	2	3	4
Leptospirosis[2]	84.6	98.0	86.3	100.0
IBR[2]	82.7	98.0	94.1	98.0
BVD[2]	82.7	98.0	92.2	98.0

[1] Quartile 1 = 3,334 to 8,187 kg;
Quartile 2 = 8,188 to 8,822 kg;
Quartile 3 = 8,823 to 9,505 kg;
Quartile 4 = 9,506 to 11,778 kg RHAM.
[2] At least one pair is significantly different (P<0.05).

Table 13. Calving facility choices for milking and replacement animals in Holstein herds.

Calving Facility	Milking Herd[1]	Heifers[1]
	----------- % of herds ------------	
Pasture	38.5	50.5
Dry lot	10.2	17.0
Maternity pens - housed with milking herd	23.5	27.7
Maternity pens - housed separately	27.0	29.5
Stanchions or tie stalls	15.0	16.1
Free stall area - housed with milking herd	2.7	0.9
Free stall area - not housed with milking herd	0.9	2.2
Loose housing area	14.2	22.3

[1] Column totals exceed 100% because some producers used more than one type of calving facility.

Table 14. Calving facilities used by Holstein herds for milking and replacement animals by state.

	State				
Calving Facility	MN[1]	MO[1]	PA[1]	VA	WA[1]
	---------------- % of herds in state----------------				
Milking Herd					
Pasture[2]	29.8	53.9	28.6	93.8	7.7
Dry lot	9.7	13.5	14.3	0.0	7.7
Maternity pens - housed with milking herd[2]	28.2	15.4	42.9	0.0	7.7
Maternity pens - housed separately[2]	29.0	26.9	4.8	6.3	69.2
Stanchions or tie stalls[2]	18.6	0.0	52.4	0.0	0.0
Free stall area - housed with milking herd	3.2	0.0	9.5	0.0	0.0
Free stall area - not housed with milking herd	0.8	1.9	0.0	0.0	0.0
Loose housing area	16.1	17.3	0.0	0.0	23.1
Heifers					
Pasture[2]	46.8	58.0	38.1	93.8	23.1
Dry lot	22.6	12.0	14.3	0.0	7.7
Maternity pens - housed with milking herd[2]	35.5	16.0	38.1	0.0	15.4
Maternity pens - housed separately[2]	31.5	34.0	0.0	6.3	69.2
Stanchions or tie stalls[2]	18.6	2.0	57.1	0.0	0.0
Free stall area - housed with milking herd	1.6	0.0	0.0	0.0	0.0
Free stall area - not housed with milking herd	0.8	6.0	4.8	0.0	0.0
Loose housing area[2]	25.8	32.0	0.0	0.0	15.4

[1] Column totals for the milking herd and heifers exceed 100% because some producers used more than one type of calving facility.
[2] At least one pair is significantly different (P<0.05).

Table 15. Calving facilities used by Holstein herds for milking and replacement animals by RHAM.

	RHAM Quartile[1,2]			
Calving Facility	1	2	3	4
	------------% of herds in RHAM quartile---------			
Milking Herd				
Pasture[3]	50.0	51.0	41.2	21.6
Dry lot	7.7	9.8	13.7	7.8
Maternity pens - housed with milking herd	17.3	17.7	29.4	27.5
Maternity pens - housed separately[3]	13.5	29.4	19.6	45.1
Stanchions or tie stalls[3]	28.9	3.9	11.8	7.8
Free stall area - housed with milking herd	5.8	3.9	2.0	0.0
Free stall area - not housed with milking herd	1.9	2.0	0.0	0.0
Loose housing area	13.5	11.8	11.8	17.7
Heifers				
Pasture[3]	69.2	54.9	53.1	35.3
Dry lot	19.2	17.7	20.4	5.9
Maternity pens - housed with milking herd	25.0	21.6	26.5	35.3
Maternity pens - housed separately[3]	11.5	39.2	26.5	41.2
Stanchions or tie stalls[3]	36.5	5.9	10.2	5.9
Free stall area - housed with milking herd	1.9	2.0	0.0	0.0
Free stall area - not housed with milking herd	3.9	2.0	4.1	0.0
Loose housing area	17.3	31.4	18.4	19.6

[1] Quartile 1 = 3,334 to 8,187 kg;
Quartile 2 = 8,188 to 8,822 kg;
Quartile 3 = 8,823 to 9,505 kg;
Quartile 4 = 9,506 to 11,778 kg RHAM.

[2] Column totals for the milking herd and heifers exceed 100% because some producers used more than one type of calving facility.

[3] At least one pair is significantly different ($P<0.05$).

it has good sod cover, is gently sloped, and is located in a conspicuous place for frequent observation of cattle. Many herds do not have land resources near the dairy center for pasture to be a reasonable choice. Pens away from the milking herd are considered advantageous from a disease prevention standpoint.

A clean calving area is important to prevent the spread of disease. Clean, dry bedding is a critical part of the calving environment. Straw was the most commonly used bedding material. No bedding was used on some farms, but those herds relied almost solely on pasture as a calving area. Differences in bedding were observed by state and herd size. Straw was the major bedding in MN and MO while PA herds relied more on hay and wet sawdust. VA herds used little bedding because of their reliance on pasture. WA herds bedded with straw and kiln-dried sawdust most frequently. Producers generally choose bedding materials based on cost and availability. Larger herds relied less on straw as a bedding source and more on kiln-dried sawdust. Bedding sources are shown by state in Table 16 and by herd size in Table 17.

Colostrum Feeding

Colostrum management is essential to the health of the calf after birth. Timing, quantity, and quality of colostrum are three critical elements in the transfer of immunity to the calf. Survey herds reported that calves received first colostrum at 3.5 h of age. Calves received 2.3 L of colostrum at first feeding and 4.2 L during the first day of life. This quantity was adequate according to Heinrichs et al. (1990) who recommended that calves receive 3.8 to 5.7 L of colostrum per day for the first three days of life, not to exceed 10% of the calf's BW. First colostrum should be fed within the first hour of life. Heinrichs et al. (1987) reported that PA producers fed 2.7 L of colostrum during the first 24 h of life and that average time after birth to colostrum feeding was 2.7 h. Significant differences were found in the amount of colostrum fed during the first day of life by calf mortality rate. Calves from herds in the two low mortality groups received less than those with higher rates. There were no significant differences in the quantity fed during the first feeding. Fifty-one percent of herds reported that the dam's udder was washed prior to calves suckling or colostrum being milked. As herds increased in size, workers were less likely to wash the dam's udder before the calf nursed.

Table 16. Use of bedding materials in Holstein calving facilities by state.

	State				
Bedding Material	MN[1]	MO[1]	PA[1]	VA	WA[1]
	% of herds				
Straw[2]	78.2	69.2	14.3	12.5	61.5
Hay[2]	3.2	7.7	47.6	0.0	0.0
Wet Sawdust[2]	0.8	0.0	47.6	0.0	15.4
Kiln dried sawdust[2]	13.1	7.7	0.0	0.0	69.2
Dry manure[2]	0.0	0.0	0.0	0.0	7.7
Newspaper	4.8	0.0	0.0	0.0	0.0
Corn stalks	8.9	1.9	0.0	0.0	0.0
No bedding used[2]	2.4	25.0	0.0	87.5	0.0

[1] Column total exceeds 100% because some producers used more than one bedding material.
[2] At least one pair is significantly different (P<0.05).

Table 17. Use of bedding materials in Holstein calving facilities by herd size.

	Herd Size (cows)[1]			
Bedding Material	1-50	51-100	101-150	>150
	% of herds			
Straw[2]	84.6	52.6	66.7	38.7
Hay	6.4	14.5	5.6	0.0
Wet Sawdust[2]	0.0	6.6	13.9	9.7
Kiln dried sawdust[2]	11.5	9.2	13.9	38.7
Dry manure	0.0	0.0	0.0	3.2
Newspaper	1.3	4.0	2.8	3.2
Corn stalks	3.9	5.3	8.3	6.5
No bedding used[2]	5.1	18.4	11.1	22.6

[1] Column totals exceed 100% because some producers used more than one bedding material.
[2] At least one pair is significantly different (P<0.05).

Most producers in the survey assisted the calf in receiving colostrum. The calf was allowed to nurse the dam without assistance in 28.9% of herds. Colostrum was fed by bucket or bottle, esophageal feeder, and assisted feeding from the dam in 72.0, 16.0, and 5.3% of herds, respectively. Colostrum was fed through unassisted nursing, assisted nursing, bucket or bottle, and esophageal feeder by 13.8, 19.9, 64.0, and 2.3% of NDHEP herds (Heinrichs et al., 1994). In the NC-119 survey, herds were less likely to rely on the calf to nurse the dam as RHAM increased. Table 18 shows the shift in colostrum feeding method from nursing to bucket or bottle in the higher RHAM groups. Surprisingly, no trends were seen in calf mortality rates based on method of colostrum feeding. The percentages of herds that allowed the calf to nurse the dam were significantly different, but herds in the low mortality groups were just as likely to allow nursing as those in the high mortality groups. Calves were separated from the dam at 0.4 d of age on average. Sixty-eight percent of NDHEP herds separated calves from the dam within the first 12 h.

Colostrum may be frozen and stored for later use. Immunoglobulins critical for development of the calf's immune system remain viable as long as colostrum is properly thawed. It is often recommended to store colostrum from older cows for emergency use later should the dam of the calf have milk fever or severe mastitis, become paralyzed due to dystocia, or die. Colostrum was frozen by 48.2% of herds, higher than the 22.8% reported in PA by Heinrichs et al. (1987). Of those herds, 78.1% used frozen colostrum for problem cases. Eighteen percent fed frozen colostrum to offspring of first calf heifers while 8.6% fed all calves frozen colostrum.

Grain, Forage and Water for Pre-Weaned Calves

Producers started offering grain to calves at 7.6 d of age. Forage was offered to calves pre-weaning in 51.6% of herds at an average age of 17.1 d. Significant differences were found between states, herd size, and RHAM for the percent of herds offering forage, but not age. PA herds were the most likely to offer forage pre-weaning while MN and MO herds were the least likely. Percent of herds offering forage dropped as herd size increased. A trend was less clear for RHAM, but herds in the lowest production group fed forage more than the other groups. Grain intake will not increase as rapidly if forage is fed, thus resulting in delayed weaning if grain intake is used as a weaning criterion. Fiber is needed to stimulate rumen development in

Table 18. Method of colostrum feeding in Holstein herds by RHAM.

	RHAM Quartile[1,2]			
Feeding Method	1	2	3	4
	--------------- % of herds in RHAM quartile---------------			
Nurse[3]	42.3	39.2	27.5	16.0
Assist feeding from dam	7.7	7.8	3.9	4.0
Bucket/bottle	63.5	64.7	72.6	80.0
Esophageal feeder	7.7	21.6	11.8	24.0

[1] Quartile 1 = 3,334 to 8,187 kg;
Quartile 2 = 8,188 to 8,822 kg;
Quartile 3 = 8,823 to 9,505 kg;
Quartile 4 = 9,506 to 11,778 kg RHAM.
[2] Column totals exceed 100% because some producers used more than one feeding method.
[3] At least one pair is significantly different ($P<0.05$).

the young calf and can be supplied with calf starter. Forages are not necessary for young calves and can be wasteful and labor intensive to feed.

Water was offered to calves pre-weaning in 70.1% of herds at an average age of 14.2 d. Free choice water was offered to calves in NDHEP herds at an average age of 25.8 d (Heinrichs et al., 1994). In the current survey, only one third of the PA herds made water available pre-weaning whereas all of the WA herds did. Herds over 150 cows were most likely to provide water pre-weaning. Ad libitum water for pre-weaned calves encourages higher dry matter intake from grain which ultimately should lead to an earlier weaning age.

Calf Housing

Calf hutches were the most popular housing type for calves in survey herds. Fifty-one percent used hutches in summer and 48.9% used them during winter. Use of calf hutches was more frequent in higher producing herds. Individual pens in separate barns ranked second. Herds using individual stalls in dairy barns had overall calf mortality rates below 20%. Producers may have spent more time around calves housed in the dairy barn and, therefore, more readily detected early signs of sickness or disease. Less than 10% of herds used any elevated stall. Herds using elevated metal stalls tended to be in the higher mortality groups. Table 19 summarizes Holstein calf housing for summer and winter months. Table 20 shows calf housing differences by state by season. Producers did not specify whether calves that were tied were indoors or outside.

Straw was the most popular bedding material for calves and was used by 75.2% of herds. Calves were bedded with sawdust or wood shavings, corn cobs or stalks, newspaper, and sand by 21.4, 6.7, 4.8, and 1.0% of herds, respectively. MN and MO herds used straw more extensively while PA and WA herds relied more on wood products. No significant differences in mortality rate were observed between bedding sources. However, herds in the lowest mortality group made heavy use of straw as a bedding material, but did not use sawdust or wood shavings. Use of straw tended to decline as herd size increased, whereas use of sawdust or wood shavings increased.

Table 19. Holstein calf housing for summer and winter months.

Housing Type	Summer[1]	Winter[1]
	------------ % of herds ------------	
Hutches	51.2	48.9
Group pens - outdoors	7.4	3.6
Group pens - indoors, dairy barn	11.1	13.3
Group pens - indoors, separate barn	14.3	16.9
Elevated stalls - wood, dairy barn	0.9	8.9
Elevated stalls - wood, separate barn	1.8	1.8
Elevated stalls - metal, dairy barn	0.5	0.4
Elevated stalls - metal, separate barn	2.3	2.2
Individual pens, dairy barn	7.8	9.3
Individual pens, separate barn	24.9	28.9
Tied	12.4	12.9
Other	0.5	0.4

[1] Column total exceeds 100% because some producers used more than one housing type.

Table 20. Calf housing used by Holstein herds by state by season.

Calving Facility	State				
	MN[1]	MO[1]	PA[1]	VA	WA[1]
	------------------ % of herds in state-----------------				
<u>Summer</u>					
Hutches[2]	54.7	60.0	19.1	37.5	53.9
Group pens - outdoors	8.6	10.0	0.0	0.0	7.7
Group pens - indoors, dairy barn[2]	17.1	4.0	4.8	0.0	7.7
Group pens - indoors, separate barn[2]	20.5	12.0	0.0	0.0	7.7
Elevated stalls - wood, dairy barn	0.9	0.0	4.8	0.0	0.0
Elevated stalls - wood, separate barn	0.9	4.0	0.0	0.0	7.7
Elevated stalls - metal, dairy barn	0.9	0.0	0.0	0.0	0.0
Elevated stalls - metal, separate barn	3.4	2.0	0.0	0.0	0.0
Individual pens, dairy barn	7.7	10.0	4.8	0.0	15.4
Individual pens, separate barn[2]	18.0	23.0	9.5	62.5	38.5
Tied[2]	4.3	10.0	71.4	12.5	0.0
Other	0.9	0.0	0.0	0.0	0.0
<u>Winter</u>					
Hutches[2]	50.8	58.8	19.1	37.5	53.9
Group pens - outdoors	3.2	5.9	0.0	0.0	7.7
Group pens - indoors, dairy barn	19.4	7.8	4.8	0.0	7.7
Group pens - indoors, separate barn[2]	22.6	17.7	0.0	0.0	7.7
Elevated stalls - wood, dairy barn	0.8	0.0	4.8	0.0	0.0
Elevated stalls - wood, separate barn	0.8	3.9	0.0	0.0	7.7
Elevated stalls - metal, dairy barn	0.8	0.0	0.0	0.0	0.0
Elevated stalls - metal, separate barn	3.2	2.0	0.0	0.0	0.0
Individual pens, dairy barn	9.7	11.8	4.8	0.0	15.4
Individual pens, separate barn[2]	22.6	39.2	9.5	62.5	38.5
Tied[2]	6.5	7.8	71.4	12.5	0.0
Other	0.8	0.0	0.0	0.0	0.0

[1] Column totals for the summer and winter exceed 100% because some producers used more than one type of calving facility.
[2] At least one pair is significantly different ($P<0.05$).

Calf Feeders

Calves were fed by the owner on 46.4% of farms. Spouses, hired help, children, and herdsmen fed calves on 36.6, 16.0, 13.9, and 3.6% of farms. The NDHEP (1993) identified calf feeders as operators, spouses, children, hired help, and others in 48.4, 24.3, 15.3, 8.2, and 3.8% of operations. Table 21 contains calf feeders by herd size. The spouse fed calves less and herdsmen and hired help fed more in herds over 150 cows. One would expect that as herd size increases beyond 150 cows, labor to feed calves would come less from family and more from outside labor.

Table 22 summarizes calf feeders by calf mortality. A significant difference was detected in the percent of herds with a child as the calf feeder, but children were just as likely to feed calves in herds with mortality greater than 25% as in herds with mortality below 5%. This result is not surprising given the general nature of children. Some children are more careful about their work while others rush to get their chores done. Hartman et al. (1974) reported that spouses were the most successful calf feeders in terms of calf mortality followed by children, owners, and hired help. Mortality was lower in SC herds when the owner or other members of the family fed calves (Jenny et al., 1981). James et al. (1984) found that calf mortality was lowest in VA herds when wives or children fed calves.

Weaning

Average age at weaning was 7.6 wk which was slightly lower than several previous studies which reported mean ages at weaning from 7.7 to 8.1 wk (Heinrichs et al., 1987; James et al., 1984; NDHEP, 1993). There were significant differences in weaning age by state. Least squares means for weaning age were 6.6, 7.1, 7.8, and 9.4 wk for MN, MO, VA, and WA herds. Pennsylvania herds were not included because of incomplete calf mortality data in the model which included state, calf mortality rate, herd size, and RHAM. Significant differences by calf mortality rate, herd size, and RHAM were not detected. Age and grain intake were the predominant criteria used in making weaning decisions. Weaning decisions were made based on grain intake by 57.6% of farms, age by 54.8%, and size by 31.3%. Less than 4% cited other miscellaneous criteria such as space restrictions. The percentage total exceeds 100% because some producers used a combination of factors in their decision. Forty-three percent of NDHEP

Table 21. Calf feeders in Holstein herds by herd size.

Calf feeder	Herd Size (cows) [1] 1-50	51-100	101-150	>150
	% of herds in herd size			
Owner	53.3	37.9	48.2	44.4
Spouse[2]	37.7	43.1	40.7	11.1
Child	15.6	13.8	7.4	11.1
Herdsman[2]	2.6	0.0	3.7	14.8
Hired help[2]	7.8	13.8	11.1	51.9
Other	2.6	12.1	3.7	3.7

[1] Column totals exceed 100% because some producers reported more than one calf feeder.
[2] At least one pair is significantly different (P<0.05).

Table 22. People responsible for feeding calves in Holstein herds by calf mortality rate.

Calf Feeder	Mortality Rate[1] <5%	5.0 - 9.9%	10.0 - 14.9%	15.0 - 19.9%	20.0 - 24.9%	≥25%
	% of herds in mortality rate					
Owner	60.0	57.5	39.5	23.5	41.2	58.3
Spouse	40.0	27.5	44.7	47.1	35.3	33.3
Child[2]	33.3	10.0	5.3	5.9	0.0	33.3
Herdsman	0.0	2.5	5.3	11.8	0.0	0.0
Hired help	0.0	20.0	26.3	17.7	23.5	8.3
Other	6.7	0.0	2.6	11.7	11.8	12.5

[1] Column totals exceed 100% because some producers reported more than one person responsible for feeding calves
[2] At least one pair is significantly different (P<0.05).

herds claimed that age was the main weaning criterion followed by grain intake (26.9%), weight (26.4%) and other factors (3.7%) (NDHEP, 1993).

Health

Producers were asked to select the most prominent disease problem among calves on their farms. Digestive problems were cited by 67.8% while 29.6% claimed that respiratory problems were greatest. A PA survey ranked scours as the number one problem in pre-weaned calves and ranked respiratory problems second (Heinrichs et al., 1987). Percent of herds vaccinating against brucellosis, IBR, BVD, PI3, BRSV, leptospirosis, and virus calf scours are found in Table 23 along with comparative data from NDHEP and PA surveys. The NC-119 Holstein herds had higher vaccination rates for all diseases except brucellosis which was comparable to the other surveys (Heinrichs et al., 1987; NDHEP, 1993). Tables 24 and 25 show percent of herds vaccinating against these diseases by herd size and RHAM. Significant differences were noted between herd size groups for brucellosis, IBR, BVD, PI3, and leptospirosis vaccinations. Herds less than 50 cows had the lowest vaccination rate for each of the diseases. Differences in RHAM quartiles were detected for vaccination against brucellosis, IBR, BVD, BRSV, and virus calf scours. The trend was for vaccination against these diseases to increase as RHAM increased. Heifers were dewormed on 68.2% of farms. Similar rates were recorded by Heinrichs et al. (1987) and NDHEP (1993). Over 87% of MO and VA herds had a deworming program. Producers in these states rely more heavily on pasture for heifers than the larger herds in WA which had the lowest implementation at 53.9%.

Coccidiostats and coccidiocides were used on 77.2% of farms, a much higher percentage than the 16.4 and 37.8% reported by Heinrichs et al. (1987) and NDHEP (1993), respectively. Significant differences were detected by calf mortality rate. Herds in the lowest (<5%) and highest (25% and above) mortality groups were least likely to use coccidiostats or cocciciocides with less than 70% of herds in those groups using these products as compared to greater than 82% for the other groups. This trend is difficult to explain. However, producers in the lowest mortality group may be better managers who use coccidiostats and coccidiocides as a tool when necessary, but rely on good management practices and attention to details to keep mortality rates

Table 23. Percent of herds vaccinating against brucellosis, IBR, BVD, PI3, BRSV, Leptospirosis, and virus calf scours in NC-119 Holstein herds, National Dairy Heifer Evaluation Project, and Survey of Calf and Heifer Management Practices in PA Dairy Herds.

	Survey		
Disease	NC-119 Holsteins	NDHEP[1]	PA Dairy Herds[2]
	---------------------------- % of herds in survey	----------------------------	
Brucellosis	73.8	66.8	74.8
IBR	80.5	60.6	58.0
BVD	80.0	58.4	30.4
PI3	71.4	57.6	41.0
BRSV	55.9	44.0	Not reported
Leptospirosis	76.4	56.1	34.0
Virus calf scours	28.6	11.1	7.3

[1] (NDHEP, 1993)
[2] (Heinrichs et al., 1987)

Table 24. Percent of Holstein herds vaccinating heifers against brucellosis, IBR, BVD, PI3, BRSV, leptospirosis, and virus calf scours by herd size.

	Herd Size (cows)			
Disease	1-50	51-100	101-150	>150
	--------------------------- % of herds in herd size	---------------------------		
Brucellosis[1]	64.0	74.3	80.6	90.3
IBR[1]	66.2	85.1	97.2	83.9
BVD[1]	63.5	87.8	97.2	80.7
PI3[1]	47.3	82.4	91.7	80.7
BRSV	46.0	57.4	71.0	65.4
Leptospirosis[1]	60.8	82.4	88.9	83.9
Virus calf scours	18.9	35.1	33.3	29.0

[1] At least one pair is significantly different ($P<0.05$).

Table 25. Percent of Holstein herds vaccinating against brucellosis, IBR, BVD, PI3, BRSV, leptospirosis, and virus calf scours by RHAM.

	RHAM Quartile[1]			
Disease	1	2	3	4
	------------------------ % of herds in RHAM quartile ------------------------			
Brucellosis[2]	58.8	75.5	71.4	86.3
IBR[2]	68.0	79.6	83.7	90.2
BVD[2]	68.0	79.6	83.7	90.2
PI3	62.0	69.4	75.5	82.4
BRSV[2]	41.9	47.8	59.1	72.0
Leptospirosis	72.0	67.4	79.6	86.3
Virus calf scours	12.0	28.6	26.5	41.2

[1] Quartile 1 = 3,334 to 8,187 kg;
Quartile 2 = 8,188 to 8,822 kg;
Quartile 3 = 8,823 to 9,505 kg;
Quartile 4 = 9,506 to 11,778 kg RHAM.

[2] At least one pair is significantly different (P<0.05).

low. Lasalocid and deccoquinate were used most frequently by these producers. Monensin was not approved for cattle less than 181 kg until recently.

Reproduction

Producer goals for AFC averaged 24.2 mo and did not vary by state, calf mortality rate, or RHAM. The decision of when to breed heifers was most frequently based on age and weight. Age became less a factor in the breeding decision as herd size increased. There is more opportunity to assemble groups of similarly sized heifers in larger herds. Seasonal calving, height, and body condition scoring were each cited by less than 5% of producers as criteria for when to breed heifers. PA herds were most likely to factor seasonal calving into their breeding decisions.

AI was used on the majority of farms as only 13.0% of producers used natural service exclusively. Fifty-eight percent used AI only while the rest used a combination of AI, natural service, and embryo transfer. Heinrichs et al. (1987) reported that 59.5% of PA herds used AI only and 20.7% only used natural service. Table 26 contains breeding methods by herd size. Herds of less than 50 cows were most likely to rely exclusively on AI. Natural service was exclusively used more in herds between 50 and 150 cows in size. Holstein bulls were service sires for heifers on 89.7% of herds, beef bulls on 10.8%, and other dairy breeds on 3.6%.

Heifers were examined by a veterinarian prior to breeding in 5.4% of herds. Pre-breeding exams check for abnormalities in the reproductive tract and signs of infection prior to breeding. Thirty-seven percent of producers synchronized estrous in heifers. Prostaglandins were used to synchronize heifers in 33.2% of the Holstein operations. Larger herds were more likely to use estrous synchronization as a management tool than herds with less than 50 cows.

Heifers were placed in a pre-calving group in 58.1% of the herds at an average of 25.9 d before expected calving to acclimate them to feeds used in the milking herd. Percent of herds with pre-calving groups significantly increased as herd size and RHAM increased. Only 6.3% of herds had a special postpartum group for first calf heifers. Larger herds and herds with higher production were most likely to group these animals separately to reduce competition at the feed bunk allowing for better performance and growth during the first lactation. Producers allowed an average of 22.5 d longer to first breeding for first calf heifers in 17.2% of herds. This

Table 26. Method of breeding Holstein heifers by herd size.

Breeding Method	Herd Size (cows)			
	1-50	51-100	101-150	>150
	------------------ % of herds in herd size ------------------			
AI only[1]	85.7	44.0	38.9	45.2
AI first time, then bull	3.9	14.7	8.3	16.1
AI first and second time, then bull[1]	3.9	13.3	22.2	25.8
Bull only[1]	3.9	17.3	25.0	9.7
Embryo transfer and AI	0.0	0.0	2.8	3.2
AI and bull	1.3	10.7	2.8	3.2
AI, embryo transfer, and bull	1.3	0.0	0.0	0.0

[1] At least one pair is significantly different ($P<0.05$).

practice allows heifers more opportunity for growth during the first lactation. Herds in the highest production group were most likely to delay breeding these animals.

Mastitis Prevention

Mastitis problems in freshened heifers were reported by 48.6% of operations in the NDHEP (1993). This statistic raises concern about mastitis prevention in the heifer herd. Producers in the NC-119 survey were asked several questions concerning mastitis prevention in the replacement herd. Eight percent responded that calves were allowed to suckle one another prior to weaning. This practice has been linked to the spread of mastitis in heifers and can result in permanent damage to the udder. Access to ponds and lagoons is another common way for mastitis pathogens to be spread in heifers. Heifers had access to ponds or lagoons on 32.3% of farms. Heifers were milked prior to calving in 19.5% of herds. Eleven percent of the heifers in these herds were milked pre-partum. Pre-partum milking has been recommended to reduce stress on the udder just prior to calving when there is excessive udder edema. Antibiotic treatment prior to calving was practiced by 2.5% of the herds. Slightly more of the herds used a dry cow product than one for lactating cows. Average time of treatment was 10.3 wk prior to expected calving date.

Culling

On average, producers sold 4.7% of heifers for extra income and 2.4% for beef. Heifers were sold as baby calves, open heifers, bred heifers, and springing heifers by 5.0, 4.1, 5.5, and 21.5% of herds. Over 60% claimed that no culling was done. Culling criteria included dam's performance in the herd (15.9%), heifer's type (15.0%), heifer's ETA (9.1%), and sire's PTA (4.6%). Other criteria were used by 13.6% of the herds for culling decisions. Culling decisions tended to be more phenotypically based which causes some concern. Genetic information should be considered more heavily in these decisions because animal performance is still an unknown.

Miscellaneous

Herd size stayed within 5% of the previous year's size for 63.2% of the herds while 28.9% increased and 7.8% decreased. Thirty-one percent of herds participated in DHI's Heifer Management Option that provides valuable information to the manager. Forty-seven percent of the herds surveyed owned no registered cattle while 9.5% were 100% registered. Seventy-five percent of the herds were less than 50% registered. A table summarizing survey responses is found in Appendix C.

NC-119 HEIFER MANAGEMENT SURVEY - JERSEY HERDS

Jersey herds were examined for differences in management practices based on calf mortality rate, herd size, and RHAM. Significant differences were difficult to detect by calf mortality rate due to the small number of herds with complete mortality information. Thirty-two out of the 67 Jersey herds had complete calf mortality data. There were 12, 12, and 8 herds in the low (<10%), medium (10 to 19.9%), and high (20% and above) mortality groups, respectively. Fifty-eight herds reported herd sizes and 60 had RHAM available. Surveys cited for comparison in this section are based largely on Holstein data. More information about management practices in Jersey herds is warranted.

Average herd size for the Jersey herds was 64.6 cows with an average of 60.9 calves born during the 12 mo prior to the survey. Overall calf mortality from birth to first calving was 15.8% which was within ranges of previous studies. James et al. (1984) reported calf mortality of 7.7% of heifer calf births up to 3 mo of age in VA DHI herds. Calf mortality up to one yr of age in PA herds was 8.7% (Heinrichs et al., 1987). Jenny et al. (1981) determined that calf mortality rates up to 6 mo of age in SC DHI herds were 19.1%. Hartman et al. (1974) found calf mortality rates of 15.8, 19.3, and 27.2% for herds under 100 cows, 100 to 200 cows, and greater than 200 cows, respectively. Calves born dead accounted for 7.2% of all births while 8.1% of calves died less than 3 mo of age and 0.5% died greater than 3 mo of age. Still births in previous studies ranged from 1.2 to 8.2% of births while mortality rates from birth to 3 mo of age had a range of 6.5 to 11.2% (Hartman et al., 1974: Heinrichs et al., 1987; James et al., 1984; Jenny et al., 1981). Results from the current study would indicate that producers need to pay particular attention to care for the calf at birth and during the pre-weaning period to reduce overall mortality. There were no significant differences among calf mortality groups due to herd size or RHAM. RHAM for the Jersey herds in the NC-119 survey was 6,251 kg and was higher than the 5,806 kg average reported for PA Jersey herds in March 1994 in the PA Dairymen's Yearbook (1994). RHAM was not significantly different by calf mortality rate or herd size although herds in the high mortality group had the lowest RHAM.

Care of the Dam

Forty-eight percent of the Jersey herds dewormed the milking herd while 69.7, 71.2, and 68.2% vaccinated against leptospirosis, IBR, and BVD, respectively. Heinrichs et al. (1987) previously reported that 54.7% of PA herds dewormed the milking herd and that vaccination against leptospirosis, IBR, and BVD was practiced by 60.2, 68.1, and 52.3% of herds. NC-119 Jersey herds had a lower deworming percentage, but had a higher percentage vaccinating against leptospirosis, IBR, and BVD compared to the previous study. Table 27 shows the percent of herds vaccinating for leptospirosis, IBR, and BVD by RHAM. There were significant differences ($P<0.05$) among RHAM groups for leptospirosis and BVD. The highest producing herds were more likely to vaccinate against these diseases. A similar trend was observed with IBR although not significant at the 0.05 level. Twenty-three percent of herds body condition scored dry cows.

Calving Facilities

Calving facilities for the milking herd and for first calf heifers were similar in Jersey herds. The top four choices for calving facilities were pasture, maternity pens housed with the milking herd, maternity pens housed separately, and stanchions or tie stalls. Pasture plus maternity stalls housed with the milking herd was the predominant calving facility choice by PA herds in a previous study (Heinrichs et al., 1987). Trends related to calf mortality, herd size, and RHAM were not observed in the current study. However, as herd size increased, the percentage of herds using maternity pens housed separately increased while stanchion or tie stall usage decreased. Table 28 summarizes the percent of herds using each type of facility for the milking herd and first calf heifers. Straw was the major bedding material used in the calving area with two-thirds of herds reporting it as a bedding source while hay and paper were each used by more than 20% of the herds.

Colostrum Feeding

Quantity, quality, and timing of colostrum feeding are important for the passive transfer of immunity which protects the newborn calf from disease. Jersey herds reported that colostrum was first fed to calves by 2.5 h. Calves received an average of 1.55 and 2.97 L of colostrum at

Table 27. Percent of Jersey herds vaccinating the dam against leptospirosis, IBR, and BVD by RHAM.

	RHAM Quartile[1]			
Disease	1	2	3	4
Leptospirosis[2]	60.0	46.7	73.3	100
IBR	73.3	60.0	60.0	100
BVD[2]	66.7	60.0	53.3	100

[1] Quartile 1 = 4,536 to 5,828 kg;
Quartile 2 = 5,829 to 6,244 kg;
Quartile 3 = 6,245 kg to 6,804 kg;
Quartile 4 = 6,805 kg to 7,938 kg RHAM

[2] At least one pair is significantly different ($P<0.05$).

Table 28. Calving facilities used by Jersey herds for milking and replacement animals.

Calving Facility	Milking Herd[1]	Heifers[1]
	------------ % of herds	------------
Pasture	43.3	61.2
Dry lot	7.5	10.5
Maternity pens - housed with milking herd	41.8	41.8
Maternity pens - housed separately	38.8	32.8
Stanchions or tie stalls	23.9	19.4
Free stall area - housed with milking herd	1.5	3.0
Free stall area - not housed with milking herd	0.0	1.5
Loose housing area	9.0	11.9

[1] Column total exceeds 100% because some producers used more than one type of calving facility.

the first feeding and during the first day of life, respectively. Heinrichs et al. (1987) reported that PA producers fed 2.7 L of colostrum during the first 24 h of life and that the average time after birth to colostrum feeding was 2.7 h. Results from the current study were an improvement over the previous one because timeliness was improved and quantity fed was slightly higher.

Sixty-five percent of herds reported washing the udder prior to calves nursing or colostrum being milked. Most herds assisted calves in obtaining first colostrum as only 29.9% allowed calves to nurse unassisted. Calves in 80.6% of herds received first colostrum through bucket or bottle feeding. Esophageal feeders were used by 10.5% of herds while another 10.5% assisted feeding from the dam. PA producers previously reported that newborn calves received colostrum by use of a bucket or bottle, allowing the calf to nurse the dam unassisted, allowing the calf to nurse and/or use bucket or bottle, assisting the calf in nursing the dam, and combinations in 58.4, 16.4, 14.6, 4.6, and 6.0% of herds (Heinrichs et al., 1987)

Frozen colostrum was used by 38.8% of herds, compared to 22.8% previously reported in PA (Heinrichs et al., 1987). Eighty-seven percent of those using frozen colostrum used it for problem cases such as milk fever, severe mastitis, or death of the dam. Twenty-nine percent fed frozen colostrum to offspring of first calf heifers. Calves were separated from dams at 0.7 d of age on average.

Grain, Forage and Water for Pre-Weaned Calves

Jersey herds offered calf starter to calves at 7.6 d of age. Forage was offered to calves pre-weaning by 79.1% of herds at an average age of 16.3 d. Significant differences were detected in forage feeding by herd size and RHAM. Herds larger than 100 cows and herds with highest milk production were less likely to offer forage pre-weaning. Water was offered to pre-weaned calves in 74.6% of herds at an average age of 19.8 d. Significant differences were not detected among mortality rates, herd size, or RHAM. Grain intake is an important determinant of when to wean calves. Several practices will encourage grain intake in calves and therefore promote earlier weaning. Calves should be offered calf starter and ad libitum water during the first week of life. Keeping fresh feed in front of calves stimulates intake. Forage feeding is not necessary if the calf starter contains adequate fiber levels. Fiber is important for rumen development in the young calf, but does not necessarily have to come from forage feeding.

Calf Housing

Calf housing choices by Jersey herds for summer and winter are found in Table 29. The calf hutch was the most popular housing type with utilization by 32.8% during the winter months and 38.8% during summer. Calves were also housed in individual pens in dairy or separate barns or were tied by greater than 20% of herds. Producers did not specify where calves were tied. Use of calf hutches tended to increase as herd size increased. Calves were not tied by any herds greater than 100 cows. Straw was the most widely used bedding source and was used by 79.1% of herds while sawdust/wood shavings, newspaper, corn cobs/stalks and other bedding materials were used by 26.9, 20.9, 1.5, and 3.0% of herds, respectively. Significant differences for calf bedding materials based on calf mortality, herd size, and RHAM were not observed with one exception. Herds over 100 cows used other bedding materials that were not categorized whereas the smaller herds did not.

Calf Feeders

Owners fed calves in 52.2% of herds while spouses, children, hired help, herdspersons, and others fed calves on 38.8, 17.9, 10.5, 7.5, and 1.5%, respectively. Heinrichs et al. (1987) reported similar findings in PA. Owners, spouses, children, and hired labor fed calves in 51.9, 252., 16.4, and 13.0% of herds. While not significantly different, there was a trend in the current survey for owners and children to feed less and for hired help to feed more as herd size increased.

Weaning

Average weaning age in the Jersey herds was 8.2 wk. This age was slightly higher than several previous studies which reported average weaning ages from 7.7 to 8.1 wk (Heinrichs et al, 1987; James et al., 1984; NDHEP, 1993). Some of the difference in weaning age may be related to breed. Other studies cited here were from predominantly Holstein herds. Age and grain intake were both cited by two-thirds of herds as weaning criteria. Almost 41% of herds used size as a weaning criterion. Only a small percentage (6%) cited other reasons as the basis for weaning decisions. Previous work in PA showed that 52.9% of producers used grain intake as a weaning criteria (Heinrichs et al., 1987).

Table 29. Jersey calf housing for summer and winter months.

Housing Type	Summer[1]	Winter[1]
	------------ % of herds ------------	
Hutches	38.8	32.8
Group pens - outdoors	9.0	4.5
Group pens - indoors, dairy barn	7.5	11.9
Group pens - indoors, separate barn	6.0	6.0
Elevated stalls - wood, dairy barn	4.5	6.0
Elevated stalls - wood, separate barn	0.0	0.0
Elevated stalls - metal, dairy barn	0.0	0.0
Elevated stalls - metal, separate barn	0.0	0.0
Individual pens, dairy barn	17.9	23.9
Individual pens, separate barn	22.4	20.9
Tied	23.9	26.9
Other	4.5	4.5

[1] Column total exceeds 100% because some producers used more than one type of calving facility.

Health

Sixty-five percent of producers identified digestive problems as their major calf disease while 31% said that respiratory problems were greatest. Calves were vaccinated against brucellosis more than any other disease. Percent of producers vaccinating heifers for brucellosis, IBR, BVD, PI3, BRSV, leptospirosis, and virus calf scours are found in Table 30 along with comparative data from NDHEP and PA surveys. Significant differences were observed for brucellosis vaccination rates among calf mortality groups in the NC-119 survey. Vaccination rates for brucellosis were 100, 90.9, and 62.5% for the low, medium, and high mortality groups, respectively. The lower calf mortality rate was likely more indicative of attention to details of which brucellosis vaccination is a part rather than the vaccination itself. Vaccinations for IBR, BVD, PI3, BRSV, leptospirosis, and virus calf scours were significantly different by RHAM. Herds in the highest production group had the highest vaccination rate for each of these diseases. Table 31 contains the percent of Jersey herds that vaccinated against each disease by RHAM. Sixty-two percent of producers dewormed heifers. No significant differences in deworming practices were observed between calf mortality rates, herd size, or RHAM. Coccidiostats and/or coccidiocides were used by nearly 75% of producers. Small herds (1 to 50 cows) used coccidiostats and/or coccidiocides less than larger herds. Heinrichs et al. (1987) reported that 72.3% of PA herds dewormed heifers and 16.4% treated for coccidiosis. The NC-119 survey showed a marked increase in coccidiostat/coccidiocide usage over the earlier study.

Reproduction

Goals stated by Jersey herds for AFC averaged 23.6 mo. This goal was lower than that stated by Holstein herds in the NC-119 survey. This goal is reflective of the fact that Jerseys mature quicker than Holsteins. Age and weight were the major criteria for making breeding decisions. Age was less of a factor in herds over 100 cows as compared to smaller herds. Only a few producers reported using height or seasonal calving in their breeding decision making. Significant differences were noted in breeding method by herd size. Table 32 contains the percent of herds using various methods for breeding heifers by herd size. Smaller herds used AI only more than the largest herds. The largest herds tended to use either AI for two services with a bull for clean-up or all natural service. There were no significant differences by RHAM. Over

Table 30. Percent of herds vaccinating against brucellosis, IBR, BVD, PI3, BRSV, Leptospirosis, and virus calf scours in NC-119 Jersey herds, National Dairy Heifer Evaluation Project, and Survey of Calf and Heifer Management Practices in PA Dairy Herds.

	Survey		
Disease	NC-119 Jerseys	NDHEP[1]	PA Dairy Herds[2]
	% of herds in survey		
Brucellosis	80.7	66.8	74.8
IBR	53.2	60.6	58.0
BVD	48.4	58.4	30.4
PI3	41.9	57.6	41.0
BRSV	38.7	44.0	Not reported
Leptospirosis	54.8	56.1	34.0
Virus calf scours	25.8	11.1	7.3

[1] (NDHEP, 1993)
[2] (Heinrichs et al., 1987)

Table 31. Percent of Jersey herds vaccinating against brucellosis, IBR, BVD, PI3, BRSV, leptospirosis, and virus calf scours by RHAM.

	RHAM Quartile[1]			
Disease	1	2	3	4
	% of herds in RHAM quartile			
Brucellosis	73.3	85.7	71.4	100
IBR[2]	53.3	28.6	42.9	92.3
BVD[2]	46.7	21.4	35.7	92.3
PI3[2]	33.3	21.4	42.9	76.9
BRSV[2]	26.7	21.4	35.7	69.2
Leptospirosis[2]	40.0	21.4	64.3	92.3
Virus calf scours[2]	13.3	21.4	14.3	61.5

[1] Quartile 1 = 4,536 to 5,828 kg;
Quartile 2 = 5,829 to 6,244 kg;
Quartile 3 = 6,245 kg to 6,804 kg;
Quartile 4 = 6,805 kg to 7,938 kg RHAM
[2] At least one pair is significantly different (P<0.05).

Table 32. Method of breeding Jersey heifers by herd size.

	Herd Size (cows)		
Breeding Method	1-50	51-100	>100
	---------------- % of herds in herd size----------------		
AI only[1]	72.4	68.8	23.1
AI first time, then bull	10.3	6.3	0.0
AI first and second time, then bull[1]	13.8	12.5	46.2
Bull only[1]	0.0	0.0	30.8
AI and bull	3.5	12.5	0.0
AI, ET, and bull	0.0	0.0	0.0

[1] At least one pair is significantly different (P<0.05).

95% of producers used Jersey bulls as service sires. Forty-two percent of herds used estrous synchronization on heifers. Prostaglandins were used in 40.9% of the herds. Synchronization was significantly higher in the highest producing herds with an implementation rate of almost 93%. Pre-breeding exams for heifers were conducted in less than 5% of the Jersey herds.

A pre-calving group was used by 56.7% of herds to acclimate first calf heifers to the milking herd ration. Heifers were placed in the pre-calving group 30 d before expected calving in herds implementing this practice. One hundred percent of herds over 100 cows reported use of pre-calving groups which was significantly higher than smaller herds. Less than 5% of herds had a separate group for first calf heifers once in the milking herd. The lack of first calf heifer groups was not surprising given an average herd size of 65 cows. Heifers were given longer days to first service than second and later lactations in 13.4% of herds.

Mastitis Prevention

Producers were asked about management practices associated with mastitis prevention in heifers. Calves were allowed to suckle each other prior to weaning in 23.1% of herds. Only 9.1% reported that heifers had access to a pond or lagoon on the farm. Suckling and access to ponds and lagoons have been identified as potential ways to spread mastitis in heifers. Pre-partum milking is a practice recommended to reduce stress on the udder when there is excessive udder edema. Pre-partum milking of heifers was practiced on 18.2% of farms. On those farms implementing the practice, 6.5% of heifers were milked pre-partum. Herds over 50 cows were more likely to milk heifers pre-partum. Six percent of herds treated heifers for mastitis with an intramammary antibiotic prior to calving. A lactating product was used on 4.5% of herds while 3.0% used a dry cow product on heifers. Herds in the lower two production quartiles did not use this form of antibiotic therapy.

Culling

Herds reported that 5.6% of heifers were sold each year for extra income and 1.3% were sold for beef. Over 60% of herds reported that no culling was done. When culling was practiced, heifers were sold as baby calves, open heifers, bred heifers, and springing heifers by 25.0, 12.5, 10.4, and 16.7% of herds, respectively. The dam’s performance in the herd was the culling criterion used most frequently followed by heifer's type, miscellaneous reasons, sire's PTA, and heifer's ETA.

Miscellaneous

Sixty percent of the herds surveyed stayed the same size during the previous year while 29.2% increased herd size by more than 5% and 10.8% of herds decreased by more than 5%. Sixty-six percent of herds were 100% registered while only 3.1% had no registered cattle. Smaller herds tended to have more registered animals. It is important to note that the herds in the Jersey survey were contacted using a Pennsylvania Jersey Association mailing list which most likely included herds with more registered cattle.

A table summarizing survey responses is presented in Appendix D.

VIRGINIA CUSTOM DAIRY HEIFER REARING SURVEY

Twenty-four custom dairy heifer grower surveys were completed. Seven growers contracted with dairy producers to raise heifers for them, nine purchased heifers, raised them, and then resold them, and eight did both. Raising dairy replacement heifers was the principal occupation for 41.7% of them. Average herd size was 194 head with a range from 22 to 550. Farms had an average of 4.8 groups of heifers. All herds used the heifer's size as a grouping determinant with 25.0 and 12.5% also considering age and number of animals in groups. One hundred percent of heifers were identified with a known sire, dam, and date of birth in 16.7% of the herds while 12.5% of herds had no identification. Fifty-four percent had no registered cattle. None of the herds contained over 60% registered animals. Producers used written records (75.0%), computer spreadsheets or databases (41.7%), and/or DHI records (8.3%) as a record keeping system.

Contract Growers

Fifteen out of the 24 growers contracted with dairy producers to raise the producers' heifers. Two-thirds of these 15 growers contracted with business associates while 33.3, 20.0, and 6.7% contracted with neighbors, family, and friends, respectively. Heifers were acquired at various ages from pre-weaning to 15 months of age. Sixty percent acquired heifers between 5 and 9 mo of age. One third received heifers before weaning while another third received heifers from weaning to 5 mo of age. Heifers from 10 to 15 mo of age were acquired by 26.7% of growers.

Growers were paid on a per diem, per head, or per pound of gain basis. Some growers used a combination of charges depending on arrangements with individual dairy producers. Twelve out of the fifteen contract growers charged on a per diem basis. Five charged a flat rate per head and two charged per pound of gain. Per diem charges averaged $1.12 and ranged from $0.65 to $1.50. A large range existed because of differences in services provided or ages of heifers reared. The average per diem rate in VA was $0.12 lower than reported by Karszes and Stanton (1991) in NY. The average per diem charge on 15 NY custom grower farms in 1990 was $1.24 with a range of $1.00 to $1.50 per day. Charges to raise heifers from birth to calving ranged from $950 to $1,200 for those who contracted on a per head basis. These charges were within the range of estimated heifer rearing costs from birth to calving of $550 to $1,325 (Bethard, 1997; Bolton, 1992; Ely and Brown, 1984; Heinrichs et al., 1991; Hoffman, 1992; Karszes, 1994; Miller and Amos, 1986; Randle et al., 1998; Smith, 1992; Virginia Cooperative Extension, 1997; Webb, 1992; Willet et al., 1992). Price per pound of gain was reported by only one of the two growers who charged per pound. The reported rate was $0.85 per pound of gain.

Contracts are crucial to a good relationship between the heifer grower and the owner of the cattle. Table 33 includes many common components of a heifer rearing contract such as breeding, veterinary management, feeding, and general management practices, and shows the percent of contracts by grower and owner responsibilities. In the herds surveyed, growers were primarily responsible for breeding services, heat detection aids, pregnancy checking, heat detection, deworming, emergency health care, medications, external parasite control, vaccinations, feed, bedding, and growth monitoring. Owners were mainly responsible for dehorning, identification, and insurance. Death loss and trucking were often shared responsibilities. Autopsies and hoof trimming were often unnecessary or undefined in contracts. Twelve growers operated with a verbal contract, two with a written contract, and one operated without any contract. Karszes and Stanton (1991) reported that 75% of custom growers in NY did not have a written contract. None of the VA growers had an identified third party to help resolve conflicts or assign fault in the case of heifer death or poor performance.

Purchase-Raise-Resell Growers

Seventeen of the 24 growers purchased heifers, raised them, and then resold them. Heifers were acquired pre-weaning, weaning to 5 mo, 5 to 9 mo, and 10 to 15 mo of age by 41.2, 58.8, 70.6, and 47.1% of growers. Only one herd (5.9%) purchased heifers over 15 mo of age. Sources of heifers included local dairy producers (58.8%), out-of-state dairy producers (58.8%), dispersal, reduction, or consignment sales (41.2%), livestock brokers (23.5%), livestock market (11.8%), and calves from leased cattle (5.9%). Seventy-five percent of growers sold heifers to local dairy producers while 87.5% sold heifers out-of-state. Heifers were also marketed through export (25.0%), consignment sales (6.25%), and other means (12.5%). When heifers were

Table 33. Grower and owner responsibilities identified in heifer rearing contracts.

Item	Responsible Party: Grower	Owner	Not Applicable
	-------- % of contracts --------		
Breeding			
Breeding services	86.7	0.0	13.3
Semen and breeding supplies	20.0	46.7	33.3
Sire selection[1]	26.7	46.7	33.3
Heat detection aids	66.7	0.0	33.3
Pregnancy checking	60.0	13.3	26.7
Heat detection	66.7	0.0	33.3
Veterinary			
Deworming[1]	86.7	20.0	0.0
Dehorning[1]	40.0	73.3	0.0
Hoof trimming	20.0	13.3	66.7
Emergency health care	73.3	26.7	0.0
Medications	78.6	21.4	0.0
External parasite control[1]	73.3	33.3	0.0
Autopsy	40.0	6.7	53.3
Vaccinations[1]	60.0	46.7	0.0
Feed			
Forage	93.3	6.7	0.0
Grain	86.7	6.7	6.7
Protein supplement	86.7	6.7	6.7
Mineral	93.3	6.7	0.0
Salt	93.3	6.7	0.0
Feed additives	93.3	6.7	0.0
General			
Bedding	73.3	0.0	26.7
Identification[1]	33.3	73.3	0.0
Insurance	21.4	71.4	7.1
Death loss[1]	57.1	71.4	0.0
Trucking[1]	57.1	64.3	0.0
Growth monitoring	71.4	0.0	28.6

[1] Row total exceeds 100% indicating shared responsibility between grower and owner in at least one contract.

purchased from a producer, 66.7% of the growers gave the producer the first option to buy them back at the end of the growing period.

Pre-Weaned Calves

Ten custom growers raised pre-weaned calves. They started feeding grain to calves at 9.2 d of age. Sixty percent offered forage to calves pre-weaning at an average age of 15.8 d. Water was offered to pre-weaned calves by 80% at an average of 15.9 d of age. The most common types of calf housing were calf hutches and individual pens in separate barns. Calf housing choices are summarized in Table 34. Ninety percent bedded calves with straw while 30% used sawdust or wood shavings. Average weaning age was 7.7 wk. Grain intake and size were the most frequently used weaning criteria with age and other factors playing a smaller role. A lower percentage of VA dairy herds in the NC-119 survey offered water to calves pre-weaning but those that did started 8 d sooner. Other results for growers and dairy producers were similar.

Replacement Herd Health

Seven (58.3%) growers identified respiratory problems as the predominant disease problem with calves less than 3 mo of age while four (33.3%) claimed that digestive problems were greater. One producer said that digestive and respiratory problems were equally troubling. In contrast, VA herds in the producer survey reported digestive problems as the greater problem. Most herds had a good vaccination program. Heifers were vaccinated against brucellosis, IBR, BVD, PI3, BRSV, and leptospirosis in 85.0, 83.3, 79.2, 79.2, 79.2. and 83.3% of herds. None of the herds vaccinated against virus calf scours. Ninety-four percent of VA dairy producers vaccinated against brucellosis, IBR, BVD, PI3, and leptospirosis, a slightly higher percentage than for growers. Heifers were dewormed in 95.8% of herds which was encouraging given that pasture utilization was 95.8% in grower herds. One herd did not use pasture and another did not deworm heifers. Coccidiostats and coccidiocides were fed by 79.2%, compared to 94% of VA herds in the producer survey. Custom growers most often acquired heifers at five mo of age and older which is beyond the period when coccidiosis is a greater concern. Eighty-four percent included a product in the grain mix, 21.1% fed it in a free choice mineral, and 10.5% used a liquid.

Table 34. Custom grower calf housing for summer and winter months.

Housing Type	Summer	Winter
	------------ % of herds ------------	
Hutches	60.0	50.0
Group pens - outdoors	10.0	10.0
Group pens - indoors, dairy barn	0.0	0.0
Group pens - indoors, separate barn	30.0	30.0
Elevated stalls - wood, dairy barn	0.0	0.0
Elevated stalls - wood, separate barn	0.0	0.0
Elevated stalls - metal, dairy barn	0.0	0.0
Elevated stalls - metal, separate barn	0.0	0.0
Individual pens, dairy barn	0.0	0.0
Individual pens, separate barn	60.0	60.0
Tied	10.0	10.0
Other	0.0	0.0

Nutrition and Feeding

Forage testing and ration balancing are recommended practices for anyone feeding dairy cattle, whether youngstock or lactating cows. Fifty-eight percent of growers reported using forage testing services and having rations balanced. These results were similar to those reported by Karszes and Stanton (1991) where 40% of NY custom growers did not have rations balanced. Of those using these services in VA, forages were tested an average of 3.8 times per year and rations were balanced 3.8 times per year. Feed company nutritionists, private consultants, growers or family members, and Extension agents or specialists balanced rations in 33.3, 16.7, 16.7, and 8.3% of herds, respectively. Forty-six percent reported weighing feed daily while one-third never weigh feeds. Producers weighed feed weekly, monthly, or yearly in 4.2, 8.3, and 8.3% of herds. These results raise concerns because of the importance of the feeding program to profitability of the grower operation. Forage testing, ration balancing, and weighing of feeds provide producers the opportunity to better control feed expenses on the farm, to increase feed efficiency, and/or to improve animal performance.

Concentrate was delivered to heifer through total mixed rations, top-dressing, or free choice feeders. Table 35 shows the percent of herds using these concentrate feeding methods by age of the animal. Top-dressing was the most prevalent method of feeding concentrates, particularly for younger animals, but total mixed ration usage increased in older heifer groups.

Producers listed feedstuffs fed to heifers of five different age groups on their farms. The results are shown in Table 36. For pre-weaned calves, milk replacer was the most common liquid feed, largely because growers were not located on a dairy operation. Calf starter was the most common grain fed with limited forage feeding of alfalfa, orchardgrass, or alfalfa-orchardgrass hay. Pasture, corn silage and orchardgrass hay were the most heavily utilized forages for older heifers. Corn and barley were used as energy supplements and soybean meal was used as a protein supplement. Commercial concentrates were fed by a similar number of growers as corn/barley and soybean meal. Broiler litter was the most commonly used by-product feed. Over one-third of growers fed litter to breeding age and bred heifers. A 2:1 mineral was the most common form of mineral supplementation. The feedstuffs reported by these growers were representative of Virginia dairy farms.

Table 35. Method of delivering concentrates to heifers by custom growers.

Method	Age Group: Weaning to 5 Months (n=16)	6 to 12 Months[1] (n=22)	Breeding Group (n=22)	Pregnant Heifers (n=22)
	% of growers			
Total Mixed Ration	18.8	36.4	45.5	45.5
Top-Dressed	50.0	54.6	45.5	45.5
Free-Choice Feeder	31.3	13.6	9.1	9.1

[1] Column total exceeds 100% because one grower used a combination of methods.

Table 36. Feedstuffs fed to heifers by custom growers.

	Age Group				
Feedstuff	Pre-weaning (n=10)	Weaning to 5 Mo (n=16)	6 to 12 Months (n=23)	Breeding Age (n=23)	Pregnant Heifers (n=23)
	------------------------- % of growers -------------------------				
Liquid Diet					
Milk	30.0	0.0	0.0	0.0	0.0
Milk replacer	80.0	0.0	0.0	0.0	0.0
Purchased Concentrates					
Calf grower	10.0	12.5	4.3	4.3	4.3
Calf starter	90.0	0.0	0.0	0.0	0.0
12% concentrate	10.0	0.0	0.0	0.0	0.0
14% concentrate	0.0	6.3	8.7	8.7	8.7
16% concentrate	10.0	18.8	13.0	17.4	13.0
18% concentrate	0.0	18.8	8.7	0.0	0.0
Energy Supplements					
Barley	0.0	18.8	13.0	13.0	13.0
Corn	0.0	31.3	21.7	26.1	21.7
Ear corn	0.0	6.3	4.3	0.0	0.0
Protein Supplements					
44% soybean meal	0.0	12.5	0.0	0.0	0.0
48% soybean meal	0.0	31.3	30.4	30.4	21.7
By-Product Feeds					
Bakery waste	0.0	0.0	4.3	0.0	0.0
Brewers condensed solubles	0.0	0.0	4.3	4.3	4.3
Broiler litter	0.0	0.0	26.1	34.8	34.8
Cereal waste	0.0	0.0	4.3	0.0	0.0
Corn distillers grain	0.0	6.3	0.0	4.3	4.3
Cottonseed hulls	0.0	0.0	4.3	4.3	4.3
Dried brewers grain	0.0	6.3	0.0	0.0	0.0
Molasses	0.0	6.3	8.7	4.3	4.3
Peanut hulls	0.0	6.3	0.0	4.3	4.3
Peanut skins	0.0	0.0	4.3	0.0	0.0
Wet brewers grain	0.0	6.3	4.3	4.3	4.3
Whole cottonseeds	0.0	0.0	0.0	4.3	4.3

Table 36. Feedstuffs fed to heifers by custom growers.

	Age Group				
Feedstuff	Pre-weaning (n=10)	Weaning to 5 Mo (n=16)	6 to 12 Months (n=23)	Breeding Age (n=23)	Pregnant Heifers (n=23)
	% of growers				
Minerals					
2:1 mineral	0.0	62.5	69.6	69.6	69.6
4:1 mineral	0.0	6.3	4.3	4.3	4.3
Mineral with ionophore	0.0	0.0	21.7	21.7	21.7
Salt	0.0	0.0	21.7	21.7	21.7
Forages					
Alfalfa-orchardgrass hay	10.0	18.8	21.7	13.0	13.0
Alfalfa-orchardgrass silage	0.0	0.0	4.3	4.3	4.3
Alfalfa-timothy hay	0.0	6.3	4.3	4.3	4.3
Alfalfa hay	20.0	6.3	8.7	4.3	0.0
Alfalfa silage	0.0	6.3	13.0	8.7	8.7
Barley silage	0.0	0.0	0.0	8.7	8.7
Clover hay	0.0	6.3	4.3	0.0	0.0
Corn silage	0.0	18.8	69.6	91.3	91.3
Fescue hay	0.0	6.3	4.3	8.7	8.7
Grass balage	0.0	0.0	4.3	0.0	0.0
Grass silage	0.0	6.3	4.3	4.3	4.3
Mixed grass hay	0.0	0.0	4.3	4.3	4.3
Oat hay	0.0	0.0	4.3	4.3	4.3
Oat silage	0.0	0.0	4.3	4.3	4.3
Orchardgrass-clover balage	0.0	0.0	4.3	4.3	4.3
Orchardgrass hay	30.0	56.3	34.8	47.8	47.8
Rye silage	0.0	0.0	4.3	4.3	4.3
Timothy hay	0.0	0.0	4.3	4.3	4.3
Wheat-orchardgrass balage	0.0	0.0	0.0	4.3	4.3
Wheat-vetch silage	0.0	0.0	4.3	4.3	4.3
Pasture	0.0	56.3	73.9	73.9	82.6

Pasture is an important component in the forage program on VA custom heifer rearing operations. Twenty-three of the 24 growers reported at least some pasture utilization. Karszes and Stanton (1991) reported that 59% of NY custom growers used pasture as a feed source. The percent of forage needs supplied by pasture during the grazing months (April - September) is found in Table 37. Pasture utilization increased as age of the animal increased. Heifers over 6 mo of age had more than 60% of their forage needs met by pasture in more than 55% of the herds. One herd offered no supplementation to heifers during the grazing months. Other herds supplemented pasture with grain (69.6%), free choice mineral (52.2%), hay (43.5%), silage (30.4%), and/or protein supplements (17.4%). Producers were asked about their pasture management practices. One hundred percent annually mowed their pastures. A fertilization program, soil testing, reseeding within the past 5 yr, and rotational grazing were practiced by 91.3, 65.2, 52.2, and 39.1% of grower operations.

Monitoring Heifer Growth

Growth monitoring is important to the custom grower for determining rearing charges, evaluating the feeding program, measuring progress toward goals, and troubleshooting poor performance. Surprisingly, fifty-eight percent of growers reported that they never monitored heifer performance by weighing and/or measuring wither heights. Twenty-nine percent weighed and/or measured wither heights whenever groups were being handled for other purposes and 12.5% reported measuring growth on a routine schedule. Of the two growers charging clients by pound of gain, one measured growth while heifers were being handled for other purposes while the other did so on a semi-annual basis. Weight tapes, balance scales, electronic scales, and wither height sticks were used by 33.3, 16.7, 12.5, and 4.2 % of growers. Producers were asked about the form of animal restraint available in heifer housing (raising) areas. Responses are summarized in Table 38. Single headgates were available on all farms for most groups. Fence-line headlocks were used on only three farms. Producers with safe, labor efficient handling facilities may be more likely to routinely measure animal growth.

Table 37. Percent of forage needs supplied by pasture during the grazing months (April-September) on custom grower farms.

Percentage of Forage Needs Supplied by Pasture	Age Group: Weaning to 5 Months (n=15)	6 to 12 Months (n=23)	Breeding Group (n=23)	Pregnant Heifers (n=23)
	---------- % of growers ----------			
0	26.7	13.0	17.4	4.4
1-20	33.3	4.4	4.4	4.4
21-40	13.3	17.4	8.7	17.4
41-60	13.3	8.7	8.7	13.0
61-80	0.0	17.4	17.4	13.0
81-99	6.7	17.4	17.4	21.7
100	6.7	21.7	26.1	26.1

Table 38. Form of animal restraint available in heifer housing (raising) areas on custom grower farms.

Form of Restraint	Age Group: Newly Weaned Calves (n=18)	Yearling Heifers[1] (n=24)	Bred Heifers[1] (n=23)
	---------- % of herds ----------		
Single headgate	94.4	100.0	100.0
Fenceline headlocks	0.0	12.5	13.0
Stanchion	0.0	4.2	4.4
Other	5.6	0.0	0.0

[1] Column total exceeds 100% because at least one grower used a combination of forms of restraint.

Reproductive Management

Average age at first breeding was 15.8 months which causes concern. Growers need to start breeding nearly two months earlier to achieve an AFC of 24-25 mo. Weight was the biggest determinant of when a heifer was ready to breed for the first time. Producers used weight, age, height, and/or season in making breeding decisions on 95.7, 34.8, 8.7, and 4.4% of farms. Forty-three percent of growers used natural service only while 8.7% used AI exclusively. A combination of AI and natural service was used by 47.8%. VA custom growers relied more heavily on natural service than VA dairy producers and NY custom growers (Karszes and Stanton, 1991). Dairy bulls of the same breed as the heifer were exclusively used on 60.9% of farms, 8.7% bred only to a beef bull and 30.4% used a combination. In conversation during surveys, growers indicated that dairy producers with whom they worked were often satisfied to have non-Holstein, non-AI offspring as long as a well-grown heifer entered the milking herd. Given that heifers should be the genetically superior animals on the farm, producers are losing a potential opportunity for quicker genetic progress by not using AI in the heifer breeding program.

Forty-three percent of growers used estrus synchronization in their reproductive management program. Prostaglandins were used most heavily. Fifty percent routinely palpated heifers in a pre-breeding examination at an average age of 14.1 mo. The purpose of this examination is to make sure that the reproductive tract is free of infection and to check for freemartins. This practice needs to occur at an earlier age to reduce age at first breeding. Over 90% had heifers confirmed pregnant by a veterinarian.

Heifer Mortality and Culling

Overall heifer mortality was 2.6% and ranged from 0.0 to 10.0%. Mortality was 1.7% under 4 mo of age, 0.5% from 4 to 12 mo, and 0.3% over 12 mo. These mortality rates are excellent, but are naturally lower because they do not include deaths at birth nor baby calves in many circumstances. Deaths at birth and among calves less than 3 mo account for much of heifer mortality on dairy farms. James et al. (1984) reported mortality for calves up to 3 mo of age at 7.7%. Calves born dead accounted for 1.2% and those that died from birth to 3 months of age accounted for 6.5%. Calf mortality in SC herds up to 3 mo of age averaged 11.2% (Jenny et al., 1981).

Eight percent of growers sold no heifers for beef whereas 79% sold between 1 to 5%, and 12.5% sold more than 5% of heifers for beef purposes. Size of the heifer herd remained within 5% of the previous year in 37.5% of herds. Thirty-three percent increased herd size while the remaining 29.2% decreased.

CONCLUSIONS

NC-119 HEIFER MANAGEMENT SURVEY

The NC-119 Heifer Management Survey provided much information about heifer management practices in dairy herds. Calf mortality and RHAM were used as performance indicators in this survey. Better managed herds would be expected to have lower calf mortality and higher milk production. One purpose of the survey was to identify management practices associated with herds that had low calf mortality (<10%) and/or were in the top 25% of herds surveyed based on RHAM. Identification of management practices associated with successful herds can benefit all producers. Herds under 50 cows are managed differently than larger herds due to land, labor, and capital resource differences. Some management practices are more feasible for smaller herds than larger ones and vice-versa. The dairy industry in the US varies greatly by region of the country. State comparisons provided evidence of these regional differences.

Level of Milk Production

Quality of management is expected to be higher in high milk producing herds. Several practices associated with herds in the high RHAM quartile were noteworthy. High producing herds tend to be proactive instead of reactive in disease prevention. Holstein and Jersey herds in the high RHAM quartile were more likely to vaccinate against brucellosis, IBR, BVD, PI3, BRSV, leptospirosis, and virus calf scours. They also had a high rate of coccidiostat and coccidiocide usage at 88.2% as compared to 64.7% of the lowest producing herds.

The higher producing herds were more proactive in colostrum management as calves were fed by bucket or bottle by over 80% of herds while less than 16% allowed the calf to nurse the dam unassisted. They were also more likely to have frozen colostrum available for problem cases. High producing Holstein herds used calf hutches most often while the high producing Jersey herds relied more on individual pens. All Jersey herds were from PA where herds are generally smaller and frequently use tie stalls for housing cattle. High producing Holstein herds were less likely than lower producing herds to allow calves to suckle each other or have access to ponds and lagoons which should be associated with lower levels of mastitis in first lactation heifers. Although not significant at the $P<0.05$ level, calf mortality rates were lowest in the high production herds.

High producing herds more heavily relied on AI in their heifer breeding programs. Ninety-eight percent of Holstein herds used AI in their herds and 72.6% used AI exclusively. All Jersey herds used some AI and 57.7% used it exclusively. These herds were somewhat more likely to use estrous synchronization in their breeding program. High producing Holstein herds were more likely to have a pre-calving group, to have a separate group for first calf heifers, and to allow longer days to first service for first calf heifers. High producing Jersey herds were also more likely to have a pre-calving group, but did not have a separate group for first lactation heifers which was more reflective of smaller herd size, than production level. These management practices allow first calf heifers to better adjust to the milking herd during first lactation. Acclimation to the milking herd ration and reduction in competition enable heifers to produce more milk during first lactation as well as prepare them for the second. Losinger and Heinrichs (1996) found the following management practices to be associated with higher RHAM: calves born in individual areas in buildings, calves hand-fed first colostrum, calf starter fed to pre-weaned calves, ionophores fed from birth to first calving, DHIA record keeping system used, computerized records, and no new cattle entering the herd in the previous 12 mo. These results were generated through the National Dairy Heifer Evaluation Project. Aggressive, preventive management was characteristic of herds with high RHAM in the NDHEP and NC-119 surveys.

Calf Mortality

Practices associated with low mortality were difficult to distinguish in the NC-119 survey as there were few significant differences by mortality groups. Part of the reason for this difficulty is that calf mortality is so complex. The regression equation generated for calf mortality was indicative of the complexity of this issue. Sixty-seven variables were entered in the full model, but only three significantly different variables remained in the final one. The final model was significant at $P<0.0001$, but could explain only 21.6% of the variation in calf mortality. Two calving facilities were included in the model as well as brucellosis vaccination. Maternity pens housed separately had a positive impact on calf mortality while calving animals in a free stall barn housed with the milking herd had a strong negative impact. These results were expected and emphasize the importance of separate housing at parturition. Vaccination for brucellosis had a positive influence on calf mortality but was more indicative of the level of management in herds overall as opposed to a direct effect.

Colostrum feeding practices seemed to be important to calf mortality in Holstein herds. Herds in the low mortality groups relied less on the calf to nurse the dam for first colostrum. These herds were more likely to assist feeding through buckets, bottles, or esophageal feeders. Low mortality herds raised calves in a variety of calf housing types with the exception of elevated metal stalls which were often associated with disease problems. However, only 5 Holstein producers used these stalls. One significant area to notice when examining herds by calf mortality level is RHAM. Herds with less than 10% calf mortality also had the highest RHAM. This result is not surprising because low mortality rates and high milk production are both good indicators of quality management and attention to details. Previous studies give support to the relationship between calf mortality and RHAM. James et al. (1984) reported a negative correlation of .16 between calf mortality up to 3 mo of age and rolling herd average for milk and fat. Jenny et al. (1981) saw a decease in calf mortality from 23.0 to 12.5% as rolling herd average for fat increased from less than 200 kg to more than 264 kg. Rolling herd average fat would be an indirect measurement of milk production as it includes milk volume and fat percent.

Herd Size

The number of US dairy farms is declining, but those remaining in business are increasing in cow numbers. As herd size increases, managers more frequently take advantage of new technology because of economies of scale. Producers are more likely to buy supplies, feed, and bedding material in bulk. Labor efficiency also becomes more important to managers as herd size increases. The NC-119 survey revealed some practices among herds greater than 150 cows that illustrate these points. The herd size discussion that follows is limited to Holsteins because of the small number of Jersey herds which fell into this category.

Although not significantly different at $P<0.05$, herds over 150 cows had a lower mean weaning age when comparing the least squares mean to other herd sizes. Calves were weaned in these herds at 7.2 wk of age. Pre-weaned calves are labor intensive. Therefore, the labor savings offered by earlier weaning would appeal more to larger herds. These herds were less likely to offer forages before weaning but more likely to offer water to calves. These practices encourage calves to consume calf starter sooner which facilitates earlier weaning. More large herds used coccidiostats and coccidiocides than other groups.

Managers of large herds factored age into breeding decisions less than smaller herds. Small herd owners often know cattle better individually because of the fewer number of animals with which they work. Large herds manage groups of cattle more than individuals. Therefore, it is easier for the large herd manager to move cattle into a breeding group based on a visual observation. As noted earlier, puberty is more of a function of size than age so this practice has merit if heifers are of adequate size. Fifty-eight percent of large herds used estrous synchronization, a higher percentage than other groups. Over 90% used AI in their heifer breeding program, but only 45.2% used AI exclusively. Forty-eight percent used a combination of AI and natural service.

First calf heifers were often handled differently in larger herds. Eighty percent of herds over 150 cows had a pre-calving group to acclimate heifers to the milking herd ration. Larger herds were also more likely to have a separate group for first calf heifers. As herd size increases, the ability to manage animals in groups also increases if adequate facilities are available.

State

One of the admitted weaknesses of the NC-119 Heifer Management Survey was the method by which herds were selected. Initial discussion by NC-119 cooperators focused on RHAM as the basis for herd selection. Herds were to be randomly chosen from different production levels according to DHI averages within each state. However, as noted in Materials and Methods, each state selected herds differently. In addition, PA Holstein herds and VA herds were from selected regions of the state as opposed to a statewide sample. Survey herds were larger and had higher RHAM than average herds in their respective states. As a result, one must be careful about the conclusions drawn about states because herds surveyed may or may not be representative of herds within the state.

Some effects observed in the data set were confounded because of the method in which herds were selected. Washington herds were not distributed among all herd size groups because all WA herds were greater than 150 cows. State DHI average herd size in WA was largest of participating states at 214 cows. The WA herds and MO herds were skewed toward the higher RHAM quartiles.

Calf mortality among states was similar. Least squares means for overall calf mortality for MN, MO, VA, and WA Holstein herds were 16.7, 12.5, 13.5, and 14.7%, respectively. These mortality rates were not significantly different at the $P<0.05$ level. A least squares mean was not reported for PA Holsteins because of incomplete calf mortality information. The raw mean for calf mortality in the PA Jersey herds was 15.8%.

Minnesota herds had an average herd size of 66 cows, smallest of the states participating. However, over 30% indicated that they had increased in herd size by more than 5% during the past year. Maternity pens were the most common calving facility and calf hutches were the most common calf housing. Since straw is readily available to herds in the Upper Midwest, it was used heavily for bedding in calving areas and in calf facilities. Calves were usually fed by family members (owner, spouse, or child) in these operations, reflective of the small, family farms found most often in the state. Seventy-five percent of these herds bred heifers by AI only. Surprisingly, 58% of these herds had a pre-calving group, a practice generally associated with larger herds.

The herds in MO represented the highest producing herds in the state. These herds had strong vaccination programs for dams and heifers. Pasture was the predominant calving area although maternity pens were used by more than 40% of herds. Calf hutches were used on roughly 60% of farms. Straw was readily available and was the major bedding source reported. Seventy-three percent of herds stored frozen colostrum for later use. The MO herds relied on a mixture of AI and natural service to breed heifers. Only 39% of herds relied exclusively on AI.

Some information on PA Holstein herds was limited because of missing calf mortality data. Stanchions or tie stalls which are common in the Northeast were the predominant calving facilities in these herds. Herds bedded with hay and sawdust most often. Eighty-five percent fed first colostrum through a bucket or bottle, but only 14.3% froze colostrum for later use. Seventy-one percent of these herds tied calves. It was not known whether calves were tied indoors or outdoors based on survey responses. These herds had the lowest brucellosis vaccination rate of any of the states at 61.9% and the lowest utilization of coccidiostats/coccidiocides at 57.1%. The PA herds relied less on AI. Natural service was used exclusively on 28.6% of farms and at least partially on 76.2% of farms. These herds used estrous synchronization less. Only 18.8% had a pre-calving group for springing heifers and none had a separate group for first calf heifers.

Virginia had the lowest rate for deworming the milking herd at 31.3%. This rate is half that of other states and was most likely lower because veterinary educators in VA have discouraged this practice. Virginia herds relied very heavily on pasture as a calving location as reported by 93.8% of herds. Calves were allowed to nurse the dam on 68.8% of farms. This rate was higher than for other states, but was not surprising because producers are not as likely to remove calves from the dam as soon when pasture is used. Virginia had the highest least squares mean for age when the calf was separated from the dam at 1.1 d. Calves were predominantly housed in individual pens in barns separate from the milking herd. Two-thirds of herds reported grain intake as a criterion for weaning calves. Least squares mean for weaning age was 7.8 wk. Nearly 88% of herds dewormed heifers which was reflective of heavy pasture utilization for heifers in the state. Fifty-six percent of herds used estrous synchronization. An equal percentage used AI exclusively whereas 18.8% only used natural service on heifers.

Washington herds were the largest and highest producing herds in the survey. These herds mostly used maternity pens housed separately from the milking herd as a calving facility. Pasture received only limited use as a calving area most likely due to larger herd sizes and wet, rainy conditions often observed in the state. Straw and kiln dried sawdust were most frequently used as bedding sources. Producers used buckets, bottles, or esophageal feeders to deliver first colostrum to calves. Calf hutches and individual pens in separate barns were most frequently used for calf housing. Hired help was the largest labor source for feeding calves as would be expected in larger herds. All WA herds in the survey reported vaccinating against brucellosis. Vaccination rates were also high for IBR, BVD, PI3, BRSV, and leptospirosis. All herds used AI although only 38.5% used AI exclusively and 61.5% synchronized heifers for estrous. Washington herds were most likely to have a pre-calving group for springing heifers and to group first calf heifers separate from older cows.

VIRGINIA CUSTOM DAIRY HEIFER REARING SURVEY

Prevalence of custom heifer rearing is expected to increase in many parts of the country over the next few years. However, in order for more dairy producers to opt for this method of heifer rearing, custom growers will need to raise heifers at a lower cost and/or raise a higher quality heifer than the dairy producer.

The VA Custom Dairy Heifer Grower Survey raised concerns about custom heifer rearing. The first concern was the lack of written contracts between custom growers and dairy producers. Only two of fifteen growers reported having a written contract. None of the growers had an identified third party to assist in solving disputes or in assigning blame in the event of death or poor performance of heifers. The relationship between grower and owner must be considered a business arrangement. A written contract serves as a guide for what is expected of both parties and may include length of contract, number of animals, rates of payment (per diem, per pound of gain, per head), frequency of payments, defined grower and owner responsibilities, a third party to negotiate disputes, and terms for cancellation or renewal of the contract.

Custom heifer growers market growth of animals as their product. Unfortunately, 58% of the growers surveyed reported that they never monitor heifer growth through the use of scales, weight tapes or wither height sticks. Growth is to the heifer grower as milk production is to the dairy producer. Growers need to be knowledgeable about growth rates to determine ADG and costs per pound of gain. This information may be used to evaluate the feeding program, measure progress toward growth goals, and conduct weak link analyses on heifer groups.

Forage testing and ration balancing were underutilized because only 58% took advantage of these tools. Feed costs account for about 55% of the cost of rearing a heifer from birth to calving (Webb, 1992). A relatively small savings in feed cost per head per day can add to a large cost savings at the end of the year. By forage testing and ration balancing, growers could better match concentrates to forages available and potentially reduce their feed costs. Animal performance may also be improved through balanced diets.

Forty-three percent of growers did not use AI in their herds. Only 8.7% used AI as the exclusive method for breeding heifers. While not documented, conversations with growers indicated that producers with whom they worked were more interested in having a fresh heifer than the calf. Growers tended to view AI as an unnecessary chore unless producers were willing to pay for the service.

When responses from growers in the Virginia Custom Dairy Heifer Rearing Survey were compared to VA producers in the NC-119 Heifer Management Survey, several differences were observed. Table 39 summarizes responses for questions common to both surveys. Percent of herds vaccinating against brucellosis, IBR, BVD, PI3, and leptospirosis was lower in custom grower operations. This result causes concern. Biosecurity is an important issue in the custom dairy heifer growing industry. It is more critical for custom growers to have strong vaccination programs because of the commingling of cattle from multiple herds. Custom growers were more likely to deworm heifers. However, they were less likely to use coccidiostats or coccidiocides than dairy producers because most were acquiring cattle beyond the postweaning transitional period which is the most risky stage of life for coccidiosis. Although calf housing choices were similar, a few custom growers used group housing for preweaned calves whereas dairy producers did not. Calves are more prone to suckle one another in group housing situations.

Heifer growers must provide a special service for dairy producers in order for custom growing to be considered a viable option. Results of the Virginia Custom Dairy Heifer Rearing Survey indicated that custom growers need to pay more attention to business arrangements with heifer owners. Feeding, breeding, and vaccination programs were other areas that deserve more grower attention. This industry is still relatively new to the state, but is a business of reputation. Dairy producers will be unwilling to pay someone else for “back forty” or low level management. To be competitive, custom growers will need to be good business managers. Knowledge of production costs is critical. Custom growers in other parts of the country where the industry is larger and more mature can quote their costs per pound of gain on almost a daily basis. The ultimate test of a quality program is customer satisfaction when the heifer enters the milking herd.

Table 39. Comparison of management practices of VA producers in the NC-119 Heifer Management Survey and growers in the Virginia Custom Dairy Heifer Rearing Survey.

Item	Survey	
	NC-119 VA Herds	VA Custom Growers
	-------------- % of herds in survey --------------	
Offered forage pre-weaning	62.5	60.0
Offered water pre-weaning	62.5	80.0
<u>Calf Housing</u>		
Hutches	37.0	60.0
Group pens - outdoors	0.0	10.0
Group pens - indoors, separate barn	0.0	30.0
Individual pens, separate barn	62.5	60.0
Tied	12.5	10.0
<u>Weaning Criteria</u>		
Size	26.7	40.0
Age	20.0	20.0
Grain intake	66.7	60.0
Other	0.0	20.0
<u>Heifer vaccinations</u>		
Brucellosis	93.8	85.0
IBR	93.8	83.3
BVD	93.8	79.2
PI3	93.8	79.2
Leptospirosis	93.8	83.3
Dewormed heifers	87.5	95.8
Coccidiostat/Coccidiocide used	93.8	79.2
<u>Breeding Method</u>		
AI only	56.3	8.7
AI first time, then bull	6.3	8.7
AI first and second time, then bull	18.5	21.7
Bull only	18.8	43.5
Other AI and bull combinations	0.0	17.4
Estrous synchronization used	56.3	43.5

FUTURE NEEDS

Additional information will be needed in the future as producers make decisions on what practices to include in their heifer management program. Dairy producers and heifer growers will not only want to know that practices work, but will also need to know if they are cost effective. Costs of rearing heifers will need to be better defined by dairy producers and heifer growers. Partial budgeting to determine profitability of management practices and use of new technology could provide much information. Producer surveys can provide more data for the further development of simulation models of heifer rearing which examine consequences of changes in management practices.

The creation of the Professional Dairy Heifer Growers Association offers an opportunity for researchers to work with growers to collect growth and financial data. A national survey of custom heifer growers is needed to characterize this industry. The VA Custom Dairy Heifer Rearing Survey could serve as a starting point for a national survey. Performance data should be included in future surveys. Average daily gains, calf mortality rates, and age at first calving should be considered as performance data options. In addition, the survey should be conducted consistently between states. A standard, random selection process wold give more validity to the survey. Collection of growth data on a large scale is another possibility with this group in the future.

BIBLIOGRAPHY

1. Bethard, G. L. 1997. A microcomputer simulation to evaluate management strategies for rearing dairy replacements. Ph.D. Diss., Virginia Tech, Blacksburg.

2. Bethard, G. L., R. E. James, and M. L. McGilliard. 1997. Effect of rumen-undegradable protein and energy on growth and feed efficiency of growing Holstein heifers. J. Dairy Sci. 80:2149-2155.

3. Bolton, K. 1992. Know what it costs to raise your heifers. Hoard's Dairyman, May 10, page 378.

4. Bungert, Kimberly. 1998. Give your heifer grower a raise. Dairy Herd Management. Feb., pages 44, 48.

5. Choi, Y. J., I. K. Han, J. H. Woo, H. J. Lee, K. Jang, K. H. Myung, and Y. S. Kim. 1997. Compensatory growth in dairy heifers: the effect of a compensatory growth pattern on growth rate and lactation performance. J. Dairy Sci. 80:519-524.

6. Ely, L. O. and R. E. Brown. 1984. Raising dairy replacements heifer budget. University of Georgia Cooperative Extension, Athens.

7. Etgen, W. M., R. E. James, and P. M. Reaves. 1987. Dairy Cattle Feeding and Management. 7th ed. John Wiley and Sons, New York, NY.

8. Foster, W. W. 1988 Microcomputer simulation of management practices affecting timing of net income in dairy cattle. Ph.D. Diss., Virginia Tech, Blacksburg.

9. Gardner, R. W., L. W. Smith, and R. L. Park. 1988. Feeding and management of dairy heifers for optimal lifetime productivity. J. Dairy Sci. 71:996-999.

10. Gill, G. S. and F. R. Allaire. 1976. Relationship of age at first calving, days open, days dry, and herdlife to a profit function for dairy cattle. J. Dairy Sci. 59:1131-1139.

11. Goodger, W. J. and E. M. Theodore. 1986. Calf management practices and health management decisions on large dairies. J. Dairy Sci. 69:580-590.

12. Greenwood, R. H., J. L. Morrill, and E. C. Titgemeyer. 1997. Using dry feed intake as a percentage of initial body weight as a weaning criterion. J. Dairy Sci. 80:2542-2546.

13. Hartman, D. A., R. W. Everett, S. T. Slack, and R. G. Warner. 1974. Calf Mortality. J. Dairy Sci. 57: 576-578.

14. Head, H. H. 1992. Heifer performance standards: rearing systems, growth rates and lactation. Pages 422-433 *in* Large Dairy Herd Management. H. H. Van Horn and C. J. Wilcox, ed. American Dairy Science Association, Champaign, IL.

15. Heinrichs, A. J. 1993. Raising dairy replacements to meet the needs of the 21st century. J. Dairy Sci. 76:3179-3187.

16. Heinrichs, A. J., R. E. Graves, and N. E. Kiernan. 1987a. Survey of calf and heifer housing on Pennsylvania dairy farms. J. Dairy Sci. 70:1952-1957.

17. Heinrichs, A. J. and G. L. Hargrove. 1987. Standards of weight and height for Holstein heifers. J. Dairy Sci. 70:653-660.

18. Heinrichs, A. J., N. E. Kiernan, R. E. Graves, and L. J. Hutchinson. 1987b. Survey of calf and heifer management practices in Pennsylvania dairy herds. J. Dairy Sci. 70:896-904.

19. Heinrichs, A. J. and L. A. Swartz. 1990. Management of dairy heifers. Ext. Circ. 385, Pennsylvania State University, University Park.

20. Heinrichs, A. J., S. J. Wells, H. S. Hurd, G. W. Hill, and D. A. Dargatz. 1994. The National Dairy Heifer Evaluation Project: a profile of heifer management practices in the United States. J. Dairy Sci. 77:1548-1555.

21. Heinrichs, A. J., S. J. Wells, and W. C. Losinger. 1995. A study of the use of milk replacers for dairy calves in the United States. J. Dairy Sci. 78:2831-2837.

22. Hoffman, P. C. 1992a. Before you hire your heifers raised. Hoard’s Dairyman, Aug. 10, page 533.

23. Hoffman, P. C. 1992b. What it’s worth to have heifers raised. Hoard’s Dairyman, Sept. 10, page 615.

24. Hoffman, P. C. 1993. Custom rearing arrangements for dairy replacement heifers: concepts and considerations. Pages 127-135 *in* Proc. Second Biennial Northeast Heifer Management Symposium. Syracuse, NY. Cornell Univ., Ithaca, NY.

25. Hoffman, P. C. 1997a. Optimum body size of Holstein replacement heifers. J. Anim. Sci. 75:836-845.

26. Hoffman, P.C. 1997b. What should we charge for raising heifers? Hoard’s Dairyman, Mar. 25, page 235.

27. Hoffman, P. C., N. M. Brehm, S. G. Price, and A. Pril-Adams. 1996. Effect of accelerated postpubertal growth and early calving on lactation performance on primiparous Holstein heifers. J. Dairy Sci. 79: 2024-2031.

28. Hoffman, P. C. and D. A. Funk. 1992. Applied dynamics of dairy replacement growth and management. J. Dairy Sci. 75:2504-2516.

29. James, R. E., M. L. McGilliard, and D. A. Hartman. 1984. Calf mortality in Virginia Dairy Herd Improvement herds. J. Dairy Sci. 67:908-911.

30. Jenny, B. F., G. E. Gramling, and T. E. Glaze. 1981. Management factors associated with calf mortality in South Carolina dairy herds. J. Dairy Sci. 64:2284-2289.

31. Jordan, E. R. and R. H. Fourdraine. 1993. Characterization of the management practices of the top milk producing herds in the country. J. Dairy Sci. 76:3247-3256.

32. Karszes, J. A. 1994. Dairy replacement programs: costs and analysis Western New York, 1993. Bulletin No. 174, Cornell Cooperative Extension, Ithaca, NY.

33. Karszes, J. A. and B. F. Stanton. 1991a. Custom raising dairy replacements: practices and costs, 1990. Bulletin No. 91-24, Cornell Cooperative Extension, Ithaca, NY.

34. Karszes, J. A. and B. F. Stanton. 1991b. Raising dairy replacements: practices and costs, New York, 1990. Bulletin No. 91-12, Cornell Cooperative Extension, Ithaca, NY.

35. Little, W. and R. M. Kay. 1979. The effects of rapid rearing and early calving on the subsequent performance of dairy heifers. Anim. Prod. 29:131-142.

36. Losinger, W. C. and A. J. Heinrichs. 1996. Dairy operation management practices and herd milk production. J. Dairy Sci. 79:506-514.

37. Matthews, C. A. and M. H. Fohrman. 1954. Beltsville growth standards for Holstein cattle. USDA Tech. Bull. No. 1099.

38. McShane, T. M., K. K. Schillo, J. A. Boling, N. W. Bradley, and J. B. Hall. 1989. Effects of recombinant DNA-derived somatotropin and dietary energy intake in developing beef heifers: I Growth and puberty. J. Anim. Sci. 67:2230-2236.

39. Meinert, R. A., C. M. J. Yang, A. J. Heinrichs, and G. A. Varga. 1992. Effect of monensin on growth, reproductive performance, and estimated body composition in Holstein heifers. J. Dairy Sci. 75:257-261.

40. Miller, W. J. and H. E. Amos. 1986. Feeding dairy heifers in the current economic climate. Feedstuffs, Feb. 10, pages 28-30, 35.

41. Moseley, W. M., J. B. Paulissen, M. C. Goodwin, G. R. Alaniz, and W. H. Claflin. 1992. Recombinant bovine somatotropin improves growth performance in finishing beef steers. J. Anim. Sci. 70:412-425.

42. Mourits, M. C. M., A. A. Dijkhuizen, R. B. M. Huirne, and D. T. Galligan. 1997. Technical and economic models to support heifer management decisions: basic concepts. J. Dairy Sci. 80:1406-1415.

43. National Dairy Heifer Evaluation Project. 1993. Dairy herd management practices focusing on preweaned calves. U.S. Department of Agriculture, Washington, D. C.

44. National Research Council. 1988. Nutrient Requirements of Dairy Cattle. 6^{th} rev. ed. Natl. Acad. Sci., Washington, DC.

45. Park, C. S., G. M. Erickson, Y. J. Choi, and G. D. Marx. 1987. Effect of compensatory growth on regulation of growth and lactation: response of dairy heifers to a stair-step growth pattern. J. Anim. Sci. 64:1751-1758.

46. Pecsok, S. R. and J. N. Spain. 1992. Optimal heifer growth rates based on forage and concentrate price relationships. J. Dairy Sci. 75:2030-2037.

47. Pennsylvania DHIA. 1994. Pennsylvania Dairymen's Yearbook. State College, PA.

48. Quigley, III, J. D. 1996. Influence of weaning method on growth, intake, and selected blood metabolites in Jersey calves. J. Dairy Sci. 79:2255-2260.

49. Powell, R. L. 1985. Trend of age at first calving. J. Dairy Sci. 68:768-772.

50. Radcliff, R. P., M J. Vandehaar, A. L. Skidmore, L. T. Chapin, B. R. Radke, J. W. Lloyd, E. P. Stanisiewski, and H. A. Tucker. 1997. Effects of diet and bovine somatotropin on heifer growth and mammary development. J. Dairy Sci. 80:1996-2003.

51. Randle, R. F., D. K. Hardin, and J. M. Zulovich. 1998. The Missouri system of dairy heifer production. Pages 266-274 in Proc. Fourth International Dairy Housing Conference, St. Louis, MO. American Society of Agricultural Engineers, St. Joseph, MI.

52. SAS® System for Windows, release 6.12. 1996. SAS Institute Inc., Cary, NC.

53. Simerl, N. A., C. J. Wilcox, and W. W. Thatcher. 1992. Postpartum performance of dairy heifers freshening at young ages. J. Dairy Sci. 75:590-595.

54. Simerl, N. A., C. J. Wilcox, W. W. Thatcher, and F. G. Martin. 1991. Prepartum and peripartum reproductive performance of dairy hefiers freshening at young ages. J. Dairy Sci. 74:1724-1729.

55. Sjersen, K., J. Foldager, M. T. Sorensen, R. M. Akers, and D. E. Bauman. 1986. Effect of exogenous bovine somatotropin on prepubertal mammary development in heifers. J. Dairy Sci. 69:1528-1535.

56. Sjersen, K., J. T. Huber, H. A. Tucker, and R. M. Akers. 1982. Influence of nutrition on mammary development in pre- and postpubertal heifers. J. Dairy Sci. 65:793-800.

57. Sjersen, K. and S. Purup. 1997. Influence of prepubertal feeding level on milk yield potential of dairy heifers: a review. J. Anim. Sci. 75:828-835.

58. Smith, T. R. 1992. Dairy replacement economics. National Dairy Database. University of Maryland, College Park.

59. Smith, T. R. 1993. Dairy replacement economics. Pages 117-126 *in* Proc. Second Biennial Northeast Heifer Management Symposium. Syracuse, NY. Cornell Univ., Ithaca, NY.

60. Stallings, C. C., M. L. Wahlberg, and R E. James. 1992. Ionophores for dairy heifers. Publication No. 404-103, Virginia Cooperative Extension, Blacksburg.

61. Stelwagen, K. and D. G. Grieve. 1990. Effect of plane of nutrition on growth and mammary gland development in Holstein heifers. J. Dairy Sci. 73:2333-2341.

62. Swanson, E. W. 1960. Effect of rapid growth with fattening of dairy heifers on their lactational ability. J. Dairy Sci. 43:377-387.

63. Swanson, E. W. 1967. Optimum growth patterns for dairy cattle. J. Dairy Sci. 50:244-252.

64. Swanson, E. W. and S. A. Hinton. 1964. Effect of seriously restricted growth upon lactation. J. Dairy Sci. 47:267-272.

65. Tomlinson, D. L., R. E. James, G. L. Bethard, and M. L. McGilliard. 1997. Influence of undegradability of protein in the diet on intake, daily gain, feed efficiency, and body composition of dairy heifers. J. Dairy Sci. 80:943-948.

66. Toro, E. O. 1987. A simulation to compare systems of raising dairy heifers. Ph.D. Diss., Virginia Tech, Blacksburg.

67. Van Amburgh, M. E. and D. M. Galton. 1993. Growth and nutrition of heifers from weaning to breeding age. Pages 59-80 *in* Proc. Second Biennial Northeast Heifer Management Symposium. Syracuse, NY. Cornell Univ., Ithaca, NY.

68. Van Amburgh, M. E. and D. M. Galton. 1994. Accelerated growth of Holstein heifers - effects on lactation. Pages 147-154 *in* Proc. Cornell Nutrition Conference, Ithaca, NY, Cornell Univ.

69. Van Amburgh, M. E., D. M. Galton, D. E. Bauman, R. W. Everett, D. G. Fox, L. E. Chase, and H. N. Erb. 1998. Effects of three prepubertal body growth rates on performance of Holstein hefiers during first lactation. J. Dairy Sci. 81:527-538.

70. Van Amburgh, M. E., D. M. Galton, D. G. Fox, and D. E. Bauman. 1991. Optimizing heifer growth. Pages 85-93 *in* Proc. Cornell Nutrition Conference, Ithaca, NY. Cornell Univ.

71. Veldman-Edmonds, T. M. 1996. A survey of Washington heifer management practices and their effects on age at first calving, growth, and costs. M.S. Thesis, Washington State Univ., Pullman.

72. Vestergaard, M., K. Sejrsen, J. Foldager, S. Kastrup, and D. E. Bauman. 1993. The effect of bovine growth hormone on growth, carcass composition, and meat quality of dairy heifers. Acta. Agric. Scand. 43:165.

73. Virginia Cooperative Extension Farm Management Staff. 1997. Dairy farm budgets. Virginia Tech, Blacksburg.

74. Webb, D. W. 1992. Replacement economics. Pages 434-439 *in* Large Dairy Herd Management. H. H. Van Horn and C. J. Wilcox, ed. American Dairy Science Association, Champaign, IL.

75. Willet, G. S., J. W. Bernard, R. A. Cady, G. R. Fredricks, D. C. Grusenmeyer, W. H. Madison, R. W. Matthews, and E. L. Thomason. 1992. Dairy heifer enterprise budget. Farm Business Management Reports. Ext. Bulletin 1319. Washington State Univ., Pullman.