**NUTRITION AND ENVIRONMENT - IMPROVING HEIFER GROWTH**

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## I. Heifer Growth Objectives

The objectives of an excellent dairy herd replacement program are well defined. A long-standing age of first calving recommendation has been 23 to 24 months to maximize profitability. Numerous studies and evaluations (5, 6, 9) have demonstrated the advantages of 24 month calving ages.

Critical to the success of 24 month calving age is proper calving weight, height, and body condition score. Hoffman and Funk (8) defined these criteria in an evaluation of high producing dairy herds (RHA > 22,000 lb). Holstein replacement heifers in high producing herds had an average weight, height, and condition score at calving of 1375 lb, 54.1 in, and 3.5, respectively (Table 1). Replacement heifers on commercial farms surveyed by Hoffman and Funk had prepuberty (3 to 10 months) growth rates of 1.8 lbs/d and postpuberty growth rates of 1.7 lbs/d. Holtz (9) reported identical growth rates of Holstein replacement heifers from high producing (22,500 lbs/lactation) New York dairy herds.

## II. Basic Nutrition

Suggested ration specifications (14) for replacement heifers gaining 1.7 to 1.8 lbs/day are presented in Table 2. Nutrient recommendations (14) are based on the following assumptions: replacement heifers are clean and dry, fed ad libitum, free of disease and parasites, unbred, and raised at moderate temperatures.

All these assumptions seldom apply to a commercial dairy herd. As a consequence, nutrient requirements need to be adjusted for special environmental and management conditions. The following text and tables define factors that alter basic nutrition requirements for replacement heifers.

## III. Nutrition-Environment/Management Relationships

### 1. Temperature

Maintenance energy ($NE_m$; Mcal) for Holstein replacement heifers is established (14) at .086 ($LW^{.75}$); (LW = live weight, kg). The equation assumes replacement heifers are raised in a thermal neutral environment (20 C; 68 F).

This equation is used to establish base energy requirements and dietary energy density for replacements heifers. The equation does not, however, accurately define $NE_m$ requirements for replacement heifers raised in cold climates where temperatures are commonly below 68 F.

Average temperatures for summer, spring/fall, and winter at Marshfield, WI are 68.4, 45.8, and 18.8 F, respectively. Therefore, $NE_m$ requirements established using the NRC equation of .086 ($LW^{.75}$) are only valid during the summer months in Wisconsin.

The National Research Council (12) defines $NE_m$ adjustments based on temperature to which the animal is exposed. For each C above or below 20 C, .0007 should be subtracted or added to the constant (.086) in the $NE_m$ equation .086 ($LW^{.75}$). Net result of this adjustment is increased $NE_m$ at temperatures < .20 C and decreased $NE_m$ at temperatures >.20 C. Table 3 defines $NE_m$ requirements for 300, 600, 900, and 1200 lb replacement heifers at various temperatures. Average seasonal temperatures (Marshfield, WI) are also highlighted in Table 3. As a result of temperature adjustment, $NE_m$ requirements are 12.4 and 24.7% higher for fall/spring and winter, respectively, as compared to summer.

Many studies (2, 7, 15) confirm that not accounting for increased $NE_m$ requirements of replacement heifers in cold weather results in decreased average daily gain (ADG). Hoffman et al. (7) evaluated 1257 replacement heifers in 18 commercial dairy herds and observed ADG of 1.90, 1.70, and 1.60 lb/d for Holstein replacement heifers raised in open housing during summer, fall/spring, and winter, respectively. Energy level of replacement heifer diets fed by commercial dairy herd producers were calculated and no adjustments in dietary energy level by season were observed (7). These data suggest that failure to provide increased dietary energy during cold seasons can result in ADG reductions of .2 to .4 lb/d.

2. Cold Stress - Body Mud

A second $NE_m$ adjustment is required for replacement heifers experiencing cold stress. Maintenance energy ($NE_m$) required for cold stress is different from previously discussed temperature, $NE_m$ adjustments.

Main factors associated with cold stress are temperature, animal size, wind, and insulation capacity of the animal. Temperature is an obvious factor in cold stress. The lower the temperature, the greater the potential for cold stress. Animal size is important as larger replacement heifers are less sensitive to cold stress than smaller replacement heifers. Exposure to wind also increases heat loss and the potential for cold stress. Most commonly, destruction of hair coat integrity by snow, rain, mud, or manure induces cold stress (12).

Adjusting $NE_m$ requirements of replacement heifers for cold stress requires a sensible, logical approach. Duration and severity of the cold stress period play important roles in this assessment. At minimum, $NE_m$ of replacement heifers should be adjusted for conditions where hair coat insulation is poor (wet or muddy). Table 4 presents a theoretical approach to adjust $NE_m$ for these factors (12).

Clean, dry replacement heifers with excellent hair coat insulating capacity can withstand relatively cold temperatures and require only modest $NE_m$ adjustments in cold weather. Conversely, $NE_m$ requirements of replacement heifers with heavily mud-laden hair coats rise dramatically when temperatures fall below 23, 14, 14, and 5 F for 300, 600, 900, and 1200 lb replacement heifers, respectively. At extremely low temperatures < 0 F, $NE_m$ requirements of replacement heifers with heavily mud-laden hair coats may rise dramatically and ration energy manipulation cannot safely meet $NE_m$ requirements and support optimum growth. Under extreme cold stress, replacement heifers may not meet $NE_m$ requirements and will catabolize body tissue to generate heat and correspondingly lose weight.

Replacement heifers in the upper midwest commonly encounter cold stress. Adjusting rations to meet cold stress $NE_m$ requirements needs to be done carefully. Extremely high energy diets formulated to meet cold stress energy needs may not meet minimum levels of dietary fiber to maintain proper rumen function. In these situations, correction of the environment is a more logical approach to maintaining replacement heifer growth.

3. Temperature - Dry Matter Intake

Dry matter intake of replacement heifers is inversely related to temperature. As temperature increases (> 77 F), dry matter intake decreases and as temperature decreases (< 59 F), dry matter intake increases (12). Changes in dry matter intake due to temperature should be accounted for in ration formulation. Table 5 defines the temperature effects on dry matter intake.

Adjusting dry matter intakes downward due to intake depression caused by high temperatures may also be required. High temperature extremes > 80 F short in duration and the negative effects associated with depressed dry matter intake are, however, commonly alleviated by compensatory gain.

Dry matter intake should be increased when temperatures are below 59 F. While data support increased intakes during cold weather (12), factors such as muddy lots, frozen feed, frozen water, and storms can temporarily depress dry matter intake.

4. Housing Type

To realistically adjust replacement heifer energy requirements for environmental conditions, true environment of the replacement heifer must be defined. Replacement heifers reared in intensively managed confinement buildings are not exposed to wind, snow, rain, or ambient temperatures. Placing such factors into nutritional programs would result in a high degree of ration formulation error. Infinite housing systems are utilized and careful assessment of true environment of individual housing systems is required.

Housing systems can greatly alter performance of growing animals. Smith et al. (15) fed 650 to 700 lb yearling feedlot heifers a similar diet in an open lot during a summer (April to August) and winter (October to March) feeding periods. Average daily gain was significantly lower during the winter feeding period as compared to summer (2.37 vs. 2.86 lb/d). The study also examined the same treatments in a warm slotted-floor barn and observed no differences in ADG between winter and summer feeding periods (2.72 vs. 2.85 lb/d).

Hoffman et al. (7) observed similar results in commercial dairy herds. Growth of Holstein replacement heifers reared in intensively managed confinement barns was not different between summer, spring/fall, and winter feeding periods (1.9, 1.9, 2.0 lb/d). Average daily gain of replacement heifers reared in open housing declined, however, during cold seasons (summer = 1.9, spring/fall = 1.7, winter = 1.6 lb/d).

These data do not suggest cold housing is inferior to warm or confinement housing. These data suggest that the housing system in which replacement heifers are reared is the true environment. Factors of temperature, precipitation, wind, and mud within the housing system are the base for adjusting replacement heifer energy requirements, not ambient measurements.

5. Pasture

Replacement heifers grazing high quality pasture can easily meet growth objectives. Maintaining consistent growth rates in pasture systems can be challenging. Commonly, forage availability is limiting during the mid-summer grazing period. Estimation of forage intake and construction of a viable supplementation scheme is required. Supplements may require higher concentrations of protein and minerals to account for dry matter forage intakes or poor forage quality. In general, pasture supplementation schemes require minimal vitamin fortification. Vitamins A and E are relatively abundant in fresh forage and Vitamin D is metabolized in animals exposed to sun.

Supplemental magnesium is often required under certain pasture conditions. Lush, fertilized, cool season pastures have low magnesium availability, inducing grass tetany. In this situation, .25 to .30 percent dietary magnesium is recommended. Supplemental magnesium should be from a readily available source such as magnesium oxide.

6. Internal Parasites

Internal parasites can alter feed efficiency and result in reduced replacement growth. Hoffman et al. (7) found that Holstein replacement heifers exposed to pasture and not de-wormed had reduced growth rates during the fall and winter feeding periods. A 10% increase in maintenance energy requirements may be required for replacement heifers with high internal parasite infestations. While increasing energy density may recapture average daily gain losses due to internal parasites, proper de-worming programs are a more prudent management approach.

7. Gestation

Nutrient requirements for pregnancy are negligible for the first 6 months of gestation. In the last trimester of gestation, however, fetal growth is approximately .9 lbs per day. Replacement heifers have nutrient requirements for maintenance, body and fetal growth during the last trimester of gestation. Often bred replacement heifers are fed low energy or dry cow diets during late pregnancy. This management practice results in the shifting of dietary energy from body growth to fetal growth. This results in replacement heifers that may be underweight or underconditioned at calving. Maintenance energy requirements ($NE_m$) should be increased 2.95 Mcals/day during the last 3 months of gestation (14). Protein, mineral, and vitamin requirements should be monitored to assure adequate intake.

8. Ionophore

Ionophores are well documented in improving feed efficiency and average daily gain of replacement heifers (1). The mode of action of both monensin and lasalocid is an improvement of energy utilization. When ionophores are fed to replacement heifers, net energy for gain ($NE_g$) requirements should be reduced by .23 Mcal/day.

9. Other Factors

There are numerous factors that can influence the nutrient requirements and ultimately the diet of replacement heifers. Table 6 identifies common environmental and management factors that should be considered in the formulation of heifer diets. For factors such as temperature, ionophore, etc., data are readily available to make appropriate nutrient adjustments. For other factors such as bunk space limitations, overcrowding, etc., research data are limiting on their effects and whether dietary compensation is feasible.

Conservative, logical nutrient adjustments can be made for factors with limited data if a heifer monitoring program is in affect to evaluate the response.

## IV. Practical Approaches

Programs are currently developed that account for environmental effects in replacement heifer diet formulation. Howard et al. (10) developed a dairy replacement heifer ration formulation program that adjusts replacement heifer diets based on housing type, season, deworming, body mud, and ionophore use. Adjustments used by Howard et al. (10) are highlighted in Table 7 and represent four uniquely different environmental scenarios in rearing an 800 lb Holstein replacement heifer at 1.8 lb/d. Environments are depicted as excellent, good, fair, and poor in relationship to $NE_m$ requirements of the animal. Under an excellent environment with low $NE_m$ requirements, 2.0 lb of shelled corn are required per day to support 1.8 lb/d ADG. Under a poor environment with high $NE_m$ requirements, 8.5 and .5 lbs of shelled corn and soybean meal, respectively, are required to maintain 1.8 lb/d ADG.

Fox et al. (3, 4) have also developed a ration formulation program for replacement heifers (Cornell Cattle Feeding Systems) which accounts for environment in ration formulation. The program of Fox et al. (3, 4) is uniquely different than of Howard et al. (10) in that specific environmental measurements such as temperature, wind speed, mud factors, hair length, etc., are required as input. While the programs of Fox et al. and Howard et al. differ in input approach, both programs make fundamentally similar changes in dietary energy under stressful environmental situations.

## V. Conclusions

The large climatic variation in the upper midwest has an extremely large influence on nutrient requirements of replacement heifers.

Data from our laboratory (7) suggest that estimating and formulating nutrient requirements for dairy replacement heifers based on environmental conditions could greatly enhance replacement heifer nutrition programs.

Ration formulation programs have and are currently being developed to account for environmental influences on replacement heifer nutrition. Speculatively, replacement heifer nutrition programs not accounting for temperature, precipitation, and body mud coverage will only be successful in summer and/or under perfect housing situations. Continued improvement of replacement heifer housing systems is also important in the overall improvement of replacement heifer management.

## REFERENCES


1 Crowley, J., N. Jorgensen, T. Howard, P. Hoffman, and R. Shaver. 1991. Raising dairy replacements. Univ. Wisconsin-Extension. North Central Reg. Ext. Publ. No. 205, Madison.

2 Defino, J. G., and G. W. Mathison. 1991. Effects of cold environment and intake level on the energetic efficiency of feedlot steers. J. Anim. Sci. 69:4577.

3 Fox, D. G. 1994. Personal Communication.

4 Fox, D. G., C. J. Sniffen, and J. D. O'Connor. 1988. Adjusting nutrient requirements of beef cattle for animal and environmental variations. J. Anim. Sci. 66:1475.

5 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.

6 Hoffman, P. C., and D. A. Funk. 1991. Growth rates of Holstein heifers in selected Wisconsin dairy herds. J. Dairy Sci. 74(Suppl. 1):212. (Abstr.)

7 Hoffman, P. C., N. M. Brehm, W. T. Howard, and D. A. Funk. 1994. The influence of nutrition and environment on growth of Holstein replacement heifers in commercial dairy herds. The Prof. Anim. Sci. (In press).

8 Hoffman, P. C., and D. A. Funk. 1991. Growth rates of Holstein replacement heifers in selected Wisconsin herds. College of Agricultural and Life Sciences Research Report. R3551. Univ. of Wisconsin-Madison.

9 Holtz, C. 1992. Personal communication.

10 Howard, W. T., P C. Hoffman, R. D. Shaver, and A. C. Wollenzien. 1993. HEIFER2.Users Guide. Department of Dairy Science Mimeo. University of Wisconsin, Madison, WI.

11 Lin, C. Y., A. J. McAllister, T. R. Batra, A. J. Lee, G. L. Roy, J. A. Vesely, and J. M. Wauthy. 1986. Production and reproduction of early and late bred dairy heifers. J. Dairy Sci. 69:760.

12 National Research Council. 1981. Effect of environment on nutrient requirements of domestic animals. Natl. Acad. Sci., Washington, DC.

13 National Research Council. 1984. Nutrient requirements of beef cattle. 6th rev. ed. Natl. Acad. Sci., Washington, DC.

14 National Research Council. 1989. Nutrient requirements of dairy cattle. 6th rev. ed. Natl.

Acad. Sci., Washington, DC.

15 Smith, R. E., H. E. Hanke, L. K. Lindor, R. D. Goodrich, and J. C. Meiske. 1978. Seasonal performance of yearling steers and heifers fed in five housing systems. West Central Experiment Station Research Report. B-243. Morris, MN.

TABLE 1.  Growth rates of Holstein replacement heifers calving at 24 months of age in high producing Wisconsin herds (8).

| Age (mo) | Weight (lbs) | | Height (in) | Body Condition |
|---|---|---|---|---|
| 1 | 130 | | 31.8 | - |
| 2 | 175 | | 33.4 | - |
| 3 | 220 | | 35.2 | 2.2 |
| 4 | 275 | | 27.1 | - |
| 5 | 335 | | 39.0 | - |
| 6 | 410 | | 41.1 | 2.3 |
| 7 | 475 | | 42.8 | - |
| 8 | 520 | | 43.8 | - |
| 9 | 600 | | 45.4 | 2.4 |
| 10 | 655 | | 46.5 | - |
| 11 | 705 | | 47.4 | - |
| 12 | 775 | | 48.5 | 2.8 |
| 13 | 825 | Breeding Age | 49.1 | - |
| 14 | 870 | | 49.7 | - |
| 15 | 940 | | 50.4 | 3.0 |
| 16 | 950 | | 50.6 | - |
| 17 | 990 | | 51.0 | - |
| 18 | 1070 | | 51.7 | 3.2 |
| 19 | 1130 | | 52.2 | - |
| 20 | 1185 | | 52.7 | - |
| 21 | 1210 | | 52.9 | 3.4 |
| 22 | 1265 | | 53.3 | - |
| 23 | 1300 | | 53.5 | - |
| 24 | 1375 | | 54.1 | 3.5 |

TABLE 2. Ration specifications for Holstein replacement heifers gaining 1.7 to 1.8 lbs/day.

| Item | | Heifer weight (lbs) 300 | 600 | 900 | 1200 |
|---|---|---|---|---|---|
| Dry matter intake | lbs/day[1] | 8.3 | 14.3 | 20.3 | 26.4 |
| Energy | | | | | |
| $NE_m$ | Mcal/day | .78 | .70 | .63 | .55 |
| $NE_g$ | Mcal/day | .50 | .43 | .37 | .30 |
| TDN | % of DM | 69.0 | 65.0 | 61.0 | 57.0 |
| Protein | | | | | |
| Crude protein[2] | % of DM | 17.0 | 16.0 | 15.0 | 14.0 |
| UIP[3] | % of CP | 69.0 | 43.0 | 31.0 | 25.0 |
| DIP[3] | % of CP | 31.0 | 57.0 | 69.0 | 75.0 |
| NPN (Max) | % of CP | 10.0 | 15.0 | 20.0 | 20.0 |
| Urea (Max) | oz/day | .8 | 2.0 | 3.5 | 4.2 |
| Macro minerals | | | | | |
| CA | % of DM | .55 | .40 | .30 | .30 |
| P | % of DM | .32 | .30 | .23 | .23 |
| Mg[4] | % of DM | .16 | .16 | .16 | .16 |
| K | % of DM | .65 | .65 | .65 | .65 |
| Salt | % of DM | .30 | .30 | .30 | .30 |
| Micro minerals | | | | | |
| S | % of DM | .16 | .16 | .16 | .16 |
| Fe | ppm | 50 | 50 | 50 | 50 |
| Co | ppm | .10 | .10 | .10 | .10 |
| Cu | ppm | 10 | 10 | 10 | 10 |
| Mn | ppm | 40 | 40 | 40 | 40 |
| Z | ppm | 40 | 40 | 40 | 40 |
| I | ppm | .25 | .25 | .25 | .25 |
| Se | ppm | .30 | .30 | .30 | .30 |
| Vitamins | IU/head/day | | | | |
| A | | 6000 | 12000 | 18000 | 23000 |
| D | | 1000 | 2000 | 3000 | 4000 |
| E | | 100 | 150 | 225 | 300 |
| Ionophor[5] | mg/head/day | | | | |
| Monensin | | 200 | 200 | 200 | 200 |
| Lasalocid | | 100 | 200 | 200 | 200 |

[1] Dry matter intake as calculated by Howard et al. (10).
[2] Crude protein requirements are approximately 15.0% above NRC requirements and Appropriate when heifers are not fed ad libitum. If heifers are fed ad libitum, use NRC requirements, which are 16, 14, 12, 12% for 300, 600, 900, and 1200 lbs, respectively.
[3] NRC requirements for UIP and DIP are not well established. Formulation of UIP and DIP requirements may not be feasible < 600 lbs.
[4] Additional magnesium, .25 to .30% of DM, may be required when pasture conditions favor grass tetany.
[5] Ionophore feeding rates are based on use as a growth promotant and are not for Control of coccidiosis.

TABLE 3. Effect of temperature on $NE_m$ requirements of dairy replacement heifers.

| Temperature | | | Heifer Weight (lbs) | | | |
|---|---|---|---|---|---|---|
| C | F | Season [1] | 300 | 600 | 900 | 1200 |
| | | | $NE_m$ Mcal | | | |
| 30 | 86 | | 3.1 | 5.3 | 7.2 | 8.9 |
| 25 | 77 | | 3.3 | 5.5 | 7.5 | 9.3 |
| 20 | 68 | Summer | 3.4 | 5.8 | 7.8 | 9.7 |
| 15 | 59 | | 3.6 | 6.0 | 8.1 | 10.1 |
| 10 | 50 | | 3.7 | 6.2 | 8.4 | 10.5 |
| 5 | 41 | Fall/Spring | 3.8 | 6.5 | 8.8 | 10.9 |
| 0 | 32 | | 4.0 | 6.7 | 9.1 | 11.3 |
| -5 | 23 | | 4.1 | 6.9 | 9.4 | 11.7 |
| -10 | 14 | Winter | 4.3 | 7.2 | 9.7 | 12.1 |
| -15 | 5 | | 4.4 | 7.4 | 10.0 | 12.5 |
| -20 | -4 | | 4.5 | 7.6 | 10.4 | 12.8 |
| -25 | -13 | | 4.7 | 7.9 | 10.7 | 13.2 |
| -30 | -22 | | 4.8 | 8.1 | 11.0 | 13.6 |

[1] Season classifications correspond with average temperatures at Marshfield, WI.

TABLE 4. Effect of temperature and body mud on $NE_m$ requirements of dairy replacement heifers.

| Temperature C | Temperature F | Season[1] | 300 None | 300 Medium | 300 Heavy | 600 None | 600 Medium | 600 Heavy | 900 None | 900 Medium | 900 Heavy | 1200 None | 1200 Medium | 1200 Heavy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Heifer Weight (lbs) / Mud Condition[2] — $NE_m$ Mcal | | | | | | | | | | | |
| 30 | 86 | | 3.1 | 3.1 | 3.1 | 5.3 | 5.3 | 5.3 | 7.2 | 7.2 | 7.2 | 8.9 | 8.9 | 8.9 |
| 25 | 77 | | 3.3 | 3.3 | 3.3 | 5.5 | 5.5 | 5.5 | 7.5 | 7.5 | 7.5 | 9.3 | 9.3 | 9.3 |
| 20 | 68 | Summer | 3.4 | 3.4 | 3.4 | 5.8 | 5.8 | 5.8 | 7.8 | 7.8 | 7.8 | 9.7 | 9.7 | 9.7 |
| 15 | 59 | | 3.6 | 3.6 | 3.6 | 6.0 | 6.0 | 6.0 | 8.1 | 8.1 | 8.1 | 10.1 | 10.1 | 10.1 |
| 10 | 50 | | 3.7 | 3.7 | 3.7 | 6.2 | 6.2 | 6.2 | 8.4 | 8.4 | 8.4 | 10.5 | 10.5 | 10.5 |
| 5 | 41 | Fall/Spng | 3.8 | 3.8 | 3.8 | 6.5 | 6.5 | 6.5 | 8.8 | 8.8 | 8.8 | 10.9 | 10.9 | 10.9 |
| 0 | 32 | | 4.0 | 4.0 | 4.0 | 6.7 | 6.7 | 6.7 | 9.1 | 9.1 | 9.1 | 11.3 | 11.3 | 11.3 |
| -5 | 23 | | 4.1 | 4.1 | 4.2 | 6.9 | 6.9 | 6.9 | 9.4 | 9.4 | 9.4 | 11.7 | 11.7 | 11.7 |
| -10 | 14 | Winter | 4.3 | 4.3 | 5.3 | 7.2 | 7.2 | 8.4 | 9.7 | 9.7 | 10.6 | 12.1 | 12.1 | 12.1 |
| -15 | 5 | | 4.4 | 4.7 | 6.3 | 7.4 | 7.4 | 9.9 | 10.0 | 10.0 | 12.8 | 12.5 | 12.5 | 13.9 |
| -20 | -4 | | 4.5 | 5.7 | 7.2 | 7.6 | 8.9 | 11.4 | 10.4 | 11.2 | 14.7 | 12.8 | 12.8 | 16.3 |
| -25 | -13 | | 4.8 | 6.6 | 8.1 | 7.9 | 10.2 | 12.9 | 10.7 | 13.0 | 16.9 | 13.2 | 14.4 | 18.7 |
| -30 | -22 | | 5.6 | 7.4 | 9.0 | 8.1 | 11.5 | 14.7 | 11.0 | 14.7 | 20.1 | 13.6 | 16.5 | 22.2 |
| -35 | -31 | | 6.4 | 8.2 | 10.0 | 9.1 | 12.7 | 17.1 | 11.8 | 16.4 | 24.6 | 14.0 | 18.6 | 27.5 |
| -40 | -40 | | 7.1 | 8.9 | 11.1 | 10.3 | 14.2 | 20.3 | 13.7 | 18.6 | 31.0 | 15.2 | 21.1 | 35.7 |

[1] Average seasonal temperatures at Marshfield, WI.

[2] Mud condition: None = no mud, Medium = mud on legs/abdomen, Heavy = mud on legs, abdomen, sides, and/or flanks.

[3] The stairstep line represents the temperature at which cold stress is induced. Values below the stairstep line represent accelerated $NE_m$ requirements for cold stress situations.

TABLE 5.  The effect of temperature on dry matter intake (12).

| Temperature F | Effect |
|---|---|
| >95 | Intake depressed 10 to 35% |
| 77 to 95 | Intake depressed 3 to 10% |
| 59 to 77 | Use standard intake equations |
| 41 to 59 | Intake increased 2 to 5% |
| 23 to 41 | Intake increased 3 to 8% |
| 5 to 23 | Intake increased 5 to 10% |
| <5 | Intake increased 8 to 25% |

TABLE 6. Environmental and management factors that may affect replacement heifer nutrient requirements.

| | |
|---|---|
| - Temperature | - Bunk space |
| - Housing type | -Animal density |
| - Body mud | - Pasture stocking rate |
| - Internal parasites | - Feed mold |
| - Ionophore use | - Limit feeding |
| - Pasture quality | - Cold stress |
| - Gestation | - Heat stress |
| - Ventilation | - Water availability |
| - External parasites | - Disease |
| - Body condition | - Hair coat |
| - Wind | - Precipitation |
| - Feed bunk life | - Bedding/resting area |

TABLE 7. The effect of environment on ration formulation for an 800 lb Holstein replacement heifer gaining 1.8 lb/d. Howard et al. (10).

| Item | | Environment | | | |
|---|---|---|---|---|---|
| | | Excellent | Good | Fair | Poor[1] |
| **Environmental Input** | | | | | |
| Housing | | Open | Confinement | Open | Open |
| Season | | Summer | Fall | Spring | Winter |
| Dewormed | | Yes | No | Yes | No |
| Body mud | | None | Medium | Medium | Heavy |
| Ionophore | | Yes | Yes | No | No |
| **Feed Ingredient** | | | | | |
| Alfalfa silage[2] lbs, DM | | 16.4 | 13.5 | 12.8 | 9.2 |
| Shelled corn lbs, DM | | 2.0 | 4.8 | 5.4 | 8.5 |
| Soybean meal lbs, DM | | --- | --- | --- | .5 |
| Mineral/vitamin premix lbs, DM | | .08 | .09 | .09 | .07 |
| Salt lbs, DM | | .05 | .05 | .05 | .05 |
| **Nutrient Composition** | | | | | |
| Dry matter intake lb/d | | 18.3 | 18.4 | 18.4 | 18.5 |
| CP | % | 14.4 | 13.6 | 13.4 | 13.0 |
| ADF | % | 32.2 | 27.2 | 26.0 | 19.7 |
| NDF | % | 42.6 | 37.8 | 35.5 | 28.2 |
| Ca | % | 1.29 | 1.11 | 1.07 | .85 |
| P | % | .33 | .33 | .33 | .33 |
| TDN | % | 63.4 | 67.6 | 68.6 | 73.8 |
| $NE_m$ | Mcal/lb | .64 | .70 | .72 | .79 |
| $NE_g$ | Mcal/lb | .38 | .43 | .44 | .51 |

[1] Diet is below minimum fiber requirements for replacement heifers. Long term feeding of this and/or similar diets is not recommended.

[2] Alfalfa, CP = 15.0; ADF = 36.0; NDF = 47.0; Ca = 1.1; P = .26%.