6

CHAPTER 6. LIVESTOCK MANAGEMENT

Livestock management has changed greatly in recent years as a result of the mechanical revolution. Before, livestock raising was a labor-intensive enterprise, with considerable manual labor involved in caring for the animals, handling the hay and feed, and cleaning of the barns. Now, much of this work is done with machines; livestock raising has become a capital-intensive enterprise as machines harvest and store hay and grains, clean barns, and distribute manure. This, along with improved genetics, has resulted in marked increases in livestock production per man-hour of labor as indicated in Figure 6-1, based on data in the 1960 Yearbook of Agriculture.

READ Y-AXIS AS A MULTIPLE OF 1910

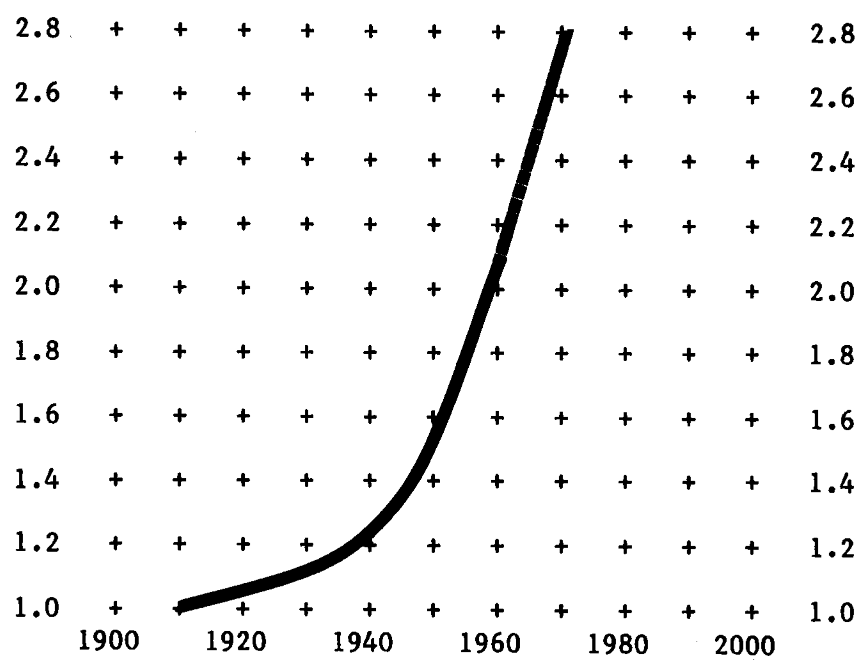


Figure 6-1. Production of livestock (dairy and beef cattle, and poultry) per man-hour of labor, expressed as a multiple of the production in 1910. (Source: Yearbook of Agriculture, 1960).

TOPIC 1. CATTLE MANAGEMENT

Cattle management is a large-scale enterprise in terms of dollars, size and numbers of animals, weight of feed required, labor, and overall herd responsibilities. Considering the value of each animal ($1,000-2,000), their weights (1,000-1,500 pounds), and the labor and knowledge required to feed and care for each of them properly, even a small herd demands much from the cattle farmer. The days when a few cows were kept for milk and butter are gone as the cattle industry has become a specialized enterprise with highly developed genetic selection and capital-intensive mechanization. Mechanization provides relief from some of the manual labor, but the animals still require the regular attention of a knowledgeable herdsman who is capable of early detection of problems. Some particulars regarding dairy and beef cattle management are given in the next two UNITS.

UNIT 1.1. DAIRY CATTLE

Dairy cattle management includes the feeding and care of the milk-producing animals and the care and handling of the milk. The average annual production of milk by dairy cattle has increased greatly in recent years due to improved feeding and management practices, and to genetic selection (Figure 6-2).

READ Y-AXIS IN THOUSANDS OF POUNDS

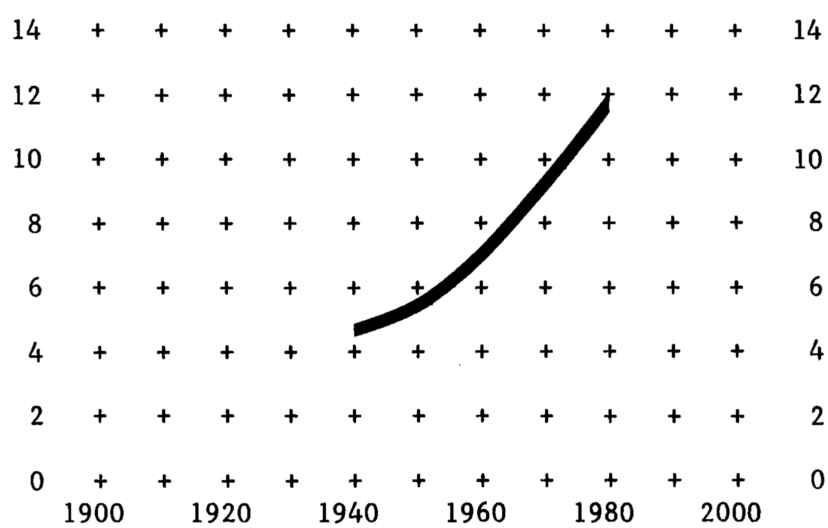


Figure 6-2. Average milk production per cow has risen rapidly in recent years.

BARN LAYOUTS

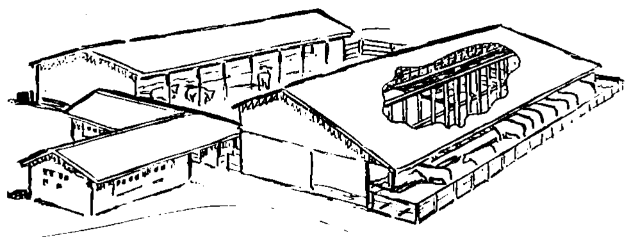
Three basic kinds of barn layouts are in use, including the stanchion barn, free-stall housing, and loose housing. Each of these has advantages and disadvantages, with the stanchion barn being the most labor-intensive and loose housing the least labor-intensive. Attention to individual cows is most easily given in the stanchion layout, and least in the loose housing.

Stanchion barns. The stanchion barn is the traditional dairy layout. Stanchion or tie-stall barns have individual stalls with devices for securing each cow in place. Each cow is treated as an individual, learns her place in the barn, and spends her time eating, resting, and being milked in that stall. The cows are let out to an exercise yard between feedings and milkings, and to pasture in the summer. Some stanchions are closed manually, and some are self-locking. Stanchion barns are usually 2-story structures, with hay stored in the hay mow, and upright silos usually stand beside the barn (Figure 6-2).

Figure 6-2. The typical dairy barn with silo, hay storage on the second floor, and stanchions or tie-stalls for the cows.

Free-stall. Free-stall housing provides stalls and a feeding area for a group of cows, and they may move from stalls to the feeding area as they wish. They are moved to a holding area and then to a milking parlor for each milking. Such a system may be more mechanized than a stanchion system, but has less individual cow care.

Loose housing. Loose housing is a fairly recent dairy development in which cows have free areas to resting and feeding areas between milkings. Daily labor is much reduced; One person can handle 50 to 60 milk cows in a loose housing, mechanized-feeding dairy operation. In the most advanced feeding systems, a cow carries an electronic device which transmits information on the amount of feed she is to receive, depending on milk production. When she stands at the feeder, the amount of feed programmed is supplied, and she eats. Then, she spends time in a "loafing area" resting and ruminating before being milked again. The layout in Figure 6-3 is an example of a loose-housing system.



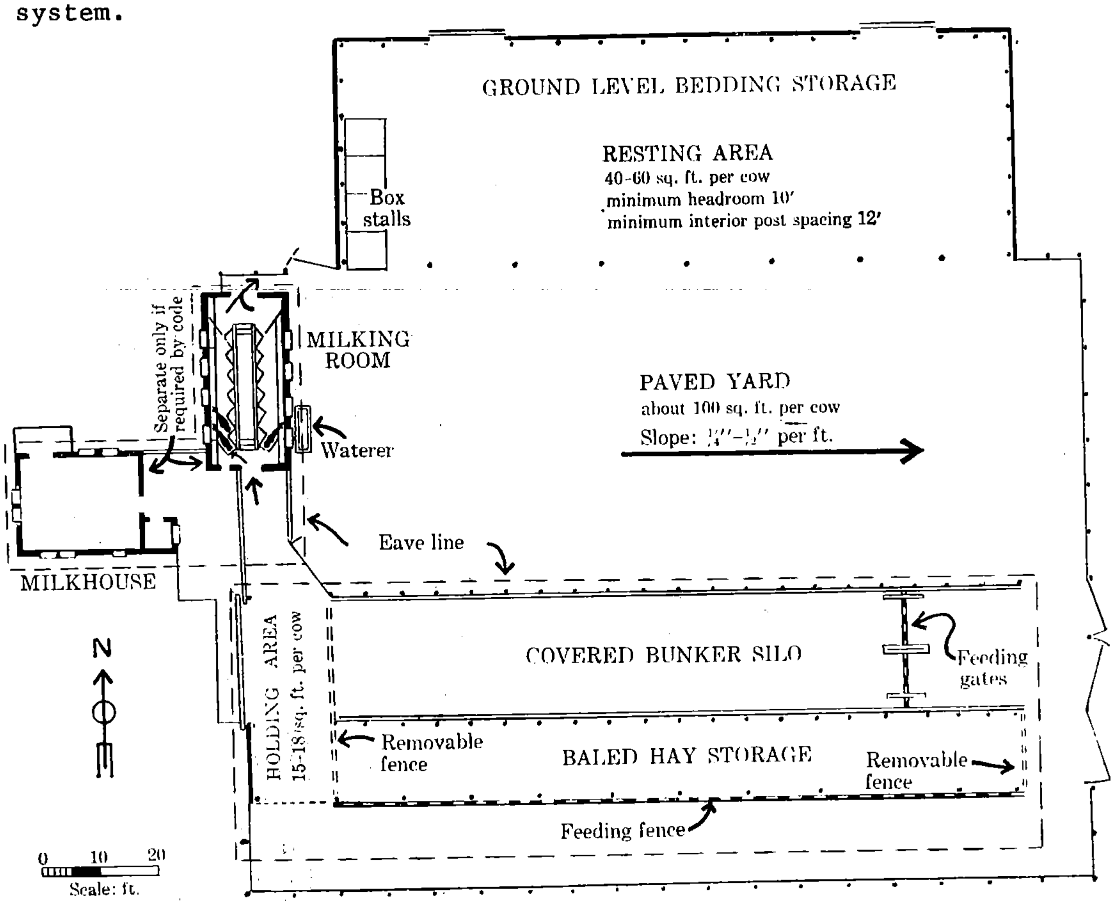


Figure 6-3. A loose-housing system for a dairy herd of about 50 cows. (Source: Yearbook of Agriculture 1960).

MILKING AND MILK HANDLING

Milking cows is not simply the attachment of a device to the teats to remove the milk. Lactogenesis is a continuous process as long as the milk is removed regularly, usually at 12-hour intervals, for about 10 months. Milk may be removed after the "let-down" hormone, oxytocin, is released. This results from stimuli such as washing and massaging the udder and teats, or from sounds associated with milking. Some cows respond more quickly than others. When milking was done by hand, each cow could be milked in relation to its "personality," and cows responded to the personalities of different milkers as well.

Several kinds of milking arrangements are available, with the kind chosen dependent on the manpower available, size of herd, production, size of the farm, weather, and other factors.

Stanchion barns. Milking in a stanchion barn is done by a milker who moves from cow to cow. The milking machine may be self-contained and collect the milk, or connected to a pipeline which leads to a cooling tank. Stanchion-barn milking is more labor-intensive than in a milking parlor, but allows for more attention to individual cows.

Milking rooms. Herds kept in loose housing or free-stall areas for feeding and resting are brought into a milking room (see Figure 6-3) where they are fed grain and milked. Four common designs of milking rooms are illustrated in Figure 6-4. Up to ten or more cows may be milked at one time.

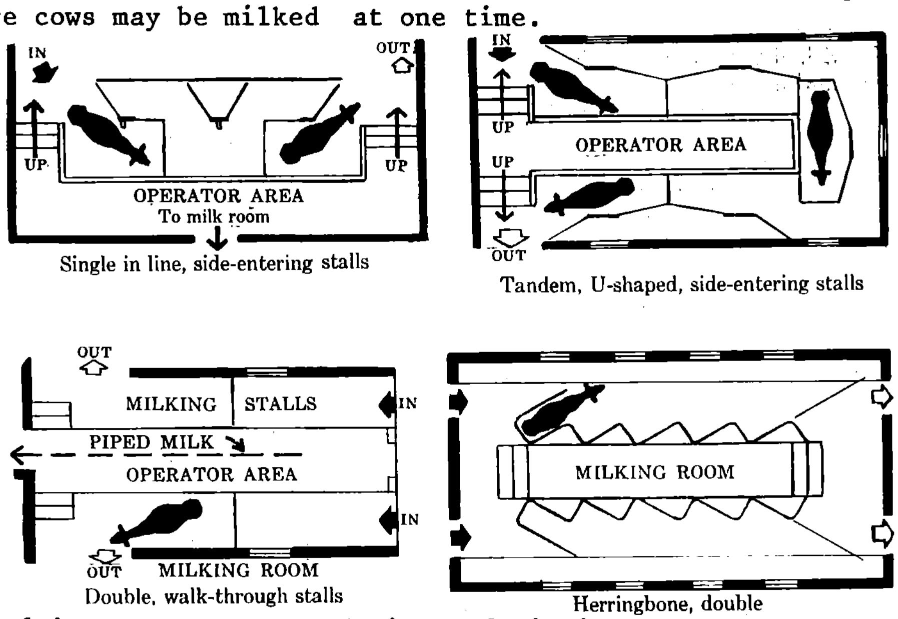


Figure 6-4. Four common designs of milking parlors. The double herringbone arrangement may be large enough to hold ten or more cows at one time. (Source: Yearbook of Agriculture, 1960).

Milk handling. Milk is a perishable product, and must be cooled and stored properly. Milking is done by machines with "teat cups" that go over the teats and have alternating suction and relaxation, a mechanical sucking effect. The milk goes to a pipeline and into a storage tank where it is cooled. After the milk is cooled in the milkhouse, it is then picked up by a refrigerated bulk milk truck and brought to a milk-processing plant where it is pasteurized, homogenized, irradiated with Vitamin D, and packaged for delivery to retail stores.

METABOLIC ENERGY REQUIREMENTS

The metabolic energy required by dairy cattle to maintain themselves and produce milk is a major biological consideration of the dairy farmer. Lactation is a very energy-demanding process, and dairy cattle must be fed a high quality ration in large quantities if milk production is to remain high. Further, activity requires energy, so dairy cattle are often not allowed to forage for themselves, but are fed to minimize the distance moved by each cow. Too little activity causes problems too, of course; the layout of barns and pastures is a matter of judgment for each operation.

An easy way to estimate the metabolic energy requirements of large ruminants is described in Moen (1978), where I presented the concept of base-line metabolism, multiples of base-line metabolism, and ecological metabolism. These are reviewed briefly here.

Base-line metabolism. One very useful expression for evaluating rates of energy metabolism for animals of different weights is base-line metabolism. This expression, which is numerically equal to (70)*(LWKG**0.75) KCAL per day (LWKG = live weight in kg), is a mathematical base-line, and is used as a divisor to determine a ratio called "multiple of base-line metabolism".

Multiple of base-line metabolism. When base-line metabolism is used as a common divider into the daily metabolic energy required per day, the resulting ratio is called the multiple of base-line metabolism (MBLM). MBLM is useful for comparisons between species and between sex, age, and weight classes within a species. Thus:

MBLM = metabolic energy required per day/base-line metabolism.

The ratio MBLM is weight-independent, and is especially useful when comparing ELMD for species with widely different weights, such as sheep and cattle and deer and moose.

Ecological metabolism. The total "cost of living" of a free-ranging animal is referred to as an ecological metabolic rate (Moen 1973). Dairy cattle and other farm animals have energy requirements that are dependent on their management; the concept of ecological metabolism applies to farm animals as well as wild ones. In terms of base-line metabolism and the multiple of base-line metabolism, ecological metabolism per day (ELMD) is:

$$ELMD = (BLMD)(MBLM)$$

where BLMD = base-line metabolism per day, and
MBLM = multiple of base-line metabolism.

This approach to calculating the metabolic energy requirements of dairy cattle is discussed and illustrated next.

The metabolic energy requirements of dairy cattle are given in most dairy science books; Appendix Table 13 in Church (1977;322) is an example. It is interesting to find that the range of metabolic energy requirements for maintenance of mature lactating cows with body weights from 350 to 800 kg (770 to 1760 lbs) is 10,100 to 19,100 kcal per day, almost a 2-fold difference. MBLM, however, is 1.8 for the entire range! Further, the metabolic energy requirements for maintenance and pregnancy during the last 2 months of gestation when the cow is not being milked vary from 13,000 to 25,600 kcal per day for the range of body weights, but MBLM is 2.3 to 2.4 for the whole range of weight! Thus, two MBLM values, 1.8 and 2.4, may be used to calculate the metabolic energy requirements of cows of different weights for maintenance during lactation and for maintenance and pregnancy.

The cost of milk production is dependent on the fat content of the milk and the quantity of milk produced. Church (1977;322) gives values for the metabolic energy required per kg of milk with fat contents from 2.5 to 6.0%, at 0.5% increments. The eight values given fit a linear regression equation just about perfectly, so the metabolic energy required per kg of milk may be calculated with the equation:

$$MEKM = 540 + 150\ PCTF$$

where MEKM = metabolic energy required per kg milk produced, and
PCTF = percent fat in the milk.

The above equation is presented here to illustrate an important point. Tables of data have been used for many years as a convenience, eliminating the need for calculations. With the common use of hand-held electronic calculators and personal computers, an equation such as the one above becomes more convenient than a table. We should learn to use such equations, which are short and easily stored, rather than bulky tables.

The background information which has been provided in the preceding paragraphs will now be used to determine the metabolic energy requirements of lactating dairy cattle. The annual production cycle begins with parturition, followed by 42 weeks of lactation and 10 weeks of rest as illustrated below.

```
                     Peak                                        Parturition
Parturition          Lactation                              End of       again
                       ↓ Bred↓ again                        Lactation ↓      ↓
            +    +    +    +    +    +    +    +    +    +    +    +    +    +
            0    4    8   12   16   20   24   28   32   36   40   44   48   52
```

The milk production curve shows a rise to a peak milk production about 6 weeks after parturition, followed by a steady decline to the end of the lactation period (Figure 6-6). The vertical scale is typical of an average holstein producer; 14000-15000 lbs per 305-day lactation period.

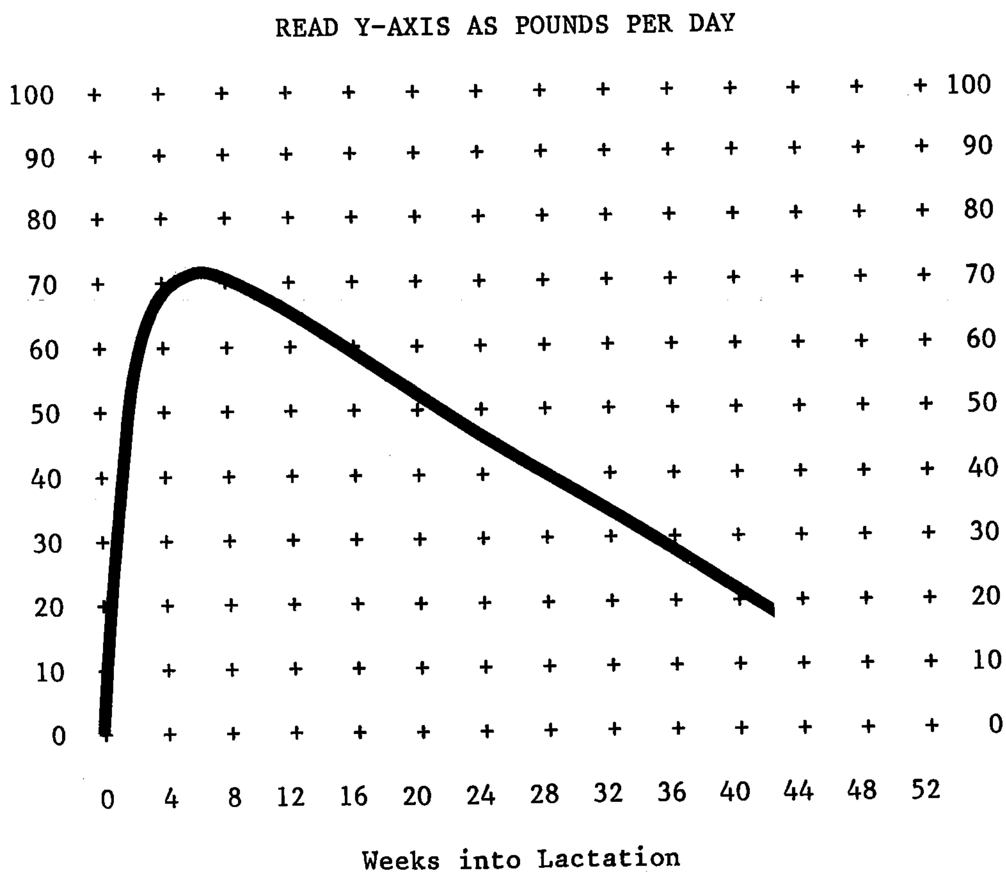


Figure 6-5. A milk production curve for an average-producing holstein.

The percent fat in the milk is highest at the beginning of the lactation period and lowest at peak milk production, with a gradual rise to the end of the lactation period. Using the percent fat curve in Schmidt and Van Vleeck (1974;85) and the equation for MEKM given earlier, the metabolic cost of milk production per kg of milk produced may be determined. Adding that cost to the cost of maintenance and gestation, the total cost may be determined. The metabolic energy cost for a holstein cow weighing about 1400 lbs, and producing about 14,000 lbs of milk with an average fat content of 3.6% is illustrated in Figure 6-6.

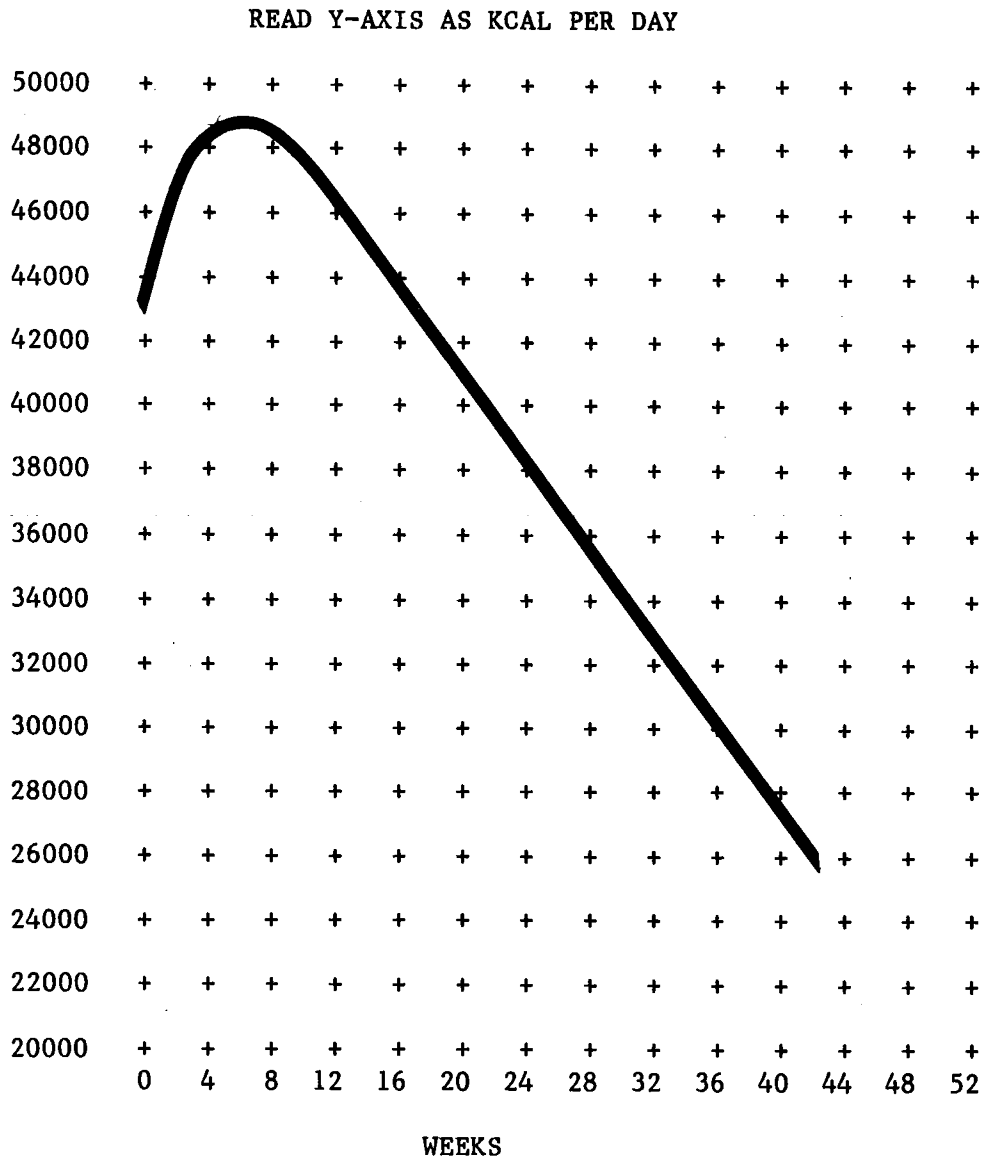


Figure 6-6. The metabolic energy cost through one production cycle for an average holstein cow.

A large number of figures would be needed to depict the caloric requirements of cattle of different sizes and milk production levels. Expressing the requirements as a multiple of base-line metabolism makes it much simpler, however. The MBLM curve in Figure 6-7 illustrates the pattern for these levels of production by a 1400 lb cow.

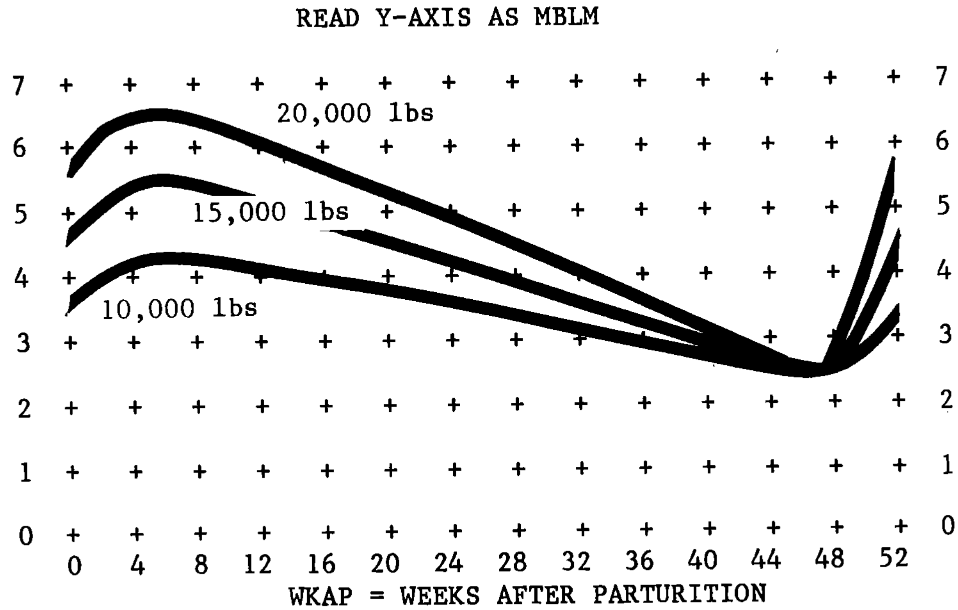


Figure 6-7. The pattern of MBLM for a cow weighing about 1400 lbs at three milk production levels.

To estimate the daily metabolic energy requirements (ELMD) at any time in the annual production cycle, simply read MBLM for the appropriate milk production level and multiply as indicated below for a cow weighing 14,000 lb (636 kg) and producing 20,000 lbs of milk at peak lactation (in BASIC syntax):

```
ELMD = (MBLM)(BLMD);
ELMD = (6.6)*(70)*(636**0.75)    =  58536 Kcal per day
```

Calculations for different combinations of weights and production levels may be completed on WORKSHEET 6-1; simple data are given on the first lines; information needed for the feed required to meet these metabolic costs is discussed next.

WORKSHEET 6-1. Metabolic and feed requirements of dairy cattle.

WKAP	LWKG	BLMD	MBLM	ELMD	DECO	MECO	FRKD

Nutrient requirements depend on the metabolic requirements for maintenance, activity, and production. The relationship between ecological metabolism and the metabolizable energy in the feed may be used to predict feed intake; metabolic energy required is the numerator and metabolizable energy in the feed is the denominator. The word formula for calculating intake is:

Intake = metabolic energy required/metabolizable energy in the feed

Daily feed consumption in relation to energy requirements may be expressed with the word formula:

Forage intake in kg per day = (ecological metabolism in kcal per day)/(gross energy x digestible energy coefficient x metabolizable energy coefficient)

This word formula for predicting intake is for an animal in a neutral energy balance, with all of the energy required being met by ingested forage. An expanded formula, using four-letter symbols, is:

FRKD = ELMD/(GEFO)*(DECO)*MECO) =
(MBLM)* 70* LWKG** 0.75)/(GEFO)*(DECO)*(MECO)

Symbol definitions are:

FRKD = Feed required in kg per day,

ELMD = ecological metabolism per day,

GEFO = gross energy in the forage,

DECO = digestible energy coefficient,

MECO = metabolizable energy coefficient,

MBLM = multiple of base-line metabolism, and

LWKG = Live weight in kg.

Now a brief word of explanation of the gross energy and digestible and metabolizable energy coefficients. Gross energy in forage averages about 4500 kcal per kg. Digestibility coefficients are variable, but an average of 0.55 may be used, indicating that 55% of the gross energy in the feed is digested. The metabolizable energy coefficients may be estimated as 0.82, a fairly constant figure for domestic ruminants.

A sample calculation follows for a 1400 lb (636 kg) cow with an MBLM of 5.5, consuming feed with a gross energy of 4500 kcal/kg and a digestibility of 0.55.

FIKD = (5.5)*(70)(636**0.75)/(4500)*(0.55)*(0.82) = 24 kg

This calculation illustrates the relationship between energy required and energy in the feed. Actual feeding practices would include grain with a higher caloric density and a higher digestibility. Corn grain, for example, may have 5500 kcal/kg and a digestibility of 0.72. Then, feed intake is:

FIKD = (5.5)*(70)*(636**0.75)/(5500)*(0.72)*(0.82) = 15 kg

Calculations of feed intake using the formula and equations given above are easy with with hand-held calculators. Estimations may be made quickly with the nomogram in Figure 6-8. Find ELMD on the X-axis, select the correct DECO line, and read the Y-axis.

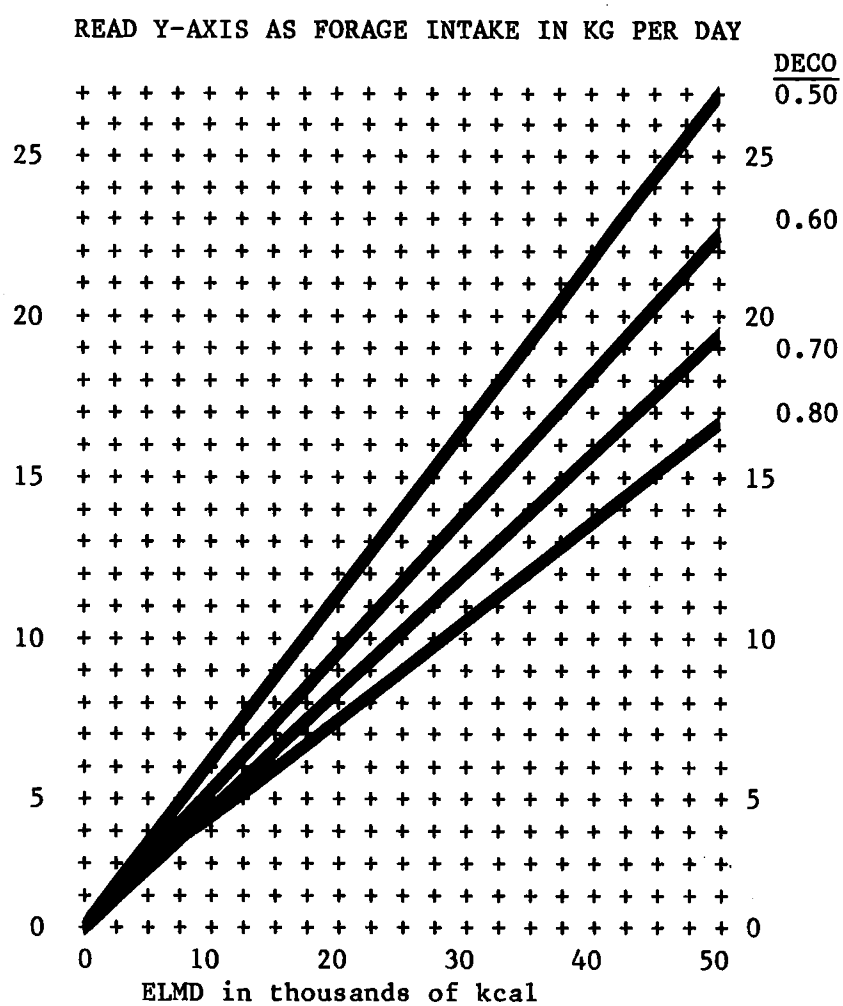


Figure 6-8. Forage intake may be estimated quickly with this nomogram by knowing ELMD and DECO.

Feed formulations are now rather sophisticated. Least-cost analyses, balanced feeding, and other recently-developed programs for domestic animals are based on nutrients required and supplied by different feeds, with cost factors considered in formulating rations, in relation to the metabolic requirements of the animals. Further, individualized feeding is possible with electronically controlled switches that are programmed to release a quantity of feed that is based on the the cow's metabolic requirements. This places a high level of control in the hands of the farmer. The basic components of such a computer-controlled system are shown in Figure 6-9 (key below).

Key to the numbers in Figure 6-9:

1. Feed mixer
2. Feed bin
3. Computer-activating switch
4. Computer controller and printer
5. Computer print-out
6. Stall
7. Computer-controlled feed-box

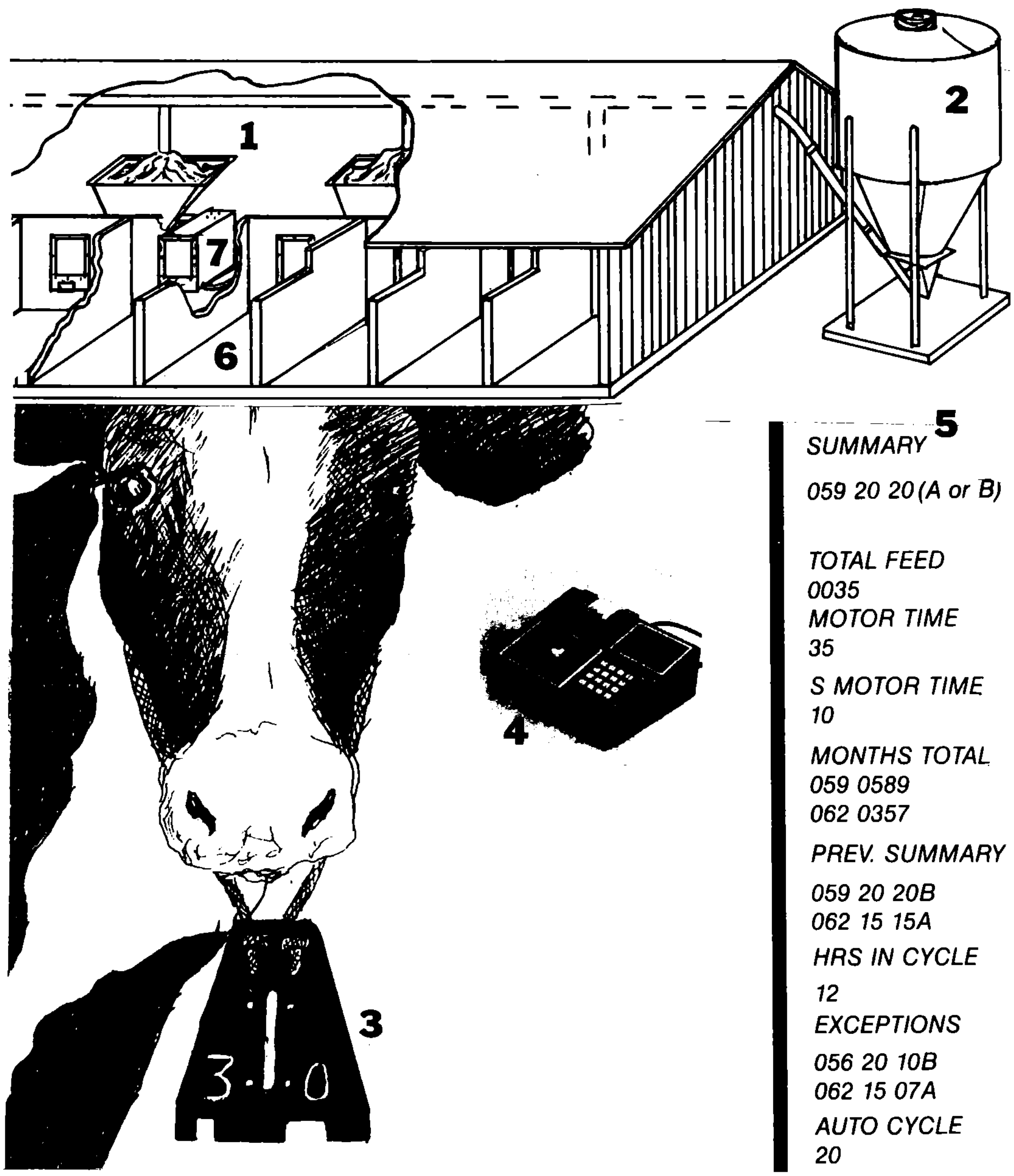


Figure 6-9. The basic components of a computer-controlled feeding system for dairy cattle. (Source: Selective Feeder Co.)

BREEDING AND HERD MAINTENANCE

The gestation period of cattle is about 270 days long, so dairy cattle are bred again early in the lactation period following parturition. Heifers are bred for the first time at about 15 months of age when they are about 1/2 to 2/3 of their mature body weight. They continue to grow during gestation, and weigh 2/3 to 3/4 of their mature body weight at first parturition. After that, body growth slows, finally reaching their mature weight when 3 to 4 years old. They continue to produce milk for several years, and then milk production begins to decline, calving difficulties may increase, and it is not economically feasible to keep old cows in the production herd. Old cows are sold to meat companies for use in mixed meat products such as sausages.

Artificial Insemination. Dairy cattle may be bred by a herd bull, or by artificial insemination. In the past, dairy farmers kept a sire on hand for breeding, with one bull capable of breeding many cows. In the last 25 years, artificial insemination techniques have been developed and perfected, providing a wide choice of semen from bulls with different character traits. Further, one bull can sire literally thousands of calves as semen may be removed with an ejaculator much more frequently than bulls can withstand naturally. Artificial insemination is feasible for dairy farmers because the cows are kept in rather close confinement and may be watched for signs of "heat," or ovulation. In larger herds, one of the dairymen may do the insemination; the process is not difficult to learn. Semen is stored at very cold temperatures and made available on the farm as necessary.

Embryo transplants. A new technique to increase the reproductive capacity of very high-producing cows is the embryo transplant. A select cow is injected with hormones after coming in heat, causing a large number of eggs (several dozen) to be released. The cow is then artificially inseminated several times within the day, and surgical techniques are used to remove the fertilized eggs 5 to 7 days later and transplant them to recipient cows which have been injected with hormones to synchronize breeding cycles. In this way, the genes of the select cow are transferred to several offspring within a single breeding cycle, making it possible to upgrade herds very quickly.

Herd replacements. A dairy herd may be built up by buying cattle or by selecting heifer calves from the best cows in the herd to raise for milk cows. They are raised on milk replacers for 4-6 weeks, with hay and grain offered after the first few days of life. The rumen develops rapidly, the calves are weaned (milk is no longer fed) and then they live on high-protein grain (usually about 16-18% protein) and hay. Heifers are bred when they are 14 to 16 months old, and weigh 500 to 800 lbs, depending on breed (see Cole and Garrett 1980;609).

Veal calves and dairy beef. Another by-product of the dairy industry is veal calf production. Veal calves are raised on milk replacers only, with no roughage. As a result, the rumen does not develop. The high protein diet results in rapid gains, however, and the calves are slaughtered at a weight about 300 pounds. The meat is very tender. The calves are housed indoors in small individual pens. Undesirable heifer calves and bull calves are raised for beef. The bull calves are castrated (testes removed) and thereafter designated as steers and raised for "dairy beef." The mechanization of dairy cattle management practices has resulted in marked increases in production per man-hour of labor (Figure 6-9). The next major step is in the electronic handling of information about each cow; we are rapidly moving from the industrial age to the information age.

The net effect of mechanization, improved genetics, and better herd management (especially herd nutrition) is a decrease in man-hours of labor per unit of milk production (Figure 6-9). A higher production per unit of labor has been achieved at high capital cost, however.

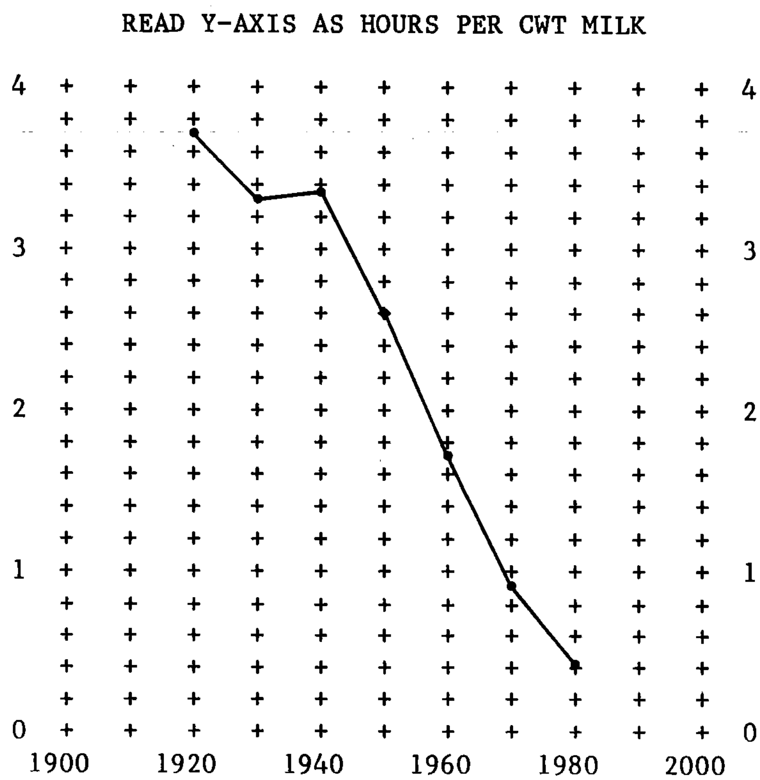


Figure 6-9. Man-hours required per hundred-weight of milk produced (Source: USDA 1981a).

UNIT 1.2. BEEF CATTLE

In the United States, cattle raising has been traditionally associated with the Plains and the West, where free-ranging cattle are kept as production herds and the weaned calves are sold to feeders in the Corn Belt. Cattle ranching has recently increased in the Southeast, on land formerly used for cotton but better suited for permanent pasture.

Beef cattle are raised for meat production. A herd of beef cattle includes the brood cows, breeding bulls and the calves. Calves stay with their dam and nurse until weaned at 400-500 pounds, which usually occurs at 5-6 months of age. After weaning, the young stock are classified as growing and finishing cattle. Prior to one year of age they are called short yearlings, and after one but before the age of two, long yearlings. Growing cattle are fed high protein and high energy diets, with the intention of getting them up to about 1000 pounds or more for slaughter in about 12 to 15 months.

Farms specializing in finishing beef cattle have feedlots where feeder calves, purchased from ranches in the west, are fed. On a diversified family farm, the feedlot is the place where their own young stock are finished, fed every day with corn silage, grain, and hay, all usually raised on the farm. In some areas, the Pacific northwest for example, large commercial feedlots have been designed to hold up to 100,000 animals. One person can feed up to 5000 head of cattle in a completely mechanized feedlot.

ECOLOGICAL METABOLISM OF BEEF CATTLE

The values of MBLM for beef cattle have been determined from data. Nutrient Requirements of Beef Cattle (NRC 1976), and are illustrated in Figure 6-11. MBLM for lactation ranges from 3.1 to 3.7 (midpoint 3.4) for cows rated as "superior" producers, and from 2.5 to 2.8 (midpoint 2.65) for those rated "average." The calculated MBLM for cows in the middle third of gestation is 1.9, and in the last third, 2.35 to 2.15 (midpoint 2.25). Equations are given in Moen (In Press); the lines in Figure 6-10 may be used for quick estimates of MBLM through the annual production cycle of beef cattle.

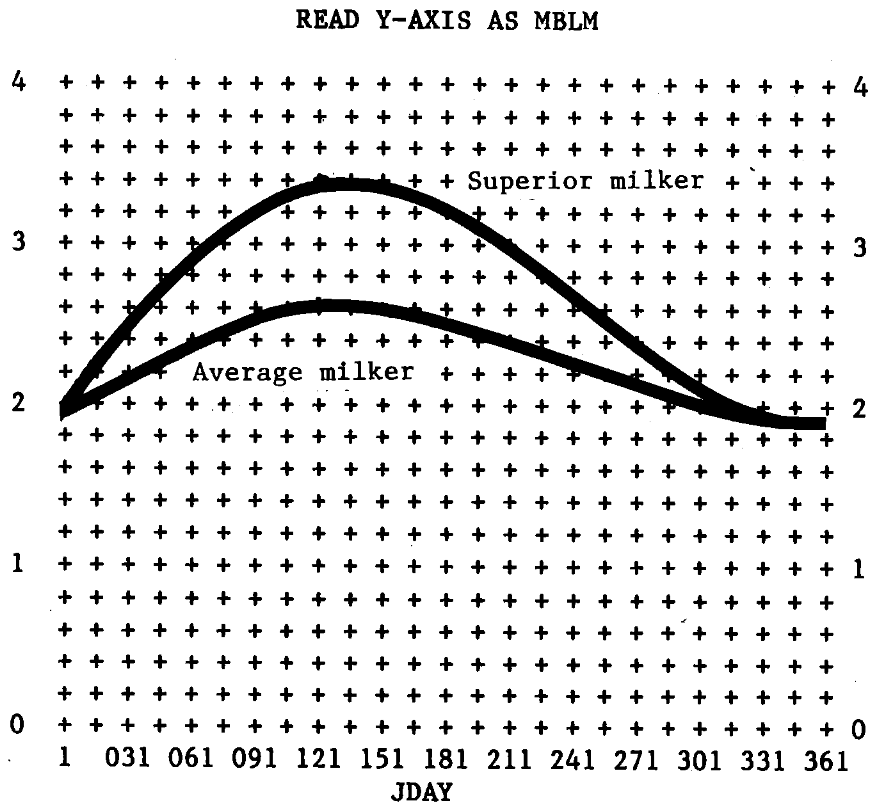


Figure 6-10. Values of MBLM for beef cattle recalculated from data in "Nutrient Requirements of Beef Cattle" (NRC 1976).

FEED INTAKE OF BEEF CATTLE

Free-ranging beef cattle forage for much of their intake. Since their milk production is less than that of dairy cattle, their ecological metabolism is less as milk production is a costly metabolic process. Free-ranging beef cattle have a higher activity cost than dairy cattle, but this is less than the greater milk production cost of the dairy cow.

The forage encountered by beef cattle on the range has a gross energy content of about 4500 kcal/kg, and digestible energy coefficients of about 0.50 to 0.75. The calculation of FIKG is done as described for dairy cattle (see Page 114), and the nomogram in Figure 6-9 may be used to estimate forage intake.

The metabolic energy requirements of free-ranging beef cattle increase in the spring after calving and decrease in the fall after weaning. The digestibility of forage plants increases with new growth in the spring, and decreases with plant dormancy.

BEEF CATTLE PRODUCTS

Beef cattle are the major source of red meat. Different parts of the animal are used for a variety of products; all parts are used for something. Uses of different parts are listed below.

PARTS	PRODUCTS
Horn	Horn meal
Hide	Leather
Pancreas	Insulin
Gall bladder	Dyes
Intestines	Surgical ligatures, heparin from mucus
Bone	Bone meal
Hooves	Buttons, neatsfood oil
Blood	Fire-suppressing foam, glues, protein
Offal	Tallow, soap, animal feed, plastics, paint

A marked decrease in man-hours per unit of beef production has occurred since 1920 as mechanization and automation has increased.

READ Y-AXIS AS HOURS PER CWT BEEF PRODUCED

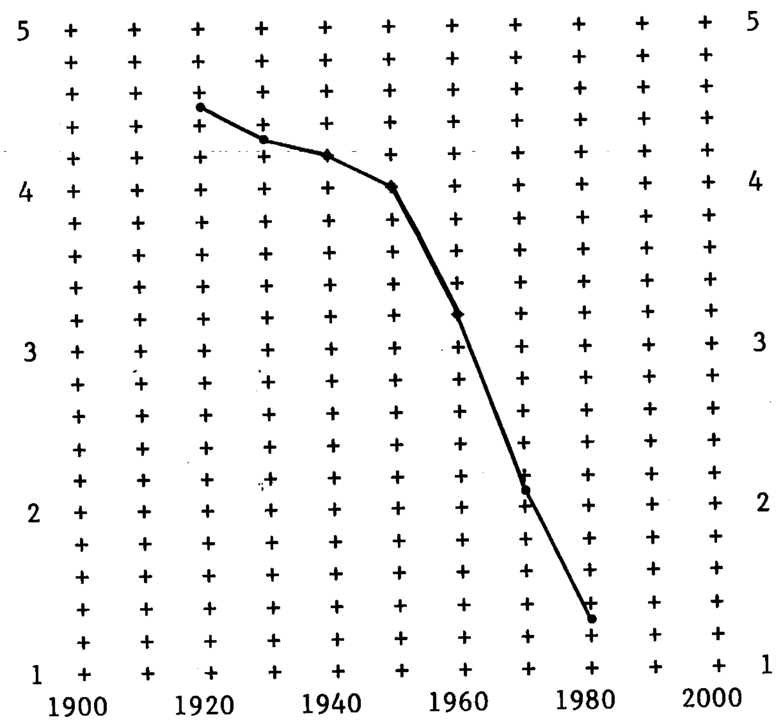


Figure 6-11. Hours per 100 lbs beef produced (Source:USDA 1981a).

TOPIC 2. SHEEP AND GOAT MANAGEMENT

Sheep raising throughout the world has an interesting history that continues to the present in the United States. About two-thirds of the sheep population is found in the wesstern ranges, grazing on arid and semi-arid pastures. The remaining one-third is found in small farm flocks scattered throughout the United States. More flocks are found in areas with more untillable land; sheep raising is usually an additional enterprise that is worked into the larger farming operation to make it more efficient and profitable. Goat-raising is similar to sheep-raising in many respects, with large herds of Angora goats maintained under range conditions in Texas and the Southwest, and smaller herds found elsewhere. The main management considerations of sheep and goat are discussed in the next two UNITS.

UNIT 2.1. SHEEP MANAGEMENT

Two kinds of sheep-raising enterprises are found in the United States. One is the range sheep industry, and the other is the farm flock. Of the 10 leading sheep states in 1968, 9 of them were range-type states, with Iowa being the only farm-type sheep-producing state in the top ten (Table 6-1). Note that total sheep numbers are partly a function of land area; the number of sheep per square mile has a different rank-order than the total number of sheep. The number of animals per square mile, or better yet, the number per square mile of suitable sheep range, is a more useful figure to the wildlife manager than the total number, of course. The discussions below are based largely on information in Ensminger (1970).

RANGE SHEEP

Range sheep graze on both public and private land, with public land being unfenced and the sheep under the care of a herder. Private lands are usually fenced. Sheep production on the western ranges is a migratory-type enterprise, with ranges at different elevations being used at different times of the year. In this way, the sheep are able to forage for themselves throughout the year. Supplemented feed is provided at critical times, such as lambing when the metabolic energy requirements are high, and when snow cover makes natural forage unavailable.

Western sheep provide both meat and wool. On the best ranges, meat production is more important because the lambs gain more rapidly and are better market lambs. On poorer ranges, wool production may be more important.

Table 6-1. The 10 States with the most sheep, 1981b (Source: USDA 1981).

State	Total number	Area in square miles	Number per square mile	Density Ranking
Texas	2,500,000	262,134	9.5	3
California	1,210,000	156,361	7.7	5
Wyoming	1,130,000	97,203	11.6	1
South Dakota	780,000	75,955	10.3	2
Colorado	710,000	103,766	6.8	6
Utah	636,000	82,096	7.8	4
Montana	616,000	145,587	4.2	10
New Mexico	615,000	121,412	5.1	9
Oregon	560,000	96,184	5.8	8
Idaho	498,000	82,677	6.0	7

Western flocks are usually large, with 1000-3500 in a band, and several bands in the flock of a single owner. Large flocks are divided into bands because there is an upper limit to the number of sheep which a herder can care for on open range.

METABOLIC ENERGY REQUIREMENTS

The metabolic energy requirements of free-ranging sheep have been evaluated in relation to base-line metabolism as described in UNIT 1.1: DAIRY CATTLE MANAGEMENT. The equations are described in detail in Moen (In Press). The MBLM pattern through the year, with lambing occurring in the spring, is illustrated in Figure 6-12. Note that maximum MBLM is 3.5 to 4.0, very similar to that of free-ranging beef cattle. The minimum MBLM--1.4--is less than for beef cattle because sheep have a gestation period of only 140-150 days, so they are not producing milk when bred.

FORAGE INTAKE

The forage required by sheep to meet their metabolic energy requirements may be calculated as described for dairy cattle in UNIT 1.1. The nomogram may also be used for quick estimates. Spring growth is more digestible and dormant forage less digestible; range-sheep have high-digestible new growth available as they move up slope with the receding snow line. Thus new growth with a digestibility of 0.75 may be available in spring and summer. Dormant forage may have a digestibility of 0.55 or less. The predicted forage intake for a 175 pound (80 kg) ewe with an MBLM ranging from a minimum of 1.4 to a maximum of 4.0 is illustrated in Figure 6-13 for digestible energy coefficients of 0.75 and 0.55; forage intake is expected to be within that corridor through the year.

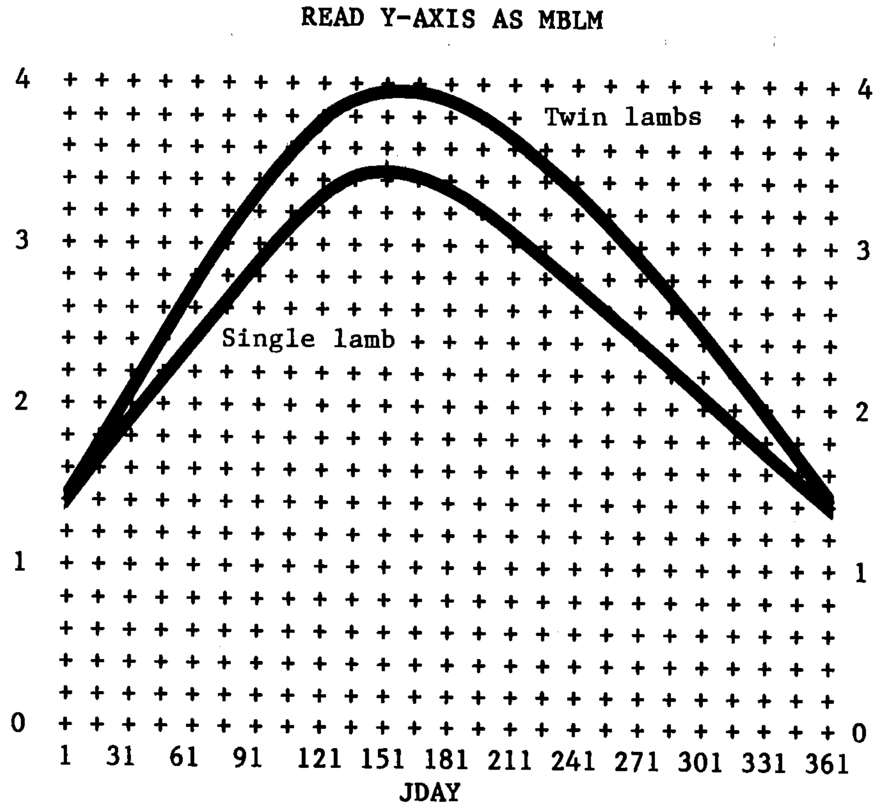


Figure 6-12. Values of MBLM for sheep based on data in "Nutrient Requirements of Sheep" (NRC 1976).

FARM FLOCKS

The basic principles of animal husbandry apply to all species of domestic livestock, and to different kinds of sheep enterprises. Nevertheless, there are some basic differences in the way farm flocks and range sheep are managed. This is due to sizes of the flocks, sizes of the areas they live on, and the purposes of the sheep enterprises in the total farming operation.

Most farm flocks are relatively small, and they are managed as a compliment to other parts of a larger operation. Sheep flocks are kept to produce quality meat and wool. This is accomplished by good management, and by improvements in breeding of successive generations.

FARM FLOCK MANAGEMENT

Farm flocks are usually on pastures in the summer, and good pastures will produce grass-finished lambs at weaning, ready for market. If the lambs are not ready, then they are treated as feeder lambs, put in confinement, and fed grain and roughage until they reach the desired weight and quality.

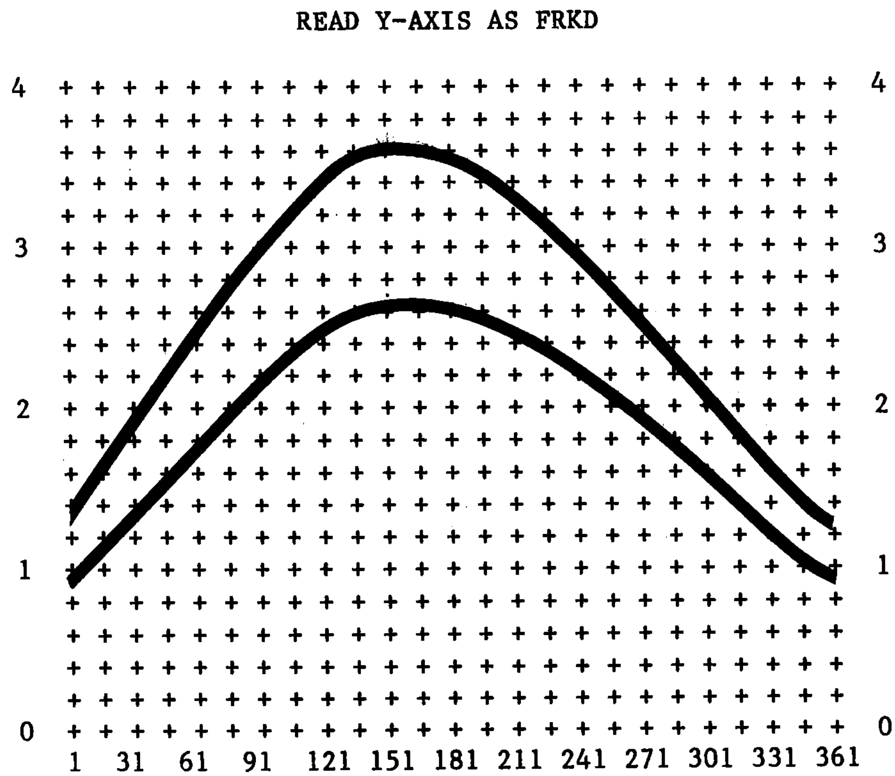


Figure 6-13. Forage required in kg per day (FRKD) for a 175 lb (80kg) pound (80kg) ewe producing twins. The corridor is bounded by forage digestibilities of 0.75 and 0.55.

Finishing lambs. Lambs may be finished in a feedlot with artificial or natural shelters where they are hand-fed. This is a more labor-intensive operation than field-finishing of lambs. In field-finishing, lambs are kept on pasture, with a grain supplement. Sometimes they may be managed as gleaners, going through harvested fields to pick up waste grain. Small grains and corn fields are used effectively in this way. They are ready for market when they reach weights of 85 to 120 pounds.

Balanced rations. A balanced ration provides all of the nutrients required for the maintenance and production level desired at a particular stage in the annual cycle. Thus protein supplements are provided in rations for finishing lambs, because growing lambs need a higher level of protein in the diet than adult sheep. The rations given in Table 6-2 are examples, with the percents given with reference to weight of the feed. The ration selected depends on the availability of the different components.

Table 6-2. Examples of different grain rations for finishing lambs; percents refer to weights of the different components.

	Percents in the feed				
Corn	50	60	20		90
Oats	20	30	30	60	
Wheat bran	20		30	25	
Protein supplement	10	10	20	15	10
	100	100	100	100	100

METABOLIC ENERGY AND FEED INTAKE

The metabolic energy requirements given in the NRC (1975) nutrient requirements of sheep convert to an MBLM of about 3.5. Thus, the metabolic energy required may be calculated with the following equation:

```
ELMD = (3.5)*(70)(LWKG**0.75)
```

The amount of feed required is dependent on the caloric density of the feed. Suppose that the grain ration had a caloric density of 4800 kcal per kg and the hay, 4000 kcal per kg, on an as-fed basis. If the digestible energy coefficients were 0.75 and 0.60 respectively, and two-thirds of ELMD was to be met by grain and one-third by hay, then the intake of each grain is calculated for a 100-pound (45kg) lamb as follows (in BASIC syntax):

```
ELMD = (3.5)*(70)*(45**0.75) = 4257 kcal/day
          4257 * 0.33 = 1405 met by hay, and
          4257 * 0.67 = 2852 by grain

          (1405)/(4000)*(0.60)*(0.82) = 0.71 kg hay, and
          (2852)/(4800)*(0.25)*(0.82) = 0.97 kg grain.
```

If the hay provided 40% of the energy and the grain 60%, then:

```
     (4257)*(0.40)  = 1703, and
     (4257)*(0.60)  = 2554.

(1203)/(4000)*(0.60)*(0.82) = 0.87 kg hay, and
(2554)/(4800)*(0.75)*(0.82) = 0.87 kg grain.
```

In the second example, equal weights of hay and grain (1.9 pounds of each) meet the calculated metabolic energy requirements of the finishing lambs.

THE CONCEPT OF CARRYING CAPACITY

The calculations of feed intake are fundamental to the analysis and determination of carrying capacity. The detail with which the estimates of metabolic energy requirements has been determined has resulted in a simplified concept--that of multiple of base-line metabolism--which is reasonably similar for different free-ranging species in both pattern and absolute value. The several examples given provide ample opportunity for practice in estimating metabolic energy requirements, ELMD.

ELMD is a necessary parameter for the determination of feed intake. Years ago, farmers determined feed requirements by trial and error. Wildlife managers tried to determine it by experimentation. Now, it may be quickly and accurately calculated for a variety of conditions throughout the year. Once feed requirements have been determined, carrying capacity may be calculated on an energy base. Thus:

Amount of feed available/amount required per animal = number of animal-days supported.

If 1000 animal days are supported and this feed is provided for a 200-day winter period, then 1000/200 = 5 animals may be kept over winter. If 100,000 animal-days are supported, then 100,000/200=500 animals may be kept. If the barn only holds 50 animals, then the operation is space-limited rather than food-limited, and the excess feed should be sold, or more space provided, or a combination of the two.

The above discussion is applicable to both domestic and wild species. The main difference between the management of the two groups is in the amount of control maintained by the manager, As I have pointed out in "Ecological efficiencies and forage intakes of free-ranging animals," in the National Academy of Science book in Press (Moen, In Press):

> Wild animals must be productive both as individuals and as populations if they are going to survive on the range. The productivity characteristics of domestic animals are much more controlled; breeding stock are dependent on the range for both growth and reproduction, while meat animals are dependent on range for growth only. The principles governing metabolic efficiencies and forage intake are the same for both wild and domestic free-ranging animals, however. It is their

biological chronology and the characteristics of the populations that are different as a result of different levels of intensity of management. Wild and domestic animals are both subject to the relationships between energy transactions and material resources, and both have upper limts to the amount of biomass that can be converted from primary to secondary production.

Having established the basic format for calculating metabolic energy, feed intake, and carrying capacity, the discussions of management practices on the following pages are more descriptive. The detailed calculations may still be applied, but general descriptions of management practice for goats, swine, poultry, and horses are sufficient for information purposes.

UNIT 2.2. GOAT MANAGEMENT

Goat management is very similar to sheep management in most ways. Large herds of goats are maintained on western ranges, especially in Texas, and small herds on farms in the rest of the United States. Goats are bred in the fall, and parturition occurs in March and April, when new spring growth is expected. The kids need more attention than lambs do, and they are raised in pens or in "toggle camps" for 10 days or so after birth, before being released to herd with their mothers A toggle camp is a staking system, with the young kids staked next to a small A-shaped box, with freedom to move the radius of the rope, and to seek shelter in the box. The goats nurse their tethered young two or more times a day.

Dairy goats are small, easy-to-handle animals that provide about 3 quarts of milk per day. They are usually hand-milked, although milking machines are available for use in larger operations. Because goats are much smaller animals than cows, they are often kept as a source of milk for a family. A few goats can be kept on a very small area of land, eating lawn grass and other locally available plant materials.

The principles of good nutrition and sanitation must be applied to goat-raising, just as any other livestock enterprise. While goats have a reputation for eating anything, this is more of a chewing response, not to be confused with the value of a balanced diet.

TOPIC 3. SWINE MANAGEMENT

Swine management is a specialized enterprise for the production of pork, a meat that is a valuable source of nutrients that have been assimilated from other less nutritious plant and animal products. The principles of swine management are discussed at length in Pond and Maner (1974); the brief discussions which follow are summarized largely from that source.

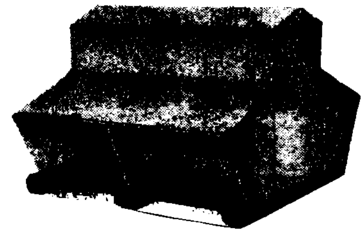
The pig has a gestation period of about 114 days, the young are weaned by the time they are 8 weeks old, they are sexually mature at about 6 months of age, and they are productive for up to 8 years. Thus the hog producer has a rather large animal (up to 400 pounds or more) with a rather accelerated life cycle. Between 50 and 70 million hogs have been raised in the United States each year for the last 10 years.

Housing. Proper housing is an important consideration because pigs do not sweat, so evaporative cooling is very limited in hot weather, and they have very sparse hair, so they are rather sensitive to cold temperatures. In hot weather, pigs are often sprayed with water to provide evaporative cooling, and they must be given shade, of course. Pigs that are kept outside need trees or other sources of shade, or they will suffer from hyperthermia and die.

Preferred temperatures. Newborn pigs like to be in conditions where the air temperature is in the 80's or 90's, with the preferred temperatures dropping to the 60-70 degree F range when they are maturing. The farrowing crate should be provided with an infra-red heat lamp or some other source of heat if needed to provide optimum temperatures for the newborn.

Postnatal care. Newborn pigs need more attention than other domestic livestock, such as lambs and calves. Further, there are several in each litter, so farrowing demands the attention of the hog farmer as needless losses at birth reduce profits. The umbilical cord should be tied, "needle" teeth clipped to prevent irritation to the swine udder and injury when the little pigs play and fight, iron should be injected to prevent anemia, and the tails removed to prevent tail-biting. Pigs are very social animals, and establishing and maintaining a dominance hierarchy is done by physical force. Males to be used for pork production are castrated at one to three weeks of age.

Feeding. Young pigs nurse up to 8 weeks of age, but they should be provided with "creep" feed beginning the second week. The "creep area" is designed so only the young pigs have access to the self-feeder (see inset) otherwise the sow would help herself to the feed and leave nothing for her young . After weaning, the growing-finishing pigs are fed well-balanced diets that approach but do not reach all they would voluntarily eat. This restriction results in leaner carcasses, which are more desired by the consumer. Clean facilities are the usual necessity for finishing hogs, keeping in mind the behavioral traits of pigs. They have the reputation of being dirty animals, but they are, rather, about the cleanest of farm animals. They use one area for urinating and defecating, separate from their eating and sleeping areas.



KINDS OF SWINE ENTERPRISES

Purebred producers. A purebred swine enterprise focuses on breeding and genetics. This is a specialized enterprise that involves attention to individuals, extensive records, showing of the pigs, and advertising of breeding stock. Selected breeding stock command higher prices than slaughter stock, but there is considerable added expense.

Feeder pig producers. This enterprise involves the production of feeder pigs that are sold to market producers at a few weeks of age and weights of about 40 pounds to be finished by hog feeders who keep them until they are sold for market at weights of about 200 pounds. This type of enterprise requires more labor and less space and feed than the market producer's enterprise.

Market producers. Market producers finish feeder pigs. Less labor and more feed is required to raise the pigs from weaning to market weights. The hogs are kept outside in some areas, and inside weather and economic conditions warrant it. Self-feeders (Figure 6-14) are usually used; pigs quickly learn how to lift a lid on a self-feeder, making clean, dry feed accessible to them when they want it. Total amounts may be regulated by feed controls which auger selected quantities of feed into the feeders at selected time intervals.

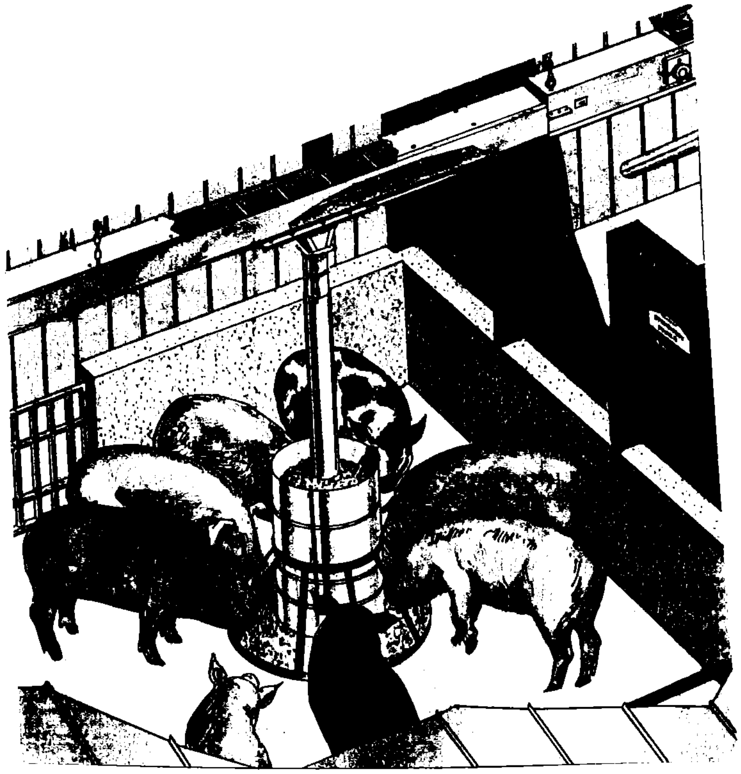


Figure 6-14. A self-feeder for growing-finishing hogs. (Source: A.O. Smith Harvestore Products).

Sow and litter producers. The farmer who raises both brood sows for pig production and the feeder pigs up to market weights combines the two previously-described operations. It is a labor and capital-intensive operation, and is successful when home-grown feeds are provided and well-designed buildings are available. Some farmers raise pure-bred breeding stock as well, combining all three operations on a single hog farm.

Hog production is most common in States with somewhat moderate winters and adequate supplies of grain, especially corn. Iowa, Illinois, and Indiana are examples of hog-producing States.

TOPIC 4. POULTRY MANAGEMENT

Poultry management, mainly chickens and turkeys, has undergone dramatic changes in the last few years. The small farm flocks have been replaced by large commercial flocks, with a high degree of mechanization of the feeding and cleaning operation. The reduction in the number of man-hours of labor required for the production of 100 eggs and per cwt of broiler production reflects this (Figure 6-15).

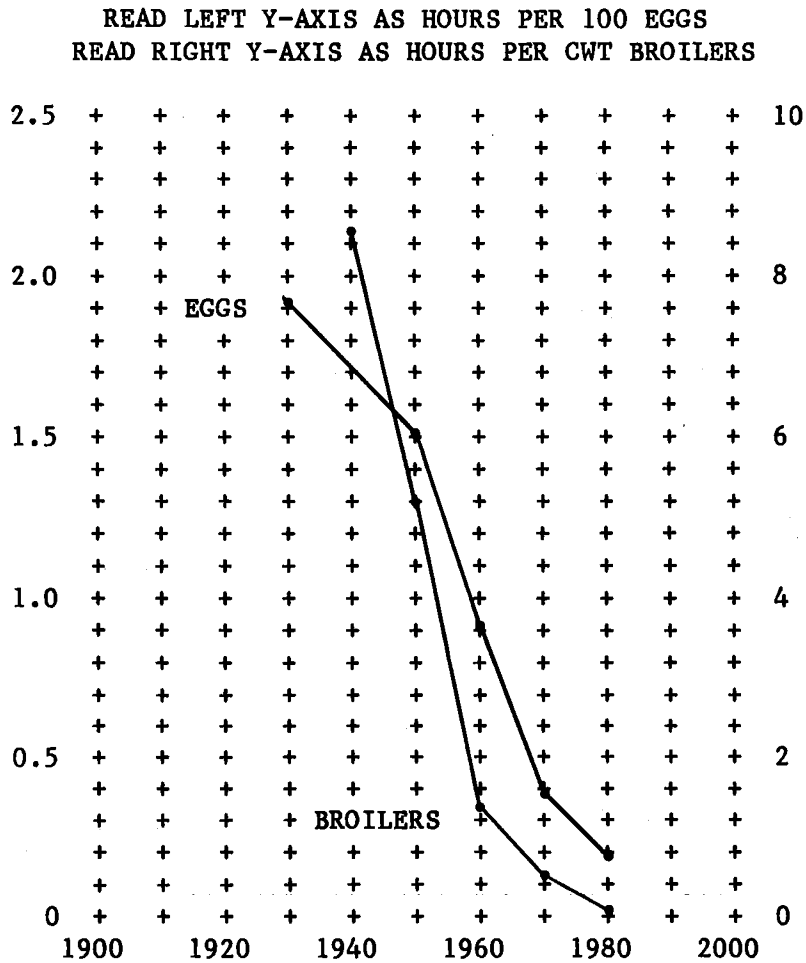


Figure 6-15. Man-hours per unit of poultry production have dropped rapidly (Source: USDA 1981a).

Management practices for different kinds of poultry depend on the production purposes. Chickens are raised for both eggs and meat, while turkeys are raised for meat only. Brief descriptions of different poultry enterprises follow.

UNIT 4.1. CHICKEN MANAGEMENT

Chicken management usually involves either egg production or meat production. Modern management systems for both kinds of production usually involve raising the birds in confinement on a commercial scale. Small farm flocks may be housed in the more traditional "chicken house," with the birds allowed to roam fully, or to have an outdoor pen. The traditional system is labor-intensive, and the modern mechanized system is capital-intensive. Discussions of egg production and meat production systems follow.

EGG PRODUCTION SYSTEMS

Profitable egg production is dependent on having quality layers, clean facilities, a balanced ration, and disease control. The business begins with the purchase of chicks. Day-old chicks may be trucked or even shipped by mail as they live off stored nutrients for the first two days of life. Egg-production flocks start with female chicks only, or pullets. Newly-hatched chicks are sexed by examination of the rudimentary copulatory organ, or by the recognition of sex-linked color characteristics. Hatcheries selling day-old pullets include 105 or more chicks for each 100 ordered, guaranteeing the number of the kind ordered.

Brooding chicks. Young chicks are raised in brooders where the air temperature is maintained in the 80-95 degree range day and night. Brooders in large-scale operations have several tiers, while those used in smaller flocks may be on the floor. Inverted cones, called hovers, are sometimes used, with a heat source under the hover. Infrared lamps may be used for small groups of chicks, with the height of the lamp easily adjusted, and the chicks selecting the most comfortable zone. Chicks in brooders are fed a dry mash, and fresh medicated water is provided at all times.

Raising pullets. Pullets being raised for egg production on the commercial scale are reared in temperature-controlled tiered units where they receive the proper amounts of feed, fresh water, and light. The light regime is important; too few hours of light keeps the birds inactive for too much time, they do not feed enough, and they grow more slowly than their growth potential. After the pullets have reached about 20 weeks of age, they begin to lay and are housed as layers.

Layers. Layers are often housed in cages now, with each cage holding from one to several chickens. The cages have slanted wire floors, allowing the droppings to fall through for excellent sanitation, and the eggs to roll to the collecting tray at the edge of the cage. Feed and water is provided on trays on the edge of the cage. The feed, water, droppings, and egg-collection trays are mechanized and automatically-controlled, eliminating much hand labor. This mechanization is responsible for the rapid rise in production per man-hour illustrated in Figure 6-15. A poultry house 1/10 mile long was described in American Agriculturist (October 1982, p.47), holding 60,000 birds in a well-controlled environment.

Metabolic energy requirements. The metabolic energy requirements of layers includes the costs of maintenance, activity and production, as with all organisms, whether free-ranging or caged. Maintenance includes not only the costs of the vital functions such as heart beat and respiration, but also the cost of maintaining homeothermy. Activity costs are less in caged systems than in free-ranging flocks. Egg production costs are high, just as gestation and lactation are high in mammals. The pattern of MBLM for chickens is interesting; the brief descriptions below present a picture similar to that of cattle and sheep in comparable stages of their reproductive cycle. MBLM tends to be slightly lower than cattle. The data in Table 6-3 are from Scott et al. (1982) for hens bred for maximum egg production and egg size. Note that weight continues to increase with age, but egg production falls off.

Table 6-3. Age, weight, egg production, and metabolic requirements of hens bred for maximum egg production and egg size.

Age in weeks	Weight in kg	Egg production	ME requirement	MBLM
25-30	2.50	85%	390	2.80
30-35	2.73	85%	415	2.79
35-40	3.00	60%	418	2.62
42+	3.10	60%	397	2.43
42+	3.10	0	345	2.11

The data in Table 6-3 indicate that MBLM peaks at 2.8 at maximum production, falls off to 2.4 as production drops, and reaches 2.11 for maintenance and activity costs alone. Another calculation for maintenance of a white leghorn hen resulted in an MBLM of 1.98. The general conclusion from these calculations is that MBLM ranges from 2.0 to up to 3.0 for chickens at metabolic levels ranging from maintenance to peak production.

Feed Formulation. There has been much progress in feed formulation for chickens in the last 60 years as feeding has progressed from providing grain, skim milk and greens, which seemed to be essential for satisfactory growth and egg production, to present-day scientific formulation of least-cost rations at pinpoint efficiency (Scott et al. 1982). The rapid progress has been possible because of the interest and dedication of the poultry scientists, and the additional advantage of having a nearly ideal experimental subject to work with. Chickens grow fast, mature quickly, can be mated easily, produce a large number of eggs to be divided into experimental lots, have well-known genetic histories, and they are small and easy to handle. No other domestic species offers all of these advantages. The result has been steady progreess in identifying 40 nutrients needed for optimum growth and development. The details are thoroughly discussed by Scott et al. (1982), a book that should be given much consideration by biologists interested in wild birds. The opportunity is taken here to discuss feed formulation by linear programming, based largely on discussions by Scott et al. (1982), a computer technique which could generate some interesting analogs when considering ecological efficiencies of wild, free-ranging birds.

Linear Programming in Feed Formulation. Linear programming techniques show optimum use of resources to reach a particular objective at least cost. The cost is expressed in dollars in feed formulations. Suppose four ingredients are available for feed formulation: corn, soybean meal, meat meal and yeast, and that these are to be combined to provide adequate energy and 20% protein, 1% calcium, and 0.5% available phosphorus. Further, corn costs 2¢, soybean meal 4¢, meat meal 4¢, and yeast 10¢ per pound. A series of equations are generated of the form:

2(corn) + 4(soybean meal) + 4(meat meal) + 10(yeast) = minimum cost, with the coefficients above being cost per pound.

Further constraints are:

1. The total quantity of feed must add up to 100%, and
2. The feed must contain adequate energy (130 units in the example given.

Equations derived with the linear program model have coefficients representing energy, protein, calcium and phosphorus contents of each of the ingredients. A row and column format is used to arrange the data, and the actual program format is dependent on the computer being used, of course. Having at least a small amount of experience with linear programming and matrix algebra, I think about the possible applications of such techniques in wildlife management, with the particularly beneficial effect of forcing the wildlife biologist to think about the biology of wildlife species in detail rather than in general natural history terms. The domestic animal scientist is far ahead of the wildlife scientist in this respect, and the applications made by the former place the modern farmer far ahead of the wildlife manager with respect to knowledge available and used in their respective professions.

BROILER PRODUCTION SYSTEMS

Broiler production involves the raising of chickens to a market weight of 3 to 4 pounds (1.5-1.8 kg) in 8-9 weeks for human consumption. They require about 2 pounds of feed for each pound of gain, an excellent feed conversion ratio. It is economically feasible to do this only when many thousands of birds are raised in four consecutive batches through the year, keeping the broiler cages filled 80% of the time, with the empty days set aside for cleaning and sanitation between batches. Mechanization makes it possible for one person to handle 60-75,000 birds in modern broiler "factories."

Broiler production and modern egg production systems do not impinge on wildlife habitat directly as the chickens are kept in light-and-temperature-controlled houses. These enterprises affect wildlife habitat indirectly by creating a demand for grains and other components of poultry rations.

UNIT 4.2. DOMESTIC TURKEY MANAGEMENT

Turkey management involves two kinds of production: egg production for hatcheries that supply turkey poults, and meat production for table use. The former is a specialized enterprise of local importance and will not be considered here. The latter, a specialized enterprise of more general importance, will be discussed briefly, with much of the information being summarized from Marsden and Martin (1955).

Turkeys may be raised on open range or in confinement, with the general trend toward more mechanized confinement housing. Thus, turkey raising is another example of the shift from a labor-intensive to a capital-intensive operation.

The large concern by poultry raisers in general and turkey raisers in particular is disease. Chickens and turkeys are not easily raised together. Free-ranging chickens and turkeys make disease practically impossible to control. Confinement housing makes disease control much easier; prevention of problems is always easier and less costly in the long run than dealing with them after they have occurred.

The peak time for marketing turkeys has always been prior to Thanksgiving, due to the traditional Thanksgiving turkey dinner. With modern methods of storage and transportation, the market is more stable through the year, and efforts are being made to promote turkey as a year-around food. Three aspects of turkey management will be discussed here: raising of the poults, range turkey production, and confinement systems.

RAISING OF POULTS

Starting poults. Poults are started 22 to 28 weeks before marketing, the time necessary to produce Grade A small to large turkeys. The down-covered poults are raised in brooders for 6-10 weeks where they are kept in an air temperature of 70 degree F (20 degree C) or more. They grow rapidly, and feather development is very rapid when provided a balanced ration in a predator-, disease-, and parasite-free environment. Brooders must be well-ventilated and dry; wire floors aid greatly by allowing droppings to fall through to a collection pit. If a litter-covered floor is used, the litter must have physical characteristics which prevent the poults from eating it and causing impaction. It must also be kept very clean and dry. The feeders and waterers are placed on the wire floor on an elevated wire-bottom platform above the litter. Roosts are also provided. Some brooder houses are movable; they are pulled by tractor to new sites. Permanent brooder houses may be quite large, are heated and ventilated and have concrete floors. After 8 weeks in the brooders, the turkeys are transferred to the range or to another type of house for rearing in confinement.

Feeding poults. Poults are fed a "starting" ration for about eight weeks and then shifted to a "grower" ration for the next 16-20 weeks, the last part of the growing period is referred to as a finishing or fattening period. The starter ration has a high protein content--22-28%--with the proper nutrients, including vitamins, in balanced proportions. Fresh water is provided at all times. The grower ration has a lower protein than the starter ration, and it can be decreased to about 15% by the time the birds have been finished for market. The rations are usually fed in pelleted form. Grains fed free choice are ranked as follows in order of preference: (1) Oats, (2) wheat, (3) grain sorghum, (4) rye, (5) cracked corn, (6) barley, and (7) whole corn. Whole corn is much more preferred by older birds; it is one of the top three choices after 18 weeks of age.

RANGE TURKEY PRODUCTION

After brooding, turkeys are often raised outside on open range. Range shelters are provided which protect the birds from stressful weather and predators, and have properly-constructed roosts, proper sanitation, and circulating fresh air. Feeding and watering facilities may be provided under the same shelter. The shelters may be moved often--weekly, even--to avoid overgrazing on the range. The range area may or may not be fenced; better control is possible with fenced ranges.

In milder climates, open-air roosts may be provided without overhead cover or windbreakers. These look like portable bleachers, with their parallel rows of roosts and slanted construction. Roost design is partly dependent on the breed; Broad Breasted Bronze Turkeys, with their large size and body conformation, must have low roosts or roost on the ground (Marsden and Martin 1955). Turkeys roost from sunset to early morning when daylight breaks. Then, they leave the roost, feed, drink water, and forage on the range, picking up greens and insects to supplement their diet. They rest several times during the day on the ground or on the roosts.

The "Minnesota plan" for range-rearing turkeys involves leaving the poults on one area for two to six weeks, or having permanent circular roosts with the feeders and waterers moved weekly around the roost. The range areas are also rotated over the years; clover and alfalfa fields are plowed and planted to corn and small grains,, then returned to alfalfa for another period as turkey range. This rotation is important for disease control.

CONFINEMENT REARING

Confinement rearing offers the advantages of better control over the turkeys, lower labor costs, and better protection from stressful weather, predators, diseases, and parasites. Disadvantages include higher equipment costs, more stress and physical problems with the birds, and higher feed costs since there is no range material to supplement the diet.

Confinement rearing involves small or large platforms, pole sheds, and houses with feed and water supplied by hand labor or by mechanized equipment. Because the birds are much less active and are more crowded, such problems as feather picking, cannibalism, and leg and foot troubles develop. The birds can be debeaked (removal of part of the upper beak) or a ring inserted into the nostrils to prevent feather picking, but such remedies involve handling each bird, an extra labor cost.

Growing turkeys require 7 to 9 square feet per bird in confinement. Thus, a 30 x 100 foot building with 3000 square feet of floor space could house from 350 to 400 birds. Large growers have long, narrow shelters covering one or more acres of land; there are 43,560 square feet in an acre, so a building one acre in area could house between 5000 and 6000 birds. That is a lrge building indeed; a football field is just over an acre in area.

UNIT 4.3. DOMESTIC WATERFOWL MANAGEMENT

Domestic waterfowl management is in it's infancy compared to chicken and turkey management. Large-scale farming operations are confined to a few commercially important areas; most of the 15 million ducks produced annually are produced on specialized farms, with the remainder raised in small flocks on scattered farms for family use and local sale.

The information below is summarized mainly from two sources: Poultry Fact Sheet No.43, by M.L. Hamre, 1980, Ag. Ext. Service, Univ. Minn., and Grow (1972).

DUCK MANAGEMENT

Ducks raised in confinement should have 1/2 square foot of floor space per bird during the first 2 weeks, 1 square foot up to 4 weeks, and 2 square feet per bird after 4 weeks. Small flocks of ducks may be easily raised outdoors in late spring with few problems as they are hardy, not susceptible to many of the common poultry diseases, and are good foragers of greens that supplement the feed provided.

Brooding. Ducklings may be brooded by chicken hens, duck hens, or under artificial heat such as infrared lamps. Supplementary heat may be needed for 5-6 weeks in cold weather, but only 2-3 weeks in warm weather. Temperatures that are too high may retard feather growth.

Feeding. Commercially-formulated rations are available for ducks, but chick rations may also be used. Pelleted feeds are best, and grit needs to be provided if the birds do not have access to natural grit. Pekin ducklings should weigh 6 to 7 pounds when 7 to 9 weeks old, and have consumed 20 to 25 pounds of feed.

Breeder flocks. A breeder flock may include a drake and 5 or 6 hens. They should be kept from being too fat (overfeeding and overprotection can be a problem for animals capable of adapting on their own), and should have clear, dry, and well-ventilated shelter. Eggs may be brooded by a chicken hen or a duck, with 9 to 11 eggs in the nest, or hatched in artificial incubators. It may be advisable to remove the early-hatching ducklings from the nest to prevent the hen from abandoning the clutch too soon. This has been observed in wild pheasants; even the sound of young chicks about the time a clutch should hatch may trigger nest abandonment as the hen seeks the peeping chicks.

GOOSE MANAGEMENT

Geese are grazing fowl, and are well adapted to foraging on succulent vegetation on their own, requiring little attention, provided they have water, space, and sanitary conditions. Geese are used as "weeders," being allowed to feed in cotton plantations, orchards, and berry patches where they eliminate many noxious weeds that would otherwise need to be controlled by hand-hoeing. Ten to fifteen geese will replace one hoe-hand.

Mating. Wild ganders are monogamous, but domestic ones will have harems of two to five females when they are young and in prime sexual condition. As they grow older, they tend to become more monogamous. A small flock of geese--one gander and two to four females--or a larger flock with several ganders with harems are the rule rather than the exception in goose management.

Goslings. Geese allowed to mate and nest will produce a single clutch of six to eight eggs, incubate them, and hatch them. Some breeds and strains can be managed to produce larger numbers of eggs (20 to 100 or more). Goslings may be reared under artificial brooding conditions, and fed a good chicken starter. Animal protein is a good component of rations for geese; free-ranging geese will eat insects as well as plant material. A protein content of 18-20% is satisfactory, and too much protein results in too rapid growth. Fresh drinking water must be supplied at all times.

Pastures. Geese may be allowed to forage with other kinds of domestic livestock. In fact, other livestock benefit geese by keeping the vegetation shorter, growing more, and succulent. Geese do best on grasses; they do not need the high-protein legumes. If geese are raised in dry lots, green crops need to be cut and provided in adequate amounts.

Shelter. Geese need the least shelter of all domestic livestock. Goose down is an excellent insulator, so the most vulnerable parts of their body are the feet and legs. If open water is available, they will seek that, and liquid water is never much colder than 32 degrees F. If forced to be on snow and ice, their feet are exposed to temperatures about equal to air temperature; snow temperature may be many degrees below zero. Dry bedding in an area sheltered from the wind proves helpful under such conditions.

Fattening geese. Geese may be fattened for market on a ration containing 50-60% corn, along with lesser amounts of such things as whole wheat, wheat bran, soybean meal, fish meal, meat scrap, alfalfa leaf meal, ground limestone, brewer's yeast, and iodized salt. Fattened geese may then be sold live for processing, or dressed and prepared as "oven-ready" geese for a local market, especially around holidays.

TOPIC 5. HORSE MANAGEMENT

Proper horse management was once a matter of survival on the farm. Horses were absolutely essential for field work and transportation. Now, engine power has relegated the horse to a pleasure animal on most, but not all farms. Roads are built for motorized traffic, not horse-drawn carriages. Horses are not even counted in the agricultural census any more, which in my opinion, was a short-sighted decision. Horse numbers are now actually increasing, although the increase is due primarily to high interest in the light or pleasure horse rather than the work horse. Nevertheless, there is a renewed interest in draft horses, both for show and work. The brief discussions of work and pleasure horses which follow in the next two UNITS are mainly summaries of information in Kays (1969).

UNIT 5.1: WORK HORSE MANAGEMENT

Work horses are large animals. A good draft horse stands over 16 hands and weighs 1,600 to 3,000 pounds (725-1,360 kg). The doctor was right when he said "your foot won't get any better until the horse gets off of it." Such large animals need large amounts of feed, and they need to be stabled in arrangements that provide safe, easy handling. Draft horses need to be warmed up and cooled down properly before and after work, to be treated as athletes, in a sense, as they use their bodies for coordinated muscular feats.

Hay is a staple item in a horses diet, with grain fed as a supplement in relation to the amount of work done by the horse. A draft horse who works all day pulling farm machinery needs a good source of concentrated energy. Grains--oats for example--provide the high caloric density needed.

Work horses usually work in teams, with two or more on a hitch, depending on the amount of work being done. Two draft horses can pull a small one-bottom plow, but four or five need to be hitched together for a two-bottom plow. Discing is very energy-demanding as the disc forces a steady pull with little or no let-up. Harrows are easier to pull, and wagons still easier. With wagons, the horses must hold it back going downhill as well as pull it on the level and uphill. Well-trained teams work well together, and are not spooked by different kinds of machines.

Horses need to be "broken," or trained to work in harness. Young horses can learn much when teamed with older horses. Having the good fortune of growing up on a farm with work horses in my grade-school years, I can recall the excitement of riding on one of the team in harness, of the different teams at threshing time, and of the occasional "runaway" when the horses were spooked and become uncontrollable. I never had the privilege of going on such an unscheduled ride, however.

UNIT 5.2: PLEASURE HORSES

The current interest in horses is directed mostly at pleasure horses used primarily for riding, with another category most properly considered in a class by itself, for racing. Riding horses are within reach of rural and urban youth alike as there are stables willing to board horses and provide riding rings and trails for those who do not live in the country.

Feeding pleasure horses. Horses should be fed as individuals, with daily attention to their carriage, temperament, and overall appearance. One of my own horses, a retired race horse, exhibited an overall appearance for a couple of days that led me to believe something was wrong, but I could not pinpoint it, nor did the vet find anything while inspecting and worming the horse. Two days later the horse was dead, an apparent victim of *Taxus* poisoning, which it picked up in some lawn clippings. Each horse is different, and each horse has different temperaments and requirements, depending on its activity. Since the stomach capacity of a horse is much smaller than a cow of similar size, horse-feeding is a little more demanding. The following considerations are fundamental to a good feeding regime for any horse.

1. Feed according to individual needs in relation to size, temperament, and activity.

2. Feed for long-time efficiency, for many years of productive work.

3. Feed a variety of ingredients of good quality to make a balanced ration.

4. Feed regularly two or three times a day rather than all at once.

Rations. Oats is the leading horse feed in the United States, safe to feed because the hulls provide bulk to the grain, and it is relatively high in protein. Oats grain and timothy hay make a good balanced ration. Corn, barley and wheat bran are also fed, and protein concentrates such as linseed meal, soybean meal, and cottonseed meal may be used to balance a ration. Apples, carrots, and other succulent foods add variety to the diets of horses that are not on pasture. All foods presented to a horse must be free from mold; horses are much more sensitive to digestive disturbances than other farm animals.

Metabolic energy requirements. The metabolic energy requirements may be estimated from mixtures of grain and hay suggested for different levels of work. Table 6-4 illustrates metabolic work levels expressed as MBLM for a horse, weighing 455 kg based on grain and hay proportions recommended by Kays (1969). Metric units are used throughout; verify the calculations of MBLM as a good exercise on an important concept.

Table 6-4. Work level, amounts of feed (kg) and metabolizable energy (kcal per day) for horses.

Work level	Amounts Grain	Amounts Hay	Metabolizable energy* Grain	Metabolizable energy* Hay	Metabolizable energy* Total	MBLM
Idle		9.00		16236	16236	2.36
Light work	2.60	6.25	7675	11275	18950	2.75
Medium work	3.98	5.11	11749	9218	20967	3.04
Hard work	5.45	4.55	16088	8208	24296	3.53

*Metabolizable energy is determined by multiplying gross energy x digestible energy coefficient x metabolizable energy coefficient as described in UNIT 1.1 of this CHAPTER.

The range of MBLM values are once again within the range for other domestic animals and within the range predicted for wild ruminants. Stallions standing at stud and brood mares should be considered equivalent to horses at hard work; the peak MBLM is once again around the 3.5 range. It appears that the energy requirements for both domestic and wild ruminants are reasonably similar when at similar levels of activity and production.

TOPIC 6. LIVESTOCK WASTE MANAGEMENT

Waste management is a necessity on any farm with livestock. The most pressing problems associated with large confinement production enterprises are manure disposal and odor control. Odor control sometimes becomes a serious problem as urban centers expand into rural areas.

Waste management begins with the design of the barns and the kinds of pens and stalls used. Then, the kind of bedding used to absorb moisture is a waste management decision, and the frequency of cleaning and disposing of the manure is yet another.

Small family farms, characteristic of agriculture until the last few years, solved waste management problems by using bedding from the small grain crops and spreading the manure on the fields as often as possible. Winter accumulations were piled behind the barns until spring when the manure was spread before tillage operations began.

Waste management is a much greater challenge to agriculture in the 1980s for two reasons. One, farms are generally larger, with more livestock in more concentrated housing, and two, a greater concern for nutrient cycling and the dispersion of chemicals from all sources into the environment. Also, two potential uses of manure are now possible: as fertilizer, and as energy. Manure has been used as fertilizer for as long as people have tended cattle. Only recently, however, has the technology been developed that involves the biological conversion of organic materials, such as livestock wastes, to methane, carbon dioxide, and other gases.

UNIT 6.1. MANURE PRODUCTION AND HANDLING

Large cattle feeing operations and dairy farms have literally tons of manure to handle each day. The amounts depend on the sizes and numbers of livestock. Estimates of the amount of manure produced by different kinds of livestock are given in Table 6-5.

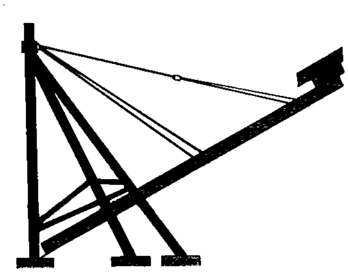
It is important to note that the amounts of manure excreted per day are given per 1000 pounds (455 kg) of live body weight. Weights of different kinds of domestic livestock were given in CHAPTER 2, permitting one to make rough estimates of the amounts per animal per day for a given farm. For example, a 50-cow dairy herd of 1400 lb holsteins would produce 4620 pounds, or 2.3 tons of fresh manure per day, which is 843 tons per year. On a dry-weight basis, the values are 970 pounds per day and 177 tons per year. The fresh weight is what must be handled by the manure-handling system, with the addition of urine.

Table 6-5. Amounts of manure produced per day by different kinds and classes of livestock, expressed as weight per 1000 pounds of live weight (Data from Ensminger 1970).

	Weight	% water	Dry weight
Dairy cow	66 lb 30 kg	79	13.9 lb 6.3 kg
Finishing cattle	47 lb 21 kg	80	9.4 lb 4.2 kg
Sheep	33 lb 15 kg	65	11.6 lb 5.3 kg
Swine	88 lb 40 kg	75	22.0 lb 10.0 kg
Chickens	25 lb 11 kg	54	11.5 lb 5.1 kg
Horses	44 lb 20 kg	60	17.6 lb 8.0 kg

MANURE HANDLING SYSTEMS

The usual manure handling practice in the first half of this century involved cleaning the barn and piling the manure behind the barn for later spreading on the fields. Wheelbarrows or manure carriers were loaded by hand and the manure dumped in the pile. This would go on all winter; there was a large pile by Spring, and it was spread as soon as possible. Increased mechanization resulted in the use of mechanical barn cleaners that clean the manure out of the gutters and load it into a manure spreader (see Inset). Then it is spread immediately, with a large tractor and a power-take-off driven spreader. This is the current practice on the majority of dairy farms. Daily spreading is necessary, whether it be warm or cold, dry or wet, rain or snow. Fields must be available to spread the manure on, and the tractor must be powerful enough and the wheels wide enough with enough flotation to make it in heavy going.



LIQUID STORAGE SYSTEMS

New manure-handling systems may include storage tanks for "liquid" manure, which contains enough waste to keep solids in suspension, and the slurry is pumped into tanks that are used to spread it on the fields (Figure 6-16).

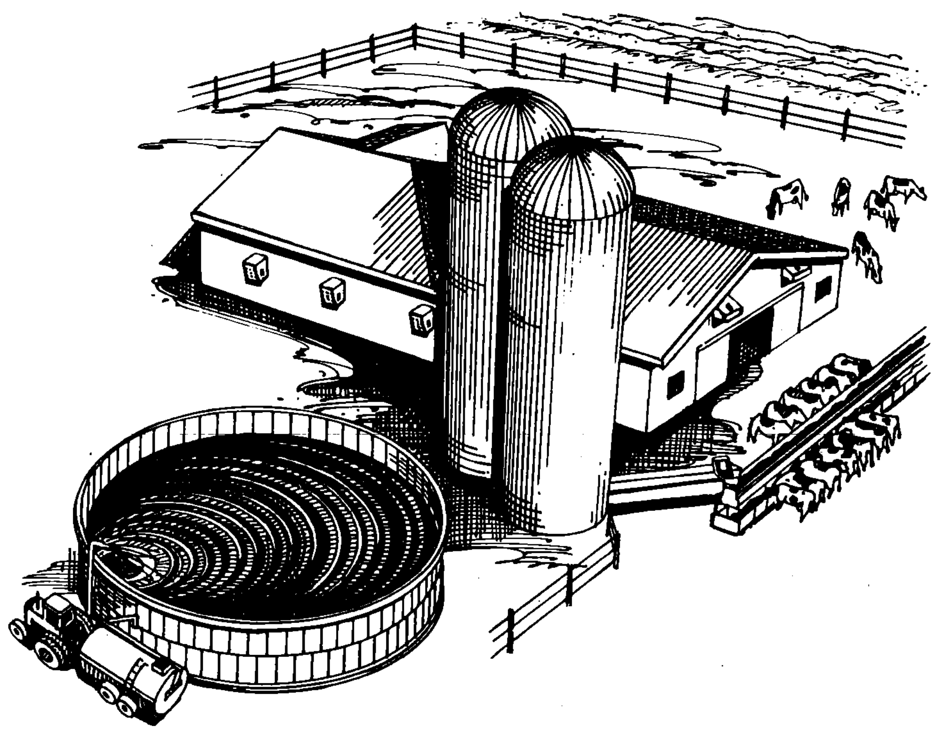


Figure 6-16. Storage tank and tractor-drawn tank for spreading the slurry on fields.

These new manure-handling systems provide some distinct advantages, such as storage of the manure and liquid wastes to be hauled out to the fields when spreading conditions are good (5-6 month intervals are recommended in some areas), and all of the nutrients are sealed in and not subject to breakdown and leaching.

A major disadvantage is cost. About two cubic feet of space is needed per cow per day, which means a tank of 30,000 to 35,000 cubic feet would be required for a 50-cow herd. Such a tank is about 55 to 60 feet square and 10 feet deep which involves a considerable expenditure. A liquid storage system cost between $300 and $400 per cow in 1971 (Schmidt and Van Vleeck 1974), so it's current cost may be more on the order of $1000 per cow.

LAGOONS AND OXIDATION DITCHES

Lagoons, used in conjunction with swine and beef operations, are open collection areas where aerobic and anaerobic decomposition occurs. Aerobic decomposition requires lagoons with large surface areas and aeration. Oxidation ditches are similar to lagoons, except the manure is circulated, incorporating air for aerobic oxidation.

Whatever the system, manure handling is an accepted part of farming. It is unfortunate that conflicts have arisen in some areas as a result of encroachment by houses on to farm land. If livstock farming is practiced in an area first, then associated noises and odors should be anticipated by suburban developers and dwellers without turning to social or even legal action to control them. This principle is similar to the depredation problem and "first use" discussed in CHAPTER 12.

UNIT 6.2. ENERGY PRODUCTION FROM MANURE

Energy in manure is recovered through a process called anaerobic digestion (Koelsch 1983). This involves the use of a digester to hold the manure for 20-25 days for decomposition and gas production. Then, uses of the biogas must be found since it is expensive to store. Gas-fired boilers, water heaters, furnaces, and engine-powered electricity generators are examples of on-farm use.

The idea of energy recovery from livestock manures is sure to capture the imagination of the resource conservationist. This is a good place to point out the need for careful energy accounting, however, rather than gross numbers such as "gross heat production in equivalent gallons of fuel oil per day equals number of cows times 0.22" (Koelsch 1983). In simple arithmetic, that means, for a 100-cow dairy, 8030 gallons of fuel oil per year, enough to heat 5 average-sized houses! Koelsch is careful to point out, however, that not all the energy can be recovered for use. The digester itself needs heat, especially in the winter. The heating needs of the digester at that time leaves much less available for home heating needs, electricity, and other energy-requiring functions, at a time when they are also greatest. Thus there is a shortage of biogas available for direct use in the winter, and there is a surplus in the summer.

Electricity generated on the farm may be one of the most promising uses of biogas. Koelsch points out that recent federal legislation requires utility companies to allow an on-farm generator to be connected with the electric utility, and to pay for the power produced. At 6¢ per kwh and the production of 2 kwh per cow per day, the gross return for a 100-cow dairy is 100 x 2 x 0.06 x 365 = $4380, or $43.80 per cow. Compare this figure to the return per cow discussed in CHAPTER 9; it is about 2% of the annual gross per cow.

Anaerobic digestion of manure does not alter its fertilizer value. Thus energy production and the use of manure as organic fertilizer are both possible, but the specialized equipment necessary for the implementation of current technology may be so expensive that only a few farmers--those with large dairy herds of 200 or more cows, for example--could afford the capital expenditures necessary. Thus, another paradox is created; small diversified farms are good for wildlife, but technology is becoming so expensive that small diversified farms cannot survive economically.

TOPIC 7. SUMMARY

Livestock management has come a long way in this century. Mechanization has relieved farmers of much tedious manual labor, and the amount of management information available has thrust farmers up to the forefront of computer applications. The list of 1500 computer programs currently available from the University of Florida (Strain and Fieser 1982) is but one example of the modern technology being used in decision-making.

The efficiency of farm labor increased rapidly in the 1940s-1960s (Figure 6-17), primarily as a result of mechanization. What the information age will bring is unknown as yet; my prediction is that the use of information-processing computers will enhance the biological components of agriculture by assisting in the development of desirable genetic characteristics and increasing the biological use of feeds, and provide options for more diversified uses of farm land with potential for wildlife benefits if wildlife biologists are prepared to communicate and interact with farmers.

READ Y-AXIS AS A MULTIPLE OF 1910 LEVEL

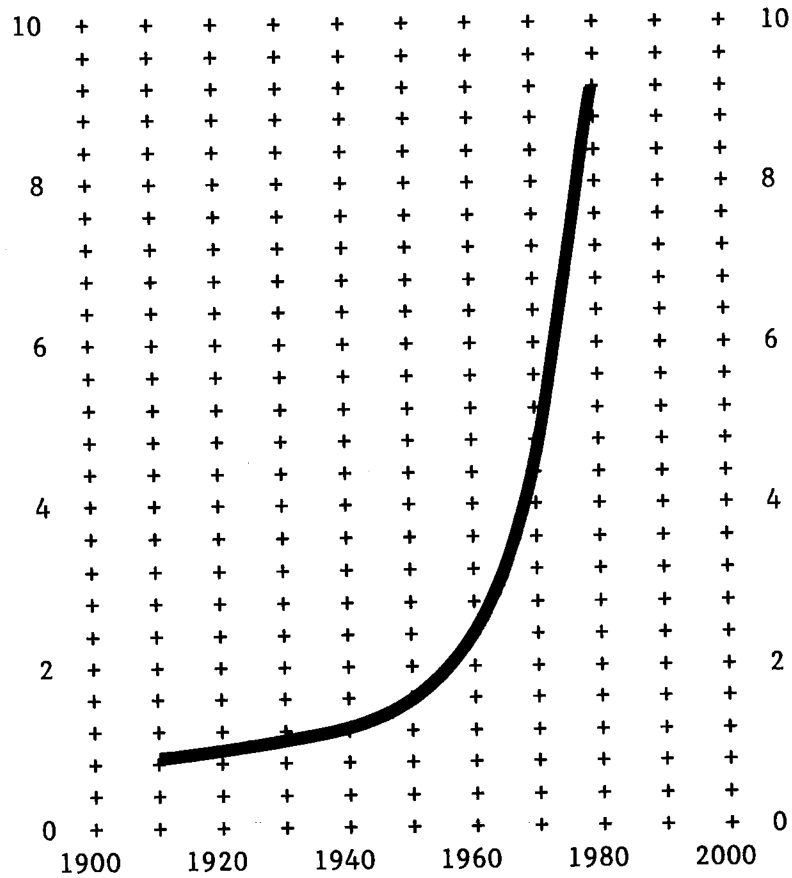


Figure 6-17. Efficiency in use of farm labor for livestock production in the United States. (Calculated from data in USDA 1981a).

The capital-intensive high technology mode of operation in livestock management is intriguing for its potential energy efficiency and conservation by use of livestock "waste," but such operations depart further from small, diversified farms. Resident farmers have a genuine love for the land and its livestock and wildlife, and for working the land and enjoying its productivity. Conflicts result from considerations of energy efficiencies and dollar returns, and they are not easily resolved because so many value judgements are involved. Wildlife biologists should have the expertise to interact with farmers at a high level of "information-age" technology. This is discussed in later CHAPTERS. For now, on to the next CHAPTER on water and soil management.

LITERATURE CITED

Church, D.C. 1977. Livestock Feed and feeding. O & B Books, Inc., Corvallis, OR. 349 pgs.

Cole, H.H. and W.N. Garrett (Editors). 1980. Animal Agriculture. W.H. Freeman Co., San Francisco. 739 pgs.

Ensminger, M.E. 1955. The Stockman's Handbook. The Interstate Printers and Publishers, Danville, IL. 598 pgs.

Ensminger, M.E. 1970. Sheep and Wool Science. The Interstate Printers and Publishers, Inc., Danville, Ill. 948 pgs.

Grow, O. 1972. Modern Waterfowl Management and Breeding Guide. American Bantam Association (other publisher information lacking). 358 pgs.

Marsden, S.J. and J.H. Martin. 1955. Turkey Management. The Interstate, Danville, Il. 999 pgs.

Kays, J.M. 1969. The Horse. Arco, NY. 439 pgs.

Koelsch, R. 1983. Methane from manure: is it for you? Hoard's Dairyman 128(1):14, 38.

Moen, A.N. 1973. Wildlife Ecology: An Analytical approach. W.H. Freeman Co., San Francisco. 458 pgs.

Moen, A.N. 1978. Seasonal changes in heart rates, activity, metabolism, and forage intake of white-tailed deer. J. Wildl. Manage. 42(4):715-738.

Moen, A.N. (In Press). Ecological Efficiencies and Forage intake of Free-ranging animals. In: National Academy of Science Publication.

National Research Council. 1966. Biological energy interrelationships and glossary of energy terms. Pub. No. 1411. National Acad. of Sci. Washington, D.C. 35 pgs.

____________. 1975. Nutrient requirements of sheep. National Acad. of Sciences. Washington, D.C. 72 pgs.

____________. 1976. Nutrient requirements of beef, National Acad. of Sciences, Washngton, D.C. 1976. 56 pgs.

Pond, W.G. and J.H. Maner. 1974. Swine Production in temperate and tropical environments. W.H. Freeman Co., San Francisco. 646 pgs.

Schmidt, G.H. and L.D. Van Vleeck. 1974. Principles of Dairy Science. W.H. Freeman and Company, San Francisco. 558 pgs.

Scott, M.L., M.C. Nesheim, and R.J. Young. 1982. Nutrition of the Chicken. M.L. Scott and Associates, Ithaca, NY. 562 pgs.

Strain, J.R. and S. Fieser. 1982. Updated Inventory of Agricultural Computer Programs. Circular 531, Cooperative Extension Service, Univ. Florida. 186 pgs.

U.S. Department of Agriculture. 1960. Yearbook of Agriculture; Power to Produce. United States Government Printing Office, Washington, D.C. 480 pgs.

U.S. Department of Agriculture. 1981a. Agricultural Statistics 1981. United States Government Printing Office, Washington, D.C. 601 pgs.

U.S. Department of Agriculture. 1981b. Economic Research Service, Statistical Bulletin Number 522. 159 pgs.