NUTRITION OF HORSES AND MULES

by Earl B. Krantz and S. R. Speelman

THE first part of this article deals with the nutritional requirements of horses insofar as these have been determined; actually, there has not been very much experimental work in this field. The second part discusses practical feeding under different conditions, including suggested rations and the use of concentrates, roughage, and mineral supplements.

The Principles of the nutrition of horses and mules fundamentally are not unlike those of other domestic livestock. Thus, for body building and maintenance, for growth, and for production, the horse and mule have need for protein, carbohydrates, fats, minerals, and vitamins, much as these essentials are required for similar vital processes by cattle, sheep, swine, and poultry. The relative importance of the various nutrients and the quantities required by horses and mules are, however, not the same as for the other farm animals.

Nor do the requirements of horses and mules necessarily remain the same from day to day or from period to period. The stage of life, the kind and degree of activity, climatic conditions, the kind, quality, and amount of feed, the system of management, the health and individuality of the animal, and perhaps other equally important factors are all continually exerting a powerful influence in the determination of nutritive needs. How well the individual feeder or experimenter understands, anticipates, interprets, and meets these requirements usually determines the success or failure of the ration and of horse or mule keeping.

The present discussion of the nutritive requirements of horses and mules considers the subject briefly from the standpoints of adequacy of rations, feed economies, and feeding practices.

1 Earl B. Krantz was formerly Animal Husbandman, and S. R. Speelman is Associate Animal Husbandman, Animal Husbandry Division, Bureau of Animal Industry.

2 Although most of the research and investigational work in the field of nutrition has not considered mules, the results obtained from some tests and from practical experience indicate that their requirements for feed are essentially the same as those of horses. The nutritive needs of horses and mules are accordingly treated as one in this article.
Horses and mules of all ages and kinds need adequate amounts of protein of suitable quality.

Protein is required for building new tissues and for replacing protein lost from the body in the general wear and tear of normal body processes. Actual protein requirements for these processes can be described in terms either of nitrogen used by the body or of amounts of a theoretically complete or perfect protein which contains all the amino acids needed in exactly the proportions required by the body. In this respect no one food protein is perfect, and proteins from various sources vary widely in their biological value.

Knowledge concerning the actual protein requirements of horses is rather scant, but feeding standards have been established as a result of experiments as well as of practical experience that suggest amounts of crude digestible protein estimated to cover the protein requirements with a suitable margin of safety. These standards take into account the variability in nutritional value of different food proteins, as well as some variations in quantitative requirements.

During the stage of growth and development of the young horse or mule, particularly the first year, the relative need for protein is greater than at any other time of life. The amounts needed daily for 100 pounds of live weight are usually greatest at the earliest ages and smallest weights, declining gradually as the animal ages and increases in size. The needs of the growing animal for protein for building new tissues are responsible for most of the excess in its protein requirements over those of mature animals. The relative demands for protein of colts and of mature horses of various classes are shown in recommendations for the daily intake of this nutrient in some feeding standards, such as those of Morrison (1949, pp. 1006-1007), which are given in table 1. Morrison suggests that the daily protein needs of the 500-pound draft colt are amply covered by 0.18 to 0.20 pound per 100 pounds of live weight, while for the 1,000-pound mature idle work horse the quantity specified is 0.06 to 0.08 pound.

In ordinary feeding practice it is assumed that the quantitative needs for protein among young growing animals are the same for both sexes. A report by Mitchell (1936), however, states that "females put on gains containing a smaller percentage of calories in protein than males." This indicates that the protein requirements of the growing female may be somewhat less than those of the male, but the difference is probably not of importance in practical feeding. Estimates for the combined amounts of protein required daily for growth and maintenance in draft colts weighing 400 to 1,200 pounds, as made by Morrison (1949, p. 1007), are given in table 1.

The optimum and minimum quantitative needs of colts for protein during the growth period are unknown at the present time, except for information developed from practical experience. The need for experimental research on this subject is evident.

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2 Italic numbers in parentheses refer to Literature Cited, p. 1075.
3 The Morrison standards have been selected for purposes of discussion because their recommendations cover the nutrition of horses of various kinds and because they are applicable to many of the methods that have been found to be practical and economical under average and normal conditions.
Table 1.—Morrison’s feeding standards for horses

<table>
<thead>
<tr>
<th>Type and weight (in pounds) of animal</th>
<th>Requirements per head daily</th>
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<tbody>
<tr>
<td></td>
<td>Dry matter</td>
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<tr>
<td></td>
<td>Pounds</td>
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<tr>
<td>Horses, idle:</td>
<td></td>
</tr>
<tr>
<td>1,000</td>
<td>13.0–15.0</td>
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<tr>
<td>1,200</td>
<td>14.8–20.6</td>
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<tr>
<td>1,400</td>
<td>16.6–23.0</td>
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<tr>
<td>1,600</td>
<td>18.3–25.4</td>
</tr>
<tr>
<td>1,800</td>
<td>20.0–27.6</td>
</tr>
</tbody>
</table>

| Horses at light work: | | | | | |
| 1,000 | 15.0–20.0 | 0.8–1.0 | 9.0–11.0 | 9.0–11.0 | 7.5–9.1 |
| 1,200 | 17.4–23.1 | 0.9–1.2 | 10.4–12.7 | 9.0–11.0 | 8.7–10.5 |
| 1,400 | 19.6–26.2 | 1.0–1.3 | 11.8–14.4 | 9.0–11.0 | 9.8–11.9 |
| 1,600 | 21.9–29.2 | 1.2–1.4 | 13.4–16.0 | 9.0–11.0 | 10.9–13.3 |
| 1,800 | 24.0–32.0 | 1.3–1.6 | 14.4–17.6 | 9.0–11.0 | 12.0–14.6 |

| Horses at medium work: | | | | | |
| 1,000 | 16.0–21.0 | 1.0–1.2 | 11.0–13.0 | 9.0–11.0 | 9.4–11.1 |
| 1,200 | 18.8–24.6 | 1.2–1.4 | 12.9–15.2 | 9.0–11.0 | 11.0–13.0 |
| 1,400 | 21.5–28.2 | 1.3–1.6 | 14.8–17.4 | 9.0–11.0 | 12.6–14.9 |
| 1,600 | 24.1–31.6 | 1.5–1.8 | 16.6–19.6 | 9.0–11.0 | 14.2–16.7 |
| 1,800 | 26.7–35.0 | 1.7–2.0 | 18.3–21.7 | 9.0–11.0 | 15.8–17.5 |

| Horses at hard work: | | | | | |
| 1,000 | 18.0–22.0 | 1.2–1.4 | 13.0–16.0 | 9.0–11.0 | 11.3–13.9 |
| 1,200 | 21.3–26.1 | 1.4–1.7 | 15.4–19.0 | 9.0–11.0 | 13.4–16.5 |
| 1,400 | 24.7–30.2 | 1.6–1.9 | 17.8–21.9 | 9.0–11.0 | 15.5–19.1 |
| 1,600 | 28.0–34.2 | 1.9–2.2 | 20.2–24.8 | 9.0–11.0 | 17.5–21.6 |
| 1,800 | 31.2–38.1 | 2.1–2.4 | 22.5–27.7 | 9.0–11.0 | 19.6–24.1 |

| Brood mares nursing foals, not at work: | | | | | |
| 1,000 | 15.0–22.0 | 1.2–1.5 | 9.0–12.0 | 6.5–7.5 | 7.6–10.0 |
| 1,200 | 17.4–25.5 | 1.4–1.7 | 10.4–13.9 | 6.5–7.5 | 8.8–11.1 |
| 1,400 | 19.0–28.5 | 1.6–2.0 | 11.8–15.7 | 6.5–7.5 | 10.0–13.1 |
| 1,600 | 21.9–32.1 | 1.7–2.2 | 13.1–17.5 | 6.5–7.5 | 11.1–14.6 |
| 1,800 | 24.0–35.2 | 1.9–2.4 | 14.4–19.2 | 6.5–7.5 | 12.2–16.0 |

| Growing draft colts, after weaning: | | | | | |
| 400 | 9.2–11.3 | 0.8–0.9 | 5.6–7.2 | 6.5–7.0 | 4.9–6.3 |
| 500 | 10.9–13.3 | 0.9–1.0 | 6.6–8.4 | 6.6–7.1 | 5.7–7.3 |
| 600 | 12.4–15.2 | 1.0–1.2 | 7.6–9.6 | 6.7–7.2 | 6.5–8.3 |
| 700 | 13.9–17.0 | 1.1–1.3 | 8.5–10.8 | 6.8–7.3 | 7.3–9.3 |
| 800 | 15.3–18.7 | 1.2–1.4 | 9.4–12.0 | 6.9–7.4 | 8.0–10.1 |
| 900 | 16.7–20.4 | 1.3–1.5 | 10.2–13.0 | 7.0–8.0 | 8.7–11.0 |
| 1,000 | 18.0–22.0 | 1.4–1.6 | 11.0–14.0 | 7.0–8.0 | 9.2–11.8 |
| 1,100 | 19.3–25.0 | 1.5–1.6 | 11.8–15.0 | 7.2–8.2 | 9.9–12.6 |
| 1,200 | 20.6–25.1 | 1.5–1.7 | 12.6–16.0 | 7.5–8.5 | 10.6–13.4 |

1 The ratio, or proportion, between the digestible protein and the digestible nonnitrogenous nutrients (including fat multiplied by 2.25).

1 A unit employed in measuring heat and energy, equal to 1,000 calories.

Next to that of the young growing colt, the relative need for protein is greatest in the brood mare, whether pregnant, or nursing young, or both (fig. 1.) This is a result of the various physiological processes involved in gestation and lactation, which increase the protein demand. In the Morrison standards, the protein requirements (100-pound body-weight basis) for the 1,000-pound idle brood mare with suckling foal are set at 0.12 to 0.15 pound daily. If her maintenance demands are assumed to be approximately the same as those for work stock of the same weight, which is logical, the conclusion may be drawn that as much protein is required daily to produce milk for the foal as is needed for the upkeep and repair of her body. Moreover, this standard is applicable to mares of greater weights. The milk yields of mares nursing foals are variable, Morrison (819, p. 467) reporting them as between 26 and 77 pounds daily as determined by tests on draft mares in Germany. Since about 2 percent of the total volume (or about 20 percent of the total solids) of the milk is protein,
the amount of protein in the daily milk yield of a mare would be between $\frac{1}{2}$ and $1\frac{1}{2}$ pounds.

Inasmuch as there is no conclusive evidence that ordinary work increases the protein requirements of healthy horses and mules, the theoretical needs of such animals for this nutrient should be the same whether idle or at labor. However, in practice, the amount of protein fed is usually increased with the amount and severity of work done, since it is difficult, using the commoner feeds, to increase total energy (digestible nutrients) without increasing the protein. The ingestion of somewhat more than the required amounts of protein will ordinarily do no harm, since protein can be readily utilized by the body to supply energy, though this may result in increased costs. The Morrison protein requirements for maintenance for idle work horses and mules have already been mentioned. The intake is practically doubled when the animals are at hard work (table 1).

None of the existing feeding standards contain specific suggestions for the intake of protein by stallions, whether idle, working, or in breeding service, nor is there available any exact experimental evidence on this subject. From practical experience, however, it appears that, unless he is worked regularly, the stallion's need for protein ordinarily should not vary greatly from that of idle work horses, mules, and open mares.

In addition to the Morrison feeding standards for horses there are others that cover this subject either directly or indirectly. One of these, which proposes standards for maintenance, was presented by Brody, Procter, and Ashworth in 1934 (157). In general, the protein

![Figure 1.—Both the mare and the young growing colt require adequate supplies of all the essential nutrients.](image)
allowances recommended by these workers are somewhat lower than those of Morrison, particularly in the case of young, lightweight animals.

In the young growing colt, the result of inadequate protein intake is usually evidenced by slow or stunted growth and improper development. With breeding stock, there may be impairment of the reproductive functions. Mature, idle stock ordinarily are not seriously affected if the lack of protein is not too great and does not extend over a long period. Work animals, however, may lack spirit and efficiency.

ENERGY

Consideration of the energy requirements of horses and mules is divided into two parts: (1) The need for and utilization of feed nutrients for body maintenance, and (2) the quantitative expenditure of nutritive material for reproduction, lactation, and the accomplishment of useful work. The first is necessarily of most importance, because it involves all functions essential to the animal's existence.

The maintenance requirement is the amount of food or its constituents required to cover the needs of an animal in good health without gain or loss of weight. In the determination of energy requirements for maintenance, several factors may influence the quantitative demand for and the intake of food material—the age, size, and individuality of the animal; the kind, quantity, quality, and proportions of feeds used; and climatic and management conditions. The probable effects of some of these on maintenance requirements can be rather readily calculated or predicted, while others may only be estimated.

Inasmuch as size and age of the animal are the major factors affecting energy requirements for maintenance, their influence on total food intake is of primary importance. Formerly it was believed that the quantitative need for energy was directly proportional to the body weight of the animal. Present knowledge, however, indicates that energy requirements for maintenance are roughly proportional to surface area, or to the 0.65 to 0.75 power of the body weight of mature animals. The energy required for maintenance per unit of surface area in young animals is somewhat greater.

The effect of individual temperament on maintenance requirements is not readily predictable. There is a wide variability in temperament among horses and mules of different ages and kinds, and incidentally this factor is probably the one most responsible for the “good and bad doers” with which every horseman is more or less familiar.

Improper balance of nutrients in the maintenance ration, caused by excessive amounts of feeds with wide nutritive ratios, may result in depression of digestibility, poor feed utilization, stunted or improper growth, and impairment of health, if continued for a very extended period. Some research work on this subject has been reported by Dunbar (286), who conducted maintenance tests with horses using oat straw (nutritive ratio 1:48) as the sole feed. The animals tested showed a marked decline in ability to digest all types of nutrients.

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5 The methods by which energy requirements of horses have been measured and determined are various and somewhat complicated. They have involved many elaborate tests for measuring the intake and expenditure of energy, digestibility of feeds, and the accomplishment of work.
except fat, a constantly increasing intake of total feed, decreasing vitality, and permanent damage to general health and efficiency.

Climatic conditions and the method of managing horses and mules affect their energy-maintenance needs. Very cold weather increases considerably the amount of energy required, as does also any mismanagement that keeps the horse or mule in a restless, excitable condition for any considerable length of time.

It has been indicated that the young, growing horse and mule have proportionately greater need of energy for maintenance per unit of body weight than the mature, idle animal owing to differences in body-surface area. The effects of rapid growth and the general acceleration of all vital processes due to a higher rate of metabolism, as well as the greater degree of body activity in the young, are also important considerations. For these reasons, the energy needs of a young horse or mule at weaning age (approximately 500 pounds body weight) may be relatively twice as great as those of the 1,000-pound, mature, idle animal and about the same as those for such a horse or mule when at hard work. Energy requirements for maintenance in young horses and mules are highest during the early stages of life and decline gradually as they approach maturity. When immature horses or mules are worked, their energy requirements will be increased somewhat, the amount being determined by the labor done.

The energy requirements of idle brood mares nursing foals are somewhat greater than those of idle geldings, dry mares, or mules of the same size. The need of the brood mare for additional nutrients is due principally to physiological demands in the production of milk for her young. It may also, however, be related to improper feeding during the gestation period, which may have caused body losses that must be repaired. The need for energy of the idle brood mare with foal is variable, depending on the milk yield. Normally, the extra feed required for the production of milk will approximate that required for light work by the open mare, gelding, or mule of the same size. Pregnant brood mares with nursing young have higher energy requirements than nonpregnant mares with suckling foals, particularly during the first few months of gestation.

Energy requirements of working horses and mules are determined almost entirely by the individuality and size of the animals and the kind, amount, and severity of the labor performed. Because of many factors difficult to evaluate, it is only possible to approximate what constitutes light, medium, and hard work under various conditions. On the farm, the operations of disk ing and breaking ground when done on a full-day basis are classed as severe work. Cultivation and haying jobs would generally come under the heading of medium labor. So far as feeding is concerned, part-time heavy work might be equivalent to medium labor. Again, from the feeding standpoint, light work could consist of any of these operations if done during short periods, or it might be easy hauling, etc. Ordinarily the feeder is the best judge of the kind of work done and the amount of energy required by the animals to do the job, the aim being to maintain body weight at a fairly uniform level throughout the work period. The feed requirements of work stock at light jobs often are not much greater than those for idle animals. With
severe work, however, the demands are greatly increased and are usually about twice those while idle.

Unless the stallion is worked, his energy requirements are about the same as those for idle work stock and animals at light work. The exact requirements, however, are determined by the amount of breeding work done, restlessness, travel, and the condition in which the stallion is kept.

Inasmuch as the major requirement for fattening farm animals of any kind is an abundant supply of total digestible nutrients (energy), the rations for increasing body weight in thin horses and mules must be relatively high in energy-producing materials, particularly carbohydrates. The total amount of energy needed by horses and mules for fattening is variable, depending on the age, individuality, and condition of the animals, the feeds used, and the rate of gain desired, but it approximates that of stock at hard work.

Lack of adequate amounts of energy-producing feeds in the rations of horses or mules may result in a number of consequences. When the energy deficiency is great in the feed of young animals, the result is usually slow and stunted growth, with consequent underdevelopment. Work animals that do not receive adequate amounts of energy will lose weight, get out of condition, and be unable to do their jobs without excessive fatigue. When the energy requirements of breeding stock and idle animals are not satisfied the effect is usually a loss in body weight.

Consideration of the many factors that may influence the energy requirements of horses and mules indicates that no hard and fast rules can be laid down that will adequately cover quantitative intake in all instances. Approximations of such requirements, however, which should be useful as guides, are presented in the Morrison feeding standards in table 1.

MINERALS

Chemical analysis of the body of a farm animal such as the horse reveals the presence of varying quantities of a rather large number of elements. Aside from hydrogen, oxygen, nitrogen, and carbon, the principal elements found are calcium and phosphorus. Other elements, present in either small or appreciable quantities, which in the light of present-day knowledge are believed to be essential to balanced, complete, and satisfactory nutrition, are sodium, chlorine, iodine, iron, potassium, sulfur, copper, magnesium, zinc, cobalt, and manganese. That the total of these elements in the horse is of considerable significance is indicated in the body analyses of three Percheron horses made by Mitchell and Hamilton (610), who found that the ash (mineral) content was 4.66 percent of the empty carcass weight.

The various mineral elements required by the animal body have both building and regulatory functions. The quantitative needs of horses and mules for these minerals and the best minerals for supplying the needs are matters of obvious importance in the practical nutrition of the horse and mule. Yet with the exception of data on water requirements, a few reports on salt (sodium chloride) consumption, and fragmentary research findings relative to calcium,
phosphorus, and iodine, experimentation to date has given the horse and mule feeder no answers to many phases of this subject and few clues to assist him to work out the correct solution.

There appears to be little likelihood that these animals will suffer from deficiencies of iron, potassium, sulfur, copper, magnesium, zinc, manganese, or other minerals when fed normally, and no special attention need be given to the inclusion of these minerals in the ration.

**Calcium and Phosphorus**

To be of economic importance, a horse or mule must have a sound, fully developed body. Such development is possible only when the skeletal framework is adequate, and this may be assured by the judicious use of rations containing rather liberal amounts of calcium and phosphorus, the bone-building minerals.

Calcium and phosphorus together constitute approximately 75 percent of the total supply of body minerals and about 90 percent of the mineral matter in the bony skeleton. The need for calcium and phosphorus in the horse and mule ration is undoubtedly most pronounced during the growing stage, particularly during the first year of life. It has long been known by practical horsemen that the colt should have acquired about one-half its total growth (body-weight basis) when it is 1 year old. This is supported by experimental evidence, particularly the recent work of Hudson at the Michigan State Agricultural College (549), and of Trowbridge and Chittenden at the University of Missouri (1149). In his investigations with young draft horses of Belgian and Percheron breeding, Hudson determined that the greatest development of the skeleton takes place before a colt is 1½ years of age, while Trowbridge and Chittenden found that during the first year of life their experimental animals (Percheron foals) had acquired 50 to 60 percent of the total increase in body weight; 65 to 70 percent of the total increase in depth and circumference of chest, width at hip points, and size of fetlocks and coronets; and as much as 90 percent of the total increase in some important body dimensions. If 99 percent of the calcium supply of the animal body and approximately 80 percent of its phosphorus content are in the bones (803, p. 10), such skeletal and body increases can logically mean but one thing—the ingestion and utilization of relatively large quantities of these two elements by the growing animal. The quantitative need for calcium and phosphorus decreases gradually as animals approach maturity. Unfortunately, there are apparently no experimental data on the requirements for calcium and phosphorus by young horses and mules that either verify or refute the practical observations and conclusions drawn. Mitchell and McClure (803, p. 87) believe that the intake of these minerals should be equivalent to 0.2 percent of the dry ration.

Reproductive functions increase the mineral requirements of the breeding mare, and her demands for calcium and phosphorus are relatively high both during pregnancy, especially the latter part, and while she is nursing her foal. As in the case of young, growing horses, no research data are available on this subject to indicate either quantitative intake or utilization of mineral matter by brood mares. If, as
frequently happens, the mare with a suckling foal is rebred and be-comes pregnant, the demands for calcium and phosphorus will be in-creased, particularly during the first half of the gestation period, for she is then called upon to supply the materials to develop the unborn fetus and at the same time produce mineral-rich milk for her nursing young.

The mineral demands for the maintenance of mature stallions are unknown, but insofar as the need for calcium and phosphorus are concerned, it is possible they may be about the same as those for work geldings and dry mares in most instances.

Despite the lack of clear experimental evidence, it seems probable that the needs for calcium and phosphorus by mature work horses (geldings and dry mares) and mules are not nearly so great as those for young stock and brood mares, because ordinary muscular work, if not carried to the point of fatigue, is not known to have any marked effect on mineral requirements where there is an adequate supply of energy material in the diet. Thus, it is thought that few de-ficiencies of these minerals will be encountered under ordinary normal farm feeding practices, particularly if some good legume hay and ade-quate pasture are supplied.

It has been stated that the literature on mineral nutrition in horses does not reveal pertinent data on the daily ingestion of calcium and phosphorus by animals of different ages and kinds. This is true in general, but note should be made of the deductions that Mitchell and McClure drew from analyses of horses carcasses, using growth data obtained from University of Missouri tests and Morrison’s feeding standards. From this calculation, they roughly estimate that between the weights of 400 and 1,600 pounds a Percheron horse needs a daily allowance of 13.5 grams of calcium (9.0 for growth and 4.5 for maintenance) and 13.6 grams of phosphorus (4.7 for growth and 8.9 for maintenance).

From the evidence on mineral malnutrition now available it is ap-parent that horses and mules of all ages may be adversely affected in various ways when the calcium and phosphorus intake is inadequate, when these elements are ingested in disproportionate amounts, and when there is a faulty utilization of either mineral by the body. In very young animals, calcium and phosphorus malnutrition is most evident in the arrest or distortion of normal bone growth. Unless this is corrected in time, it quite often culminates in the disease known as rickets. With older horses and mules calcium and phosphorus malnutrition may lead to a number of consequences. If the deficiency is one of calcium alone, both the skeletal tissues and the reproductive functions of horses may be affected. Phosphorus deficiencies do not seem to occur as often in horses and mules as in other species of live-stock, although in certain localities they frequently cause under-development in horse stock.

Lack of calcium in the horse ration, when intensified by the presence of high-phosphorus protein concentrates, is believed to produce the condition commonly known as osteomalacia or osteodystrophia fibrosa, which is prevalent in various parts of the world and affects not only horses but asses and their hybrids, with the young of

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6 Over 50 percent of the mineral matter in milk is calcium and phosphorus.
the species most susceptible. This disease is usually characterized by an initial period of stiffness and lameness, followed by swelling of the jaws and the nasal and frontal bones of the head, bone fractures, detachment of ligaments, anemia, emaciation, and death. Because of the great increase in head size that may occur during osteodystrophia fibrosa, it has become popularly known as bighead in some countries. It is said to develop when the calcium-phosphorus ratio of the ration is 0.55 to 1 or less and to be arrested by the addition of calcium supplements until the ratio becomes 1.8 or more of calcium to 1 of phosphorus (805, p. 17).

No data definitely indicate the optimum proportions of calcium and phosphorus for horses and mules. It is thought, however, that the ratio of calcium to phosphorus should be somewhere between 2 to 1 and 1 to 1 under ordinary conditions.

Salt

Horses and mules of all ages and kinds need sodium chloride—common salt—regularly in their diet. Aside from the function which sodium chloride has in the maintenance of body-cell osmotic pressure and the role of hydrochloric acid in digestion, the part that these elements, sodium and chlorine, play in the mineral metabolism and other life processes of such animals is not well understood. Nor is there much experimental evidence which pertains to this matter in any way. Insofar as the quantitative intake of salt by horses and mules is concerned, existing data and practical observations indicate that the principal determining factors are individuality of the animal (irrespective of age) and the degree of body activity. That the matter of individuality is a particularly pertinent factor is indicated by tests conducted with draft horses at Michigan State Agricultural College (548), which showed a range in daily salt consumption of 0.27 to 3.26 ounces and an average daily intake of 1.82 ounces per head for animals kept under like conditions of feed and work. Such consumption, however, does not necessarily indicate the needs of the individual animals for sodium and chlorine, because it is entirely possible that more salt was consumed by some of the horses than was actually required. The influence of hard work on salt consumption and possibly on salt requirements is apparent from practical experience and observation. When at heavy labor, particularly during warm weather, the horse and mule sweat profusely and this carries considerable salt from the body in the form of visible excreta. Unless this salt is replaced, the animals will soon exhibit signs of excessive fatigue, a fact that points to the possibility of some direct correlation between salt requirements and the expenditure of energy.

Iodine

According to Mitchell and McClure (803, p. 71):

The only known function of iodine in the nutrition of the higher animals is to serve as an indispensable constituent of thyroxine, an amino acid found in thyroglobulin, the characteristic protein of the thyroid gland.

Except in certain areas and under abnormal feeding conditions, the problem of adequate iodine intake and utilization is of minor significance with horses and mules. There is a region, however—the so-
called goiter belt—where iodine deficiencies in feeds may be a major problem, particularly with brood mares and colts. In this section, experimental evidence indicates that the use of iodine supplements is generally beneficial. For this purpose Rodenwold and Simms (978), of the Oregon State Agricultural College, recommend 15 grains of potassium iodide weekly for pregnant mares during the last 5 or 6 months of the gestation period in order to produce normal, strong foals, free of congenital goiter. Iodine is also given to horses and mules by some feeders in the form of iodized salt, which is apparently an effective method of administration when properly handled. The amount of potassium iodide in such salt usually approximates 0.02 percent (equivalent to 1 ounce in 300 pounds), but some may be lost by oxidation when the salt is exposed to air. Consideration should be given this fact when calculating the iodine supply needed.

**VITAMINS**

The role played by vitamins in the nutrition of the horse and mule has not been explored extensively. However, there is reason to suppose that the vitamin requirements of horses and mules are similar to those of other animals, and it seems probable that ordinarily there will be few serious deficiencies of any of the vitamins except A and D.

The importance of vitamin A or its precursor carotene is indicated by its relation to two important attributes of a horse—eyesight and hoofs. Night blindness resulting from a deficiency of vitamin A has been demonstrated experimentally in horses; and the injurious effect of lack of vitamin A on the hoofs has been indicated by experiments with horses in the army of Finland (636). The uneven and poor development of the hoofs of these horses, which had been fed chiefly on old hay, was cured by supplementary feeding of pasture grasses, grass silage, or cod-liver oil.

**FEEDS AND ECONOMICAL FEEDING PRACTICES**

Size, age, condition, individuality, working conditions, and production needs of horses and mules are the principal factors affecting feed requirements.

As indicated, little definite knowledge exists on the nutritive values of feeds for horses and mules or the protein, energy, mineral, and vitamin requirements of these animals. Although a few digestion trials have been made with horses, the number of animals used in such tests has been limited, and most of the theoretical feed requirements for horses and mules have been calculated from experiments with ruminants. Comparative feeding tests with horses and mules are also limited in number. In addition, the number of animals used was often so small or the differences in body weight were so slight that the experimental results were reported as of doubtful statistical value. Simms (1060) points out extreme variations of 136 pounds per individual within the same lot of experimental animals over a period of 21 months, and he doubts—

if average differences in gains or losses in weight amounting to much less than 100 pounds in 12 months are of real significance in feeding tests where teams or small groups of horses are compared.

Individuality among horses may be a big factor in much of the
irregularity found in the experimental results obtained with small numbers of animals. Kind and amount of work done also may have varied the results obtained from similar rations in such tests.

In determining the comparative merits of the more common feeds for horses and mules and the most efficient feeding practices for their production and use, results of practical feeding experience may be added to the limited knowledge of theoretical requirements and the somewhat doubtful results of comparative tests.

Oats, corn, and barley, all farm-grown concentrates, are the grains most generally used for horses and mules, and alfalfa, clover, soybean, timothy, prairie, Johnson grass, and grain hays are the most common forages fed in different sections of the United States. Wheat bran and linseed meal are the most favored supplements to the grains, although cottonseed meal and some other supplemental concentrates are fed to horses and mules in considerable quantities in the South and other sections where such feeds are available at low prices.

Of the common feeds, those grown locally are ordinarily the cheapest to use and as a general rule work into the ration most satisfactorily. For this reason it is well to plan the ration largely on the basis of the feeds most readily available, and sufficient variety may usually be obtained by a judicious combination of home-grown products.

**CONCENTRATES**

**Oats**

Oats rank as one of the best grains for horses. While they are not so high in total digestible nutrients as either corn or barley, a suitable protein content and the bulky nature of this feed make it particularly valuable for many horses. Many horsemen consider that oats have no equal as a horse feed. This may be erroneous, however, as both experimental and practical feeding experience have shown that some other feeds, when properly combined, may be either equal or superior to oats. Oats are especially suitable for work horses and mules during hot weather, for horses worked irregularly, and for the steady feeding of light-type horses.

**Corn**

Corn is the most commonly used concentrate for horses in the Corn Belt. It has a higher energy value than oats, it is ordinarily cheaper per hundred pounds, and it is particularly valuable when used in combination with oats. Corn does not, however, have as great a calcium or phosphorus content as oats. When fed with alfalfa or other legumes, corn usually produces excellent results. The alfalfa adds the necessary protein and supplies minerals and vitamins, all of which are low in corn. If corn is fed as the only grain with grass hay, some protein supplement should be used to balance the ration. Corn is most commonly fed to farm horses on the ear or shelled. Corn meal, if used at all, should be combined with oats, wheat bran, or some other light, bulky feed.

Most experiments have shown very little difference between the feeding values of corn and of oats for work stock. Feeding tests in
Ohio, New York, Illinois, Kansas, and Missouri (191, 478, 707, 866, 1147), for example, proved that corn in the ration of the farm work horse or mule was entirely satisfactory and lowered the cost of the ration somewhat.

Barley

Barley is used as the principal grain for horses in many parts of the West. Because of its physical character it should be either rolled, crushed, or coarsely ground to prevent digestive disturbances. While barley has a little more digestible protein and more total digestible nutrients than oats, it is neither so widely grown or used nor so generally popular a feed among horsemen.

Other Grains

Wheat, rye, rice, and some leguminous seeds (92), are used as feed for horses under limited conditions. Wheat is satisfactory when crushed or rolled, and may be fed in moderate quantities in conjunction with some bulky concentrate. Rye also must be crushed or rolled and should be limited to not more than one-third of the grain ration. Rice must be ground, rolled, or soaked, and should be used in limited amounts combined with such feeds as corn, blackstrap molasses, and protein supplements. All leguminous seeds should be ground, and even then they may cause digestive disturbances if they constitute more than one-third of the concentrate allowance.

Wheat Bran

Wheat bran is a favorite feed among horsemen because it is high in protein and phosphorus, is palatable and bulky, and has a laxative effect. Where corn is the principal grain and the cheapest feed available, the use of wheat bran (10 to 20 percent) is particularly desirable. Even with alfalfa hay, the use of a small amount of wheat bran improves any grain ration, because alfalfa, while high in calcium, is low in phosphorus. Wet bran is more laxative than dry bran and is often used once or twice weekly as a mash for horses doing irregular work.

Linseed Meal

Old-process linseed meal is used both as a protein supplement and as a conditioner. Its laxative and conditioning properties make it an ideal commercial supplement in amounts from ½ to 1 pound per horse daily. Larger allowances may prove too laxative. In Kansas (707), corn, wheat bran, and linseed meal, in a 6:3:1 ratio, with prairie hay, proved to be well adapted for horses at hard work. The advisability of using linseed meal in limited amounts ordinarily depends upon the type of hay fed, comparative feed prices, and whether or not its utilization makes possible the major use of feed of lower cost.

Cottonseed Meal

Cottonseed meal is a nonlaxative protein supplement that may be fed to horses and mules in limited quantities, if the animals are put gradually on bright, choice-quality meal. While most authorities have
recommended that not more than 1 pound daily per 1,000 pounds live weight be fed, experiments in Texas (1226) indicate that 1 to 2 pounds of 43-percent-protein cottonseed meal usually may be fed to horses and mules. It is best to mix cottonseed meal with oats, wheat bran, or some other bulky feed. In the South, this feed is a valuable supplement to corn-and-cob meal, particularly if a legume hay is not available.

**HAYS AND OTHER ROUGHAGE**

It is very important to consider both the quality and the percentage of roughage in planning an efficient and economical ration for horses and mules. Because the stomach of these animals is comparatively small and the energy expended in work is large, the need for a balanced ration of suitable quality and physical character is most important, especially when the animals are at hard work. At this time the amount of roughage should be relatively small and its quality high. More roughage, of lower quality, may be used under light work conditions and during idle periods. In making the choice of roughage it is well to remember that legume hay is particularly valuable for its mineral and vitamin content and may be used to correct deficiencies of these nutrients in some of the common farm grains.

**Timothy Hay**

Bright, clean timothy hay has long been considered one of the best dry roughages for horses. Much of this popularity is due to the excellent quality of hay that may be made when timothy is properly cut and cured and to its wide distribution and availability. As timothy hay is lower in protein and total digestible nutrients than either mixed or legume hays, it is generally not so valuable for horses as legume hay of equal quality fed in limited amounts or mixed hay of equal quality and quantity.

**Johnson Grass Hay**

Johnson grass is grown extensively in certain sections of the South. In these sections, this grass is used to advantage as forage for horses. Johnson grass hay compares favorably with timothy in protein and total digestible nutrients and is higher in both calcium and phosphorus.

**Alfalfa Hay**

Alfalfa hay, because of its high content of protein, energy, minerals, and vitamins and its palatability, is much more valuable than timothy or other grass hays for horses. As pointed out in the discussion on corn, alfalfa is especially suited for use with a grain ration that is low in protein. First-cutting alfalfa, which is coarser and not so "wasy" (laxative) as later cuttings, is preferred for horses, and its use fits well into the management program of many general stock farms. Various experiments have been conducted to determine the feeding value of alfalfa hay for horses and mules. In one of these, Hudson (547) found that horses weighing 1,670 pounds and fed a daily ration of 12.23 pounds of corn and 17.91 of alfalfa when at medium to heavy work gained in weight, while similar horses on a ration of 8.02 pounds of corn, 6.23 of oats, and 19.59 of timothy hay lost weight. Also, the corn and alfalfa ration was 6 cents a day cheaper.
As the unlimited feeding of alfalfa hay has been said to result in softness, excessive sweating, heavy breathing, digestive disturbances, and filling (swelling) of the legs and hocks, its use should be restricted to about 1 pound or less daily per 100 pounds live weight of the animal. Alfalfa hay is especially valuable for brood mares, foals, and young stock.

**Clover Hay**

Bright clover hay that is free from dust is a good roughage for horses. Its content of protein, total digestible nutrients, minerals, and vitamins is high. Though various kinds of clovers are used for hay in different parts of the country, medium red is the one most widely favored. For light horses especially, a combination of timothy and clover is preferred to clover alone, as the quality of this mixture is often better than that of straight clover.

**Soybean Hay**

Soybean hay, an annual legume grown throughout most of the Corn Belt, may be used in the economical feeding of horses in many instances. This roughage is about equal to alfalfa hay in total digestible nutrients, is slightly laxative, and is particularly suitable for combination with corn or other concentrates that are high in carbohydrates. Soybean hay should be limited to about 50 percent of the roughage allowance; if it makes up the entire roughage ration, no more should be fed than is cleaned up in a reasonable time.

**Grain Hay**

Grain hay is extensively used on the Pacific coast and is economically important in the rations of horses throughout the Rocky Mountain area. Oats, barley, and wheat, when cut before maturity and cured properly, make hays that are palatable and nutritious. On account of the grain content, the amount of such forage fed should be restricted. Very little concentrate feed is needed with good grain hay, but it is desirable to include a feed relatively high in protein.

**Miscellaneous Hays**

Many other roughages are used for horses and mules in sections of the United States where they are commonly found and are of particular importance. Prairie hay of the range sections, for example, is an excellent roughage for horses, being about equal to timothy in feeding value. Hays from cowpeas, millet, and the sorghums are also used extensively in some areas, particularly in the South and Southwest.

**Other Miscellaneous Roughages**

Corn fodder, oat and wheat straw, and similar roughages are economical feeds for horses, particularly when they are idle or at very light work. If hay is scarce and high in price, these roughages may also be used for other stock when supplemented by a limited feed of good legume hay. These cheap roughages, of course, are low in protein, minerals, and vitamins, furnishing bulky material principally. Some high-protein, laxative concentrate feed and sometimes a small quantity of good roughage should be fed with them. Work by Trow-
bridge (1148), showed that oat straw could be used as the only forage in a winter ration with corn, oats, and bran while horses were at light winter farm work. Oat straw alone, however, does not furnish enough nutriment for wintering horses (286). Moreover, the use of cheap, low-quality roughages should not be carried to the extreme. It should be confined primarily to work stock during idle seasons.

**Silage**

Silage should not be considered as the principal roughage for horses and mules, but rather as a supplement or appetizer. Corn silage, which is bulky, appetizing, and slightly laxative, is the only kind that has met with much favor. Too little work has been done with grass silage to draw definite conclusions. It is generally considered that the amounts of corn silage should not exceed 10 to 15 pounds daily per head for mature animals, although much larger amounts have been used satisfactorily in some instances. None but choice, fresh silage should ever be given, as severe losses from botulism have resulted from silage that did not fulfill these specifications. Frozen or moldy silage must not be used for horses or mules under any circumstances.

Alfalfa silage has more protein, energy, minerals, and vitamins than corn silage. Brood mares have been successfully wintered on alfalfa silage with a small amount of dry roughage, and it seems that this feed should be used to a greater extent.

**Pasture**

Although pasture is a natural feed for all horses and mules and is often sufficient for the maintenance of idle stock, it does not furnish enough nutrients for animals at steady work. It is, however, an excellent source of minerals and vitamins, and its use for work stock during periods of rest and idleness is an excellent means of toning up the system. During the summer work season particularly the use of a night and Sunday pasture for work stock is recommended, for it keeps the animals in better spirits and condition. The regular use of pasture is also a vitally important factor in the economical production of horses and mules, and brood mares and colts should have access to good pasture a large part of the year.

**PREPARATION OF FEEDS**

The grinding or crushing of concentrate feeds, except the small, hard grains (such as barley, wheat, rye, and the grain sorghums), is not generally recommended for work stock. The value of using such prepared feed depends on the cost of preparation, work conditions, and the age and condition of the animals. If prepared grains are fed, those that are crushed or coarsely ground, free of dust and not pasty, are preferred to finely ground grains.

Roughages such as corn stover and sorghum can generally be fed most economically to horses and mules when shredded or cut. The advisability of chopping, chaffing, or cutting hays of different kinds, however, depends largely on the quality and value of the feed and the cost of such preparation. Ordinarily, low-priced good-quality hay
should not be prepared for feeding, but it may be economically advisable to chop, cut, or chaff poor-quality hays.

WATER

Water is essential to the horse and mule in various physiological processes and in supplying minerals. The average water consumption of a mature horse is variable, but it approximates 10 to 12 gallons daily \((92, 1224)\). While horses will voluntarily drink more water when fed a protein-rich ration, they should be encouraged to use more water when eating dry, coarse roughage. Shy drinkers can often be made to drink more water by mixing a small amount of salt with the feed.

There is a diversity of opinion on the proper time and method of watering horses. Other things being equal, however, regularity and frequency of watering and working conditions are the most important considerations influencing water requirements. If the horse has been at moderate work, he usually may be watered before being fed and again offered water before being returned to work. It is dangerous, however, to water heavily a horse that has been deprived of water for a long time or that is very warm. During hot weather the horse should be watered often when at work and, if stabled, the last thing at night.

MINERALS AND VITAMINS

An adequate hay and grain ration—that is, one containing legume or mixed hays and wheat bran—should supply sufficient minerals (except salt) for the mature work horse and mule. Because there is not enough in this feed, salt must be given regularly. While neither the kinds of vitamins nor the quantities required by horses and mules are known, the use of pasture and good-quality leafy hay and exposure to sunlight should provide sufficient vitamins for the work animal in most instances.

Mineral-deficiency problems in colt production are generally local in character. Where there are possibilities of a mineral deficiency in the available feeds, young stock especially should be provided with supplementary sources of minerals. If there is a known deficiency of calcium, ground limestone or oystershell flour may be used to correct it. If the ration is low in phosphorus, however, the addition of dried-milk products, steamed bonemeal, or dicalcium phosphate is recommended. In no instance should calcium supplements alone (ground limestone and oystershell flour) be added to rations low in phosphorus. This will increase the imbalance of minerals and accentuate the deleterious effects of the phosphorus deficiency. Where self-feeding is employed, the mineral supplements should be mixed with common salt and kept available in a self-feeder. For such purposes mixtures made in the following proportions by weight are recommended:

<table>
<thead>
<tr>
<th>Deficiency</th>
<th>Mix Proportions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium deficiency</td>
<td>2 parts calcium supplement.</td>
</tr>
<tr>
<td>Phosphorus deficiency</td>
<td>2 parts phosphorus supplement.</td>
</tr>
<tr>
<td>Calcium and phosphorus deficiency</td>
<td>2 parts phosphorus supplement.</td>
</tr>
</tbody>
</table>

Calcium and phosphorus deficiency mix is made up of 2 parts calcium supplement, 2 parts phosphorus supplement, and 1 part common salt.
Under free choice, varying amounts of these mixtures are consumed, depending upon pasture and feed conditions. Salt should also be fed ad libitum.

**FEEDING UNDER WORK CONDITIONS**

The proper nutrition of horses and mules when at work is a big factor in maintaining them in service for many years. Improper feeding for a short time may not cause much damage, but, if it is carried on over a long period or often repeated, it may result not only in lowered efficiency but in more serious consequences (286).

The kind and quantity of grain and hay required by work horses or mules depend among other things on the age, size, and condition of the animals and the kind, regularity, amount, and speed of the work performed. As the stomach capacity is relatively small, the amount of concentrates must be increased and the roughage decreased as the amount, severity, or speed of work increases. Although the exact amounts of feed are variable, a general guide is to allow 1¼ to 1½ pounds of grain daily with 1 pound of hay per 100 pounds live weight for horses at heavy work; about 1 pound of grain and 1 to 1½ pounds of hay at medium work; and about ½ pound of grain and 1¼ to 1½ pounds of hay at light work. The maintenance ration for idle horses is considered later in this article.

The method of feeding has a great deal to do with the utilization of feed and the condition of the horse. The grain part of the ration for horses at work is usually divided into three equal feeds, given morning, noon, and night. If the horse does not clean up his grain in a reasonable length of time, the quantity should be reduced. About

*Figure 2.*—Horses on pasture provided with supplemental grain in a convenient feeding trough.
two-thirds of the daily allowance of hay is given at night, with most of the remaining hay fed in the morning, leaving a very small allowance for a noon feed, if there is no hay left in the manger.

The quantity of roughage should be limited so that all edible forage will be cleaned up. Moreover, it is generally advisable to allow the horse to eat some hay before the grain at night. This will prevent his gorging on hay after eating the grain, thereby forcing the grain through the stomach too quickly for proper assimilation.

Overfeeding, rather than underfeeding, is common when horses are working irregularly. This is wasteful, expensive, and often has a harmful effect on the digestive system. When horses are working intermittently, the grain ration usually should be reduced about one-half, and only enough other feed given to keep them in fit condition. All feed should be given regularly, however. Turning work horses and mules regularly on pasture at night keeps the digestive system accustomed to succulent feed and decreases the quantity of grain and hay required. It is sometimes advantageous to provide equipment for feeding grain in the pasture (fig. 2).

SELECTING THE RATION

In selecting a ration for the farm horse or mule, the feeds should be confined principally to those grown on the home farm. Where the feed must be purchased, attention should be given to unit costs, inasmuch as it is usually possible to mix a satisfactory ration from a combination of available feeds on the market. In building the ration, one should remember also that not only is it important to consider the feed nutrients, including minerals, but that the ration must have enough bulk so that it is not too heavy, and that it should be made up of good-quality, palatable feeds, with enough variety to be relished by the animals.

In compiling the rations for the horse and mule at medium work given in table 2, theoretical requirements and feeds common to different parts of the United States have been considered.

As the rations suggested are for the average (1,000-pound) work horse, increase the quantity of feed in the ration by about one-fifth if the horse weighs 1,200 pounds, and by about two-fifths if the horse weighs 1,400 pounds. For example, in the case of the first ration, a 1,400-pound horse should receive 11.3 pounds of oats and 17 of timothy. In practical feeding this horse would get 4 quarts of oats three times daily, with about 12 pounds of hay at night and 5 in the morning. Sufficient hay probably would be left in the manger after the morning feed so the horse could eat a little before receiving his grain at noon, or a little hay should be given him then. If a horse weighs 1,000 pounds and is at heavy work, an increase of 3 pounds of grain (oats) daily (1 quart at each meal) and a slight reduction in the amount of hay fed should supply the necessary nutrients. However, it must be remembered that experimental work has shown that a ration of oats and timothy hay will not maintain the horse at hard work, so it would be best to use a combination of corn and oats under those conditions. When the horse is at light work, the grain should be reduced and the forage increased somewhat. An idle horse may often be carried on a ration consisting almost entirely of roughage,
only enough grain being fed to keep the horse quiet when others in
the stable that have worked are being fed.

**Table 2.**—Suggested daily rations for the 1,000-pound horse or mule at medium work

<table>
<thead>
<tr>
<th>Feed</th>
<th>Quantity</th>
<th>Total dry matter</th>
<th>Digestible protein</th>
<th>Total digestible nutrients</th>
<th>Nutritive ratio, 1 to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oats (whole)</td>
<td>8</td>
<td>7.38</td>
<td>0.78</td>
<td>5.36</td>
<td>8.5</td>
</tr>
<tr>
<td>Timothy hay</td>
<td>12</td>
<td>10.20</td>
<td>41</td>
<td>5.99</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20</td>
<td>17.58</td>
<td>1.19</td>
<td>11.29</td>
<td>8.5</td>
</tr>
<tr>
<td>Corn (ground ear)</td>
<td>10</td>
<td>8.44</td>
<td>0.43</td>
<td>7.05</td>
<td></td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>5</td>
<td>4.58</td>
<td>0.57</td>
<td>2.67</td>
<td></td>
</tr>
<tr>
<td>Timothy hay</td>
<td>5</td>
<td>4.23</td>
<td>0.17</td>
<td>2.40</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20</td>
<td>17.27</td>
<td>1.17</td>
<td>12.21</td>
<td>9.4</td>
</tr>
<tr>
<td>Corn (shelled)</td>
<td>7</td>
<td>6.10</td>
<td>0.50</td>
<td>5.73</td>
<td></td>
</tr>
<tr>
<td>Bran (wheat)</td>
<td>2</td>
<td>1.81</td>
<td>0.25</td>
<td>1.23</td>
<td></td>
</tr>
<tr>
<td>Timothy hay</td>
<td>10</td>
<td>8.50</td>
<td>0.34</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20</td>
<td>16.41</td>
<td>1.09</td>
<td>11.95</td>
<td>10.0</td>
</tr>
<tr>
<td>Corn (ground ear)</td>
<td>10</td>
<td>8.44</td>
<td>0.43</td>
<td>7.05</td>
<td></td>
</tr>
<tr>
<td>Red clover hay</td>
<td>10</td>
<td>8.71</td>
<td>0.82</td>
<td>5.08</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20</td>
<td>17.15</td>
<td>1.25</td>
<td>12.13</td>
<td>8.7</td>
</tr>
<tr>
<td>Corn (ear)</td>
<td>6</td>
<td>5.06</td>
<td>0.26</td>
<td>4.23</td>
<td></td>
</tr>
<tr>
<td>Oats (whole)</td>
<td>3</td>
<td>2.77</td>
<td>0.29</td>
<td>1.99</td>
<td></td>
</tr>
<tr>
<td>Bran (wheat)</td>
<td>.5</td>
<td>.45</td>
<td>.06</td>
<td>.31</td>
<td></td>
</tr>
<tr>
<td>Mixed hay:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timothy</td>
<td>5</td>
<td>4.25</td>
<td>0.17</td>
<td>2.49</td>
<td></td>
</tr>
<tr>
<td>Clover</td>
<td>5</td>
<td>4.33</td>
<td>0.41</td>
<td>2.54</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>19.5</td>
<td>16.88</td>
<td>1.19</td>
<td>11.56</td>
<td>8.7</td>
</tr>
<tr>
<td>Corn (shelled)</td>
<td>7</td>
<td>6.10</td>
<td>0.50</td>
<td>5.73</td>
<td></td>
</tr>
<tr>
<td>Soybean hay</td>
<td>5</td>
<td>4.58</td>
<td>0.34</td>
<td>2.68</td>
<td></td>
</tr>
<tr>
<td>Corn stover</td>
<td>7</td>
<td>6.25</td>
<td>0.16</td>
<td>3.57</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>19</td>
<td>16.93</td>
<td>1.20</td>
<td>11.88</td>
<td>8.9</td>
</tr>
<tr>
<td>Barley (rolled)</td>
<td>8</td>
<td>7.23</td>
<td>.82</td>
<td>6.34</td>
<td></td>
</tr>
<tr>
<td>Prairie hay (Colorado and Wyoming)</td>
<td>10</td>
<td>9.45</td>
<td>.44</td>
<td>5.82</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>18</td>
<td>16.68</td>
<td>1.26</td>
<td>12.16</td>
<td>8.7</td>
</tr>
</tbody>
</table>

**WINTERING IDLE WORK STOCK**

Maintaining farm work stock in healthy condition during the winter season is the first step toward fitting them for spring work. Open sheds adjacent to fields and pastures often make an ideal setup for wintering purposes. Under this system horses and mules are provided with dry, comfortable protection during the idle season, yet have the benefit of the exercise obtained in getting a large part of their feed from fields or pastures. When large amounts of dry roughage are being used, it should be possible for the animals to obtain pure water at will. If necessary, a heater should be used to keep the drinking tank free from ice.

A horse should not be so fed during the winter that it becomes fat and soft. Nor, on the other hand, should it receive such poor care that it loses weight and vitality, becomes subject to disease, and is not in condition for spring work. A horse that is thin or run-down at the beginning of the winter or idle season should be gradually
brought into thrifty physical condition by correct feeding over an extended period.

The liberal use of carbohydrate-rich roughages, supplemented with the right amount and kind of other nutritious feed, will maintain an idle horse properly during the winter. Cornstalk fields, grain-stubble fields, or pastures that have not been too closely grazed during the summer are very desirable sources of a large part of the winter maintenance feed. To supplement these feeds a limited amount of alfalfa, clover, or other palatable roughage may be used economically. The legumes are rich in protein, mineral matter, and vitamins, and supply materials needed to replace those lost in the natural wear of the body. Being somewhat laxative in effect, they also help to keep the digestive tract in good condition and are especially valuable for use in connection with straw and similar feed. In some instances, especially when it is not possible to feed a legume hay, a small quantity of grain is necessary to maintain idle horses in thrifty condition.

Corn silage, if fed with care, may be utilized in the winter ration of idle work horses. Its bulk, succulence, laxativeness, and the presence of carotene or vitamin A in good silage are of value when cheap, coarse roughages make up the major part of the ration.

PREPARING FOR SPRING WORK

During the fitting period preceding heavy spring work, horses and mules must be so conditioned that they will be able to convert the vitality and energy that have been stored up in the winter into full power each work day and even be prepared for an overload during the peak of heavy work. The amount of fitting necessary depends largely on the way the animals have been wintered. The condition of a horse that has been properly cared for in the open during the winter is more nearly ideal than that of the horse that has been kept in the stable. While the length of the fitting period varies, the average time usually allotted for it is 2 to 4 weeks. A horse that is either very thin or very fat requires a longer fitting period than one in thrifty condition with fair flesh. Also, a young horse, especially if just broken, requires a longer time for fitting and training than a mature horse.

While the use of coarse, nonsalable feeds is generally an economical practice during the winter, the horse should gradually be put on a ration of good-quality hay and a light feed of grain just before the fitting period begins. The quantity of grain is increased as the fitting period progresses, and when light work has commenced a 1,400-pound horse should be ready to utilize daily about 14 pounds of grain together with 14 or 15 pounds of fine-quality hay.

FEEDING THE BROOD MARE

Brood mares need a ration sufficient to supply both their own feed requirements and those of the fetus or suckling foal. A well-balanced ration containing sufficient protein and minerals is particularly needed. Brood mares should always be kept in thrifty condition, but it is important that they do not become too fat.

The right amounts of good-quality legume or mixed hay with a mixed grain ration will supply the nutritional requirements for the brood mare under work conditions. Idle brood mares generally need
little grain if they are on good pasture or are supplied with a liberal amount of good-quality legume or mixed hay. In the winter, an open shed adjacent to pasture fields or paddocks is especially valuable in forcing brood mares to exercise and remain thrifty. A common practice in handling idle brood mares is to feed some good legume hay at night, a little grain or 10 to 20 pounds of corn silage in an open grain bunk in the morning, and coarse field roughage, timothy hay, or good straw to supply the balance of the feed.

The brood mare should not be fed heavily on grain or hay for the first 24 hours after parturition, although she may have a little hay and water from which the chill has been taken. The first grain fed should be light, such as a wheat-bran mash with a little cooked flaxseed meal in it. If confined to the stable, the mare should be kept on a limited ration for a number of days after parturition. A mixture of oats and wheat bran is satisfactory for the limited early feedings. Other feeds may be added later as the mare is returned to work or when the colt needs an increased milk supply (fig. 2). The use of good pasture or good-quality legume hay with mixed grain will stimulate milk production. Feeding too much grain at first, however, may produce too much milk, which may cause indigestion in the foal. The exact method of feeding the mare at this time depends upon her individuality and the existing conditions.

**COLT PRODUCTION**

It is important that the foal be fed for optimum, efficient growth. The mare that is handled and fed properly will ordinarily supply the milk needs of the foal. The young animal will, however, begin to pick at grain, grass, and hay at an early age, and proper use of these feeds will determine to a great extent how well the colt will grow.

At a month or two of age the foal will start to take dry grains, if allowed to eat from the feed box of the dam. The use of ground oats, corn meal, and wheat bran for the mare at this time will assist in starting the foal on grain. Foals that are following their mothers on pasture may benefit from a supplementary ration of grain.

If a foal is getting plenty of nourishment from grain and grass or legume roughage, it will not be seriously set back at weaning (6 months). The foal should be eating about 4 pounds of grain daily at this age. During the weanling period (6 to 12 months) it is most important that the ration be sufficient in protein, minerals, and vitamins. The liberal feeding of good legume hay with some mixed grain is generally necessary for efficient growth. The thrifty colt should not be too fat but should be in good flesh.

The amount of grain necessary to produce efficient growth in colts may be limited if good roughage is available. Heavy feeding is not required, but steady growth should be maintained. In experiments with draft colts in Missouri, Trowbridge and Chittenden (1149) found that a limited ration produced a satisfactory 3-year skeletal growth. Also, they had less difficulty in keeping colts sound in their feet and legs on a limited grain ration than on a heavy ration. In his

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7 This discussion is limited to feeding for production under ordinary conditions, as the feeding of the very young foal, especially the orphan, has been discussed in the article, The Nutrition of Very Young Animals (p. 501).
tests with colts of Belgian and Percheron breeding, Hudson (549) found that the use of limited amounts of grain and alfalfa hay with free access to straw in winter rations did not stunt the animals and that it had a greater effect on weights and condition than on skeletal development, although it did retard the latter. As a result of this work, it is Hudson's opinion that when feeds are cheap and the value of horses is high, the use of liberal rations may be advisable in order to hasten maturity, but that "where cheap pasture land is available and if hay and grain are high, it seems advisable to limit the feed of colts in the winter time and to take more time for their development."

Edmonds (305), in tests with Percheron fillies in Illinois, found alfalfa hay fed with corn and oats gave such satisfactory results in developing weanlings and yearlings that there was little need of using purchased mill feeds when alfalfa could be grown on the farm. During the first winter an average of 5.674 pounds of grain and 4.266 of hay were required per pound of gain, while during the second winter feeding period an average of 9.228 pounds of grain and 12.99 of hay per pound of gain were needed.

Harper (477), at Cornell University, over a period of 10 years, found it required an average of 4,746 pounds of grain and 6,804 of hay to grow a farm colt to an average of 1,270 pounds the spring it was 3 years of age.

Edmonds and Crawford (306) state that weanling draft fillies made good gains in height and frame and kept thrifty on 2.3 pounds of grain and approximately 8 each of sheaf oats and soybean hay daily. During the second winter their daily consumption was 3.41 pounds of grain and over 9 each of sheaf oats and soybean hay. At about 2 years of age the fillies, in medium condition, averaged 1,484 pounds in weight.

In another test, Edmonds and Kammlade (307) found that limiting daily grain rations to 6.36 pounds of crushed oats and bran per head in one lot, and 5.4 of corn and bran per head in the other lot, with alfalfa hay and oat hay, gave satisfactory and economical results in the rate and quality of growth over the weanling and yearling periods. They also reported that the grain ration of 75 percent of crushed oats and 25 percent of bran proved the most satisfactory of those fed.

While the preparation of grain for mature draft horses is usually recommended only when concentrates like wheat and barley are fed, ground grains should be fed to the suckling foal. Caine (184), in an Iowa experiment, found that weanling colts made slightly larger gains on prepared oats than on whole oats and appeared to be fatter, and that colts fed rolled oats required less feed per pound of gain than those fed whole oats. Two years of work indicated no advantage in cutting hay for colts when good-quality hay was fed.

FATTENING FOR MARKET

Little experimental work has been done on the fattening of draft horses for market. It has been assumed by some that the principles for fattening other livestock are applicable to horses. To just what extent such principles may be applied to horses, however, is questionable, for in the case of horses heavy fleshing must be gained without sacrificing action or soundness or causing filling of legs and hocks.
In fattening the horse it is especially important to remember that the animal must be gradually accustomed to a heavy grain ration, and that the amount of feed must be increased very slowly to a maximum of about 2 pounds of grain for each 100 pounds of live weight.

During fattening, regular exercise for draft horses is important. Exercise is also highly essential in the fitting of light horses. Here the conditioning process is also a matter of hardening, and the horse is used daily in harness or under saddle. In fattening, the feeder of draft horses uses the lot for exercise. For the purchaser it would probably be much better if the same system were followed as with the light horse — daily use in harness — but economically this may not be possible. Obrecht (865), of Illinois, found that horses getting exercise made nearly one-half pound, or 20 percent, less gain in weight per day than did those not getting exercise, and that exercise increased the cost of finishing horses.

FEEDING LIGHT HORSES

The principles of feeding draft horses may be applied to light horses except that the latter require proportionately less hay and a little more grain per unit of body size. The qualities desired in light breeds are trimness, spirit, action, and endurance. These cannot be obtained with large, paunchy stomachs or lack of energy, which may result from excessive use of roughage.

Oats easily rank first among the grains for light horses, but for variety a small amount of crushed barley, wheat bran, cracked corn, or a commercial mixed feed may be used with oats. When corn or other carbohydrate feeds are fed, it is important that a little linseed meal or wheat bran be used. About 6 or 8 pounds of grain daily should be sufficient for the average light horse at medium or light work.

A mixture of one of the legume hays with timothy or other grass hay should be fed with the grain. During off-work seasons, much good will result if the grain ration is decreased somewhat and the roughage increased. Two or three months of pasture may often be used advantageously. In some instances a light grain ration may be desirable while the idle horse is on pasture. The advisability of using grain at this time is determined by the individuality and condition of the horse and related factors. In bringing the light horse into condition after a period of idleness the amount of roughage may be larger than when the animal is at steady work, as the "good doer" is one with a "good middle." Later the amount of hay should be reduced gradually and the grain increased before heavy use, sale, or show. Proper nutrition and management will tend to preserve a healthy condition year after year without the occurrence of summer sores and boils or the filling of hocks or fetlocks.