

STORRS
Agricultural Experiment Station

Hay Requirements of City
Work Horses

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and
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*In Cooperation with the Bureau of Animal Industry,
Bureau of Public Roads and Bureau of Agricultural
Economics, United States Department of Agriculture.*

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Hay Requirements of City Work Horses

J. A. SIMMS¹ and J. O. WILLIAMS²

In 1924 and 1925 a series of feeding trials was conducted by the senior author, in stables of city work horses in two cities in Connecticut, and reported in Bulletin No. 132 of the Storrs Agricultural Experiment Station under the title, "Preliminary Experiments in Feeding City Work Horses." (1) These trials demonstrated the possibility of using animals kept under normal city stable conditions for certain types of feeding experiments and also showed convincingly that large numbers of horses are necessary for such experiments, since the variations in the weights of individuals within a group were often greater than the differences between groups.

These preliminary experiments also led to this hypothesis: There is a minimum amount of roughage required by the horse at work, and nothing is gained by feeding roughage in excess of this minimum; additional feed required to maintain weight can be supplied more economically in grain than in hay. For idle horses there may be advantage in feeding large amounts of roughage with a very limited grain ration, but the present investigation was limited to horses at work.

In order to test this hypothesis and to determine the minimum hay requirement, more carefully controlled trials were necessary. A cooperative arrangement between the Storrs Agricultural Experiment Station and the United States Department of Agriculture made this possible, and the data here presented are the result of the trials so conducted.

The plan as finally arranged included cooperation on the part of the Bureau of Animal Industry, the Office of Public Roads, and the Bureau of Agricultural Economics. Mr. J. O. Williams, Senior Animal Husbandman, represented the Bureau of Animal Industry throughout the experiment. Dr. Paul E. Howe of the same bureau made many helpful suggestions. Mr. M. A. R. Kelley of the Office of Public Roads personally secured draft records on the wagons used. The hay used was graded by the Bureau of Agricultural Economics under the direction of Mr. K. B. Seeds. To all of these the authors gratefully acknowledge their indebtedness.

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Mr. R. E. Simms, Field Agent of the Bureau of Animal Industry, was in direct charge throughout, handling the details and obtaining the records. For the first six months of 1927 the senior author was on sabbatic leave, during which period Professor A. G. Skinner of the Connecticut Agricultural College had general supervision.

Special credit is due Mr. E. H. Walker and Mr. E. S. Sprague of the Bridgeport Ice Delivery Company and Mr. W. L. Worden and Mr. R. E. Fisher of R. F. Worden & Sons, who made this work possible



FIGURE 1. ONE-HORSE HITCH
Worden Stables, Waterbury, Conn., June, 1928

by furnishing the animals, stables, feed and labor used in carrying out the experiments.

The photographs were taken by the Bureau of Animal Industry photographic staff.

Review of the Literature

The amount of hay fed to horses in experimental trials seems to vary widely. In the Fort Riley experiments (2) McCampbell fed from 10 to 16 pounds daily of timothy, prairie or alfalfa hay, or alfalfa meal, to horses weighing 1100 to 1200 pounds. The amount of hay fed varied from 0.85 percent to 1.4 percent of the weight of the

animals. Templeton, in mule feeding experiments at the Mississippi Station (3), fed hay in amounts varying from 1 percent to 1.5 percent of the weight of the animals, while Trowbridge averaged 1.18 percent in a two-year trial at the Missouri Station (4). Edmonds and Kamm-lade (5) report four years' experiments during which the hay fed to horses averaged from 0.93 percent to 1.14 percent, while the mules received from 0.85 percent to 1.22 percent. "Each animal received as much grain and hay, weighed separately, as it would eat readily."

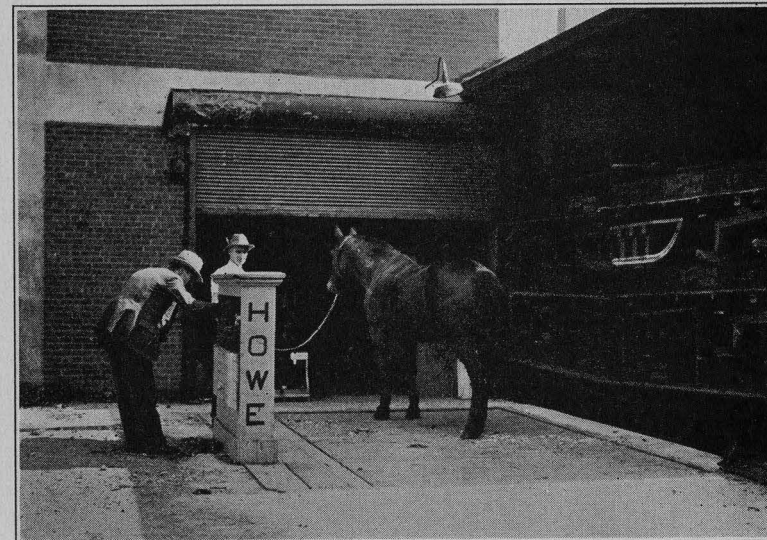


FIGURE 2. WEIGHING HORSE
Worden Stables, Waterbury, Conn., June, 1928

Clark (6), however, at the Montana Station found that horses would eat from 1.5 percent to 3 percent or more of their weight if the quality of the hay was good. One horse weighing about 1400 pounds was reported to have consumed an average of 60 pounds of hay per day, or 4.3 percent of his weight. In an experiment at the Nebraska Station (7), Gramlich fed only 0.78 percent to mules and 1.17 percent to horses. Carroll (8) stated that horses at the Utah Station ate 35 to 40 pounds of hay daily, or between 2.5 and 3 percent. Alfalfa hay was the roughage and they were given all they would eat.

Again, little experimental data are available regarding the optimum amount of hay to be used in feeding horses. At the Montana Station, Clark (6) fed four horses for about five months. Two of them

received all the hay that they would eat readily and two were fed on two-thirds as much as the others were consuming. Those on the heavy hay ration received an average of 25.8 pounds per day and those on the light ration, 17.2 pounds. Those getting the smaller hay ration did not maintain their weights quite as well as the others did, but Clark states that the horses receiving the smaller amount of hay had more life and sweat less than those that were not limited in their hay. Harper (9) reports two tests carried out by the reversal method, in



FIGURE 3. HORSES—LOT I
Worden Stables, Waterbury, Conn., June, 1928

which he varied the proportion of grain to hay. Each group was fed for 56 days on each of the two rations in one test and for 50 days on each of the rations in the other test. The advantage for the "light hay—heavy grain" group was 24.6 pounds gain per horse for each of the four periods. In these tests 100 pounds of hay replaced 73 pounds of grain and the result was a considerable and uniform loss in the weight of the "heavy hay" group as compared with the "light hay" group.

Hansson (10) carried out a series of eight experiments, in six of which grass hay was compared with oats, and in the other two, grass hay with corn. These tests lasted 48 to 100 days, including the preliminary periods, and either four or five horses were used in each of two lots throughout the series. Assuming one kilo (2.21 pounds) of

barley, 0.95 kilo (2.09 pounds) of corn, or 1.2 kilos (2.65 pounds) of oats equal to one food unit each, Hansson gave timothy and other hay "rich in grasses" a value of one food unit for each 2.5 kilos (5.51 pounds). The hay fed in these tests varied from 0.3 percent to two percent of the weight of the animal, but where the smaller amounts were fed, straw amounting to nearly one percent of the weight of the animal was fed also. Hansson concluded that "horses are able to consume as much as 18 to 20 kilos (39.68 to 44.09 pounds) of hay

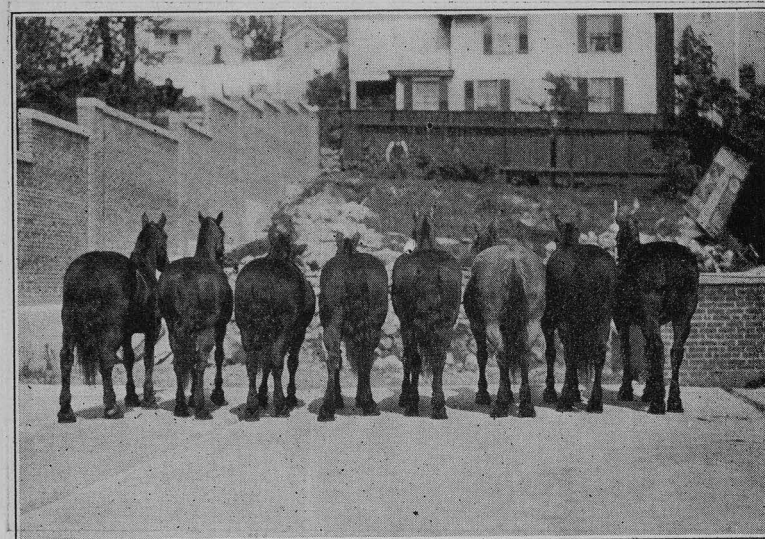


FIGURE 4. HORSES—LOT I
Worden Stables, Waterbury, Conn., June, 1928

per head per day when hay alone is used as fodder, but the great bulkiness of the hay and the low nutritive concentration value of the same cause a considerable reduction in the working capacity of the horses," and "With a quantity of 12 to 14 kilos (26.46 to 30.86 pounds) per head per day a clearly perceptible reduction in the efficiency of the hay is brought about and the hay has been utilized best when the maximum quantity given was restricted to about 6 to 8 kilos (13.23 to 17.64 pounds)." Most of the horses used in these tests weighed from 1300 pounds to 1400 pounds.

Common Feeding Practices

The variations in amounts of hay fed in both city and farm stables are fully as great as those cited above. In 1919 and 1920 the senior author obtained the approximate weights of hay fed to more than 2,000 horses and mules in the cane, rice and cotton belts. The amounts fed in different stables ranged between 15 and 30 pounds per day, with the average about 25 pounds. The animals, mostly mules, weighed about 1200 pounds. The waste was quite large on most of the plantations

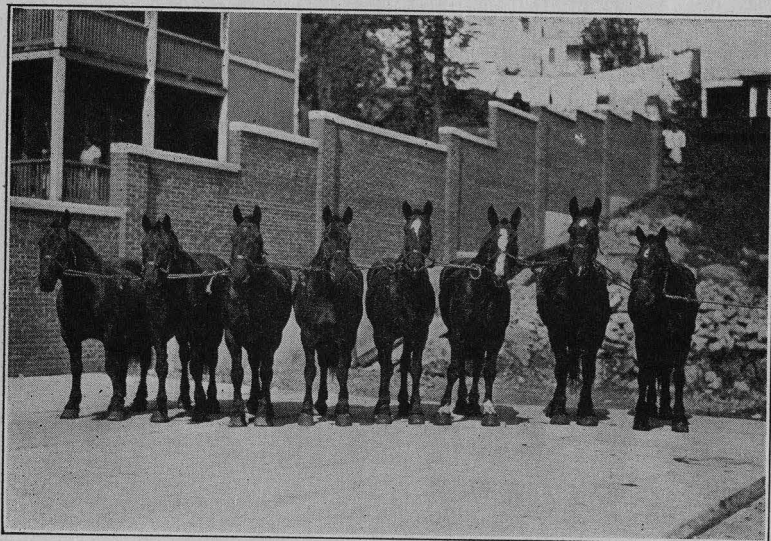


FIGURE 5. HORSES—LOT II
Worden Stables, Waterbury, Conn., June, 1928

as the common method of feeding was to fill long racks around which all of the animals were allowed to eat. All of the hay that fell on the ground was trampled under foot. Records secured from 1921 to 1924 on 40 Connecticut farms showed an average hay ration of about 25 pounds. The estimated average weight of the horses was 1350 pounds.

Estimates on about 50,000 city work horses have been secured which indicate that they are fed a little less hay than are country horses. Some of these estimates are quite accurate, being based on the amount of hay purchased divided by the total number of horses, over periods up to six years. Others are based on the hay fed during periods as short as thirty days, and still others are feeding schedules. The latter are not accepted as being sufficiently accurate for inclusion in averages

here unless other checks on the horses have been made, which indicate that they are approximately correct.

The large corporations owning 1,000 or more horses seem to feed hay more economically than the smaller horse owners. Their averages range from 15.5 pounds per horse to 22 pounds, or from 1.2 percent of the weight of the animal to 1.8 percent. In one corporation with horses scattered from Boston to St. Louis and from Detroit to New Orleans, the average hay consumption in the various stables ranged from

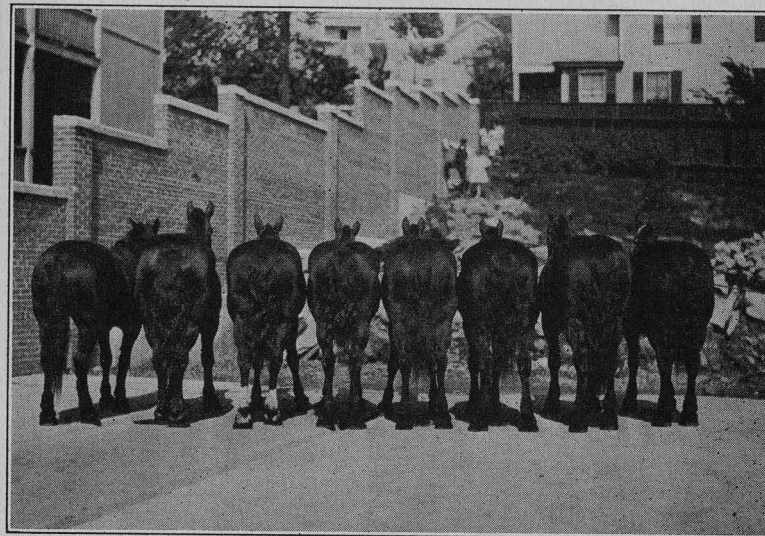


FIGURE 6. HORSES—LOT II
Worden Stables, Waterbury, Conn., June, 1928

11.4 pounds to 40 pounds per day, with a general average for all the stables of 18.7 pounds. The average hay consumption of 8,342 horses owned by companies with less than 1,000 horses was 24.4 pounds per day or 1.75 percent of their weight, assuming the mean weight of horses was 1400 pounds.

The stables from which estimates could be secured were usually those in which better than ordinary care was taken of the horses. It is probable that the amount of hay fed in such stables is above the average for both city and country horses.

The figures secured from the various stables and from the experimental literature cited shows little if any fixed relation between the amounts of hay and grain fed.

Experimental

The preliminary trials mentioned above (1) indicated that the hay ration can be reduced materially below the amount commonly fed without causing the animals to lose weight and with a considerable saving in cost of feed. However, the conditions did not permit accurate control of the feeding and the plan was necessarily simple. No attempt could be made to determine either the minimum or the optimum hay requirement.

With the cooperation of the United States Department of Agriculture it was possible to secure the services of Mr. R. E. Simms, Field Agent in the Bureau of Animal Industry. Mr. Simms had immediate charge of the feeding and records throughout the several trials reported herein.

The feeding trials were conducted in two series, the first at Bridgeport in the stables of the Bridgeport Ice Delivery Company and the second at Waterbury in the milk plant of R. H. Worden & Sons. The conditions and procedure were different in the two stables and they will be discussed separately.

The Bridgeport Experiments

Most of the preliminary experiments reported earlier (1) were conducted in the stables of the Bridgeport Ice Delivery Company. Mr. E. H. Walker, the manager, had kept good records since 1919, so that conditions were very favorable. Beginning in 1925, the feeding instructions called for 15 pounds of grain per day (5 pounds on Sunday) and 12 pounds of hay. This was less than half the hay ration fed in previous years. Mr. Walker was greatly interested and readily cooperated in an experiment to determine the minimum hay requirement.

Description of Horses, Equipment and Work Performed

The horses were typical western work animals used on city ice delivery and weighed about 1400 pounds. They were worked in pairs, but in some cases there was shifting of horses. In the "Naugatuck" stable each team covered the same route each day with the same driver. In the "Sprague" stable, the drivers kept the same routes but the teams were shifted. The loads varied from day to day, hot weather greatly increasing and cool weather decreasing the demand for ice. The wagons used there were the heavy, covered, two-horse ice delivery type, all equipped with roller bearings. The horses worked six days a week, resting on Sunday.

It was impossible to determine the amount of work done or even the average load, but it is safe to say that the work would be about the average for city work horses.

Plan of the Trials

Two stables (designated as "Naugatuck" and "Sprague") were used, but the plan was the same for both. In each stable the horses were divided into three lots. As a basis for balancing these lots there was available a series of weights secured at intervals during the previous 24 months. These, with the age and condition of the horses, the work performed, and the skill of the drivers, were all taken into consideration in making up the groups.

The grain to be fed was fixed for all horses at 15 pounds per day, this being reduced to 5 pounds on Sundays when the horses were idle. This had been the regular ration for some years. The only difference, then, was in the hay allowed,—Lot I, 8 pounds, Lot II, 12 pounds, and Lot III, 16 pounds per day. Eight pounds was arbitrarily chosen as an irreducible minimum. For a 1400 pound horse this is 0.57 percent of the live weight, somewhat lower than anything reported in the literature reviewed.

At the outset, each lot consisted of 10 horses, but because of sales, changes in work, or injury, the number was reduced. In the data presented there are included only those animals that completed the tests without interruption. None of these lost a single day because of sickness or other disability.

Feed and Feeding

The grain fed was a mixture of crushed barley and oats, in the ratio of one to two by weight. In the Naugatuck stable where the test was continued for eight weeks only, the grain was fed by measure, one man doing all feeding. A measure was provided that held just five pounds, the amount fed at each meal. In the long test of 36 weeks at the Sprague stable, canvas bags were provided, three for each horse. Mr. R. E. Simms personally weighed the grain for each day into these bags and hung them behind the stalls. The barn man emptied one of these into the manger at each feeding, or in case of feeding on the road, the noon meal was put in the nose bag carried on the wagon.

The hay fed in the 36 week trial at the Sprague stable was sampled three times during the period and sent to the Bureau of Agricultural

Economics. The report of Mr. Seeds is given below—

Sample No. 1—U. S. No. 2 Mixed Hay, approximately 55 percent grass, 25 percent clover, 15 percent timothy and 5 percent foreign material.

Sample No. 2—U. S. No. 2 Mixed Hay, approximately 60 percent clover, 15 percent grass, 10 percent timothy and 15 percent foreign material.

Sample No. 3—U. S. No. 2 Mixed Hay, approximately 55 percent timothy, 20 percent grass, 15 percent clover and 10 percent foreign material.

While there would seem to be considerable variation in the percent of clover present, Sample No. 2 being higher than the others, there seems to be no reason to believe that this was a significant factor under the conditions of this test.

All of the hay was fed at night, the entire allowance being placed in the rack at one time by the barn man. A scale was installed in the loft and the hay for each horse was weighed until the feeder became able to judge quite accurately the amount desired. Throughout the trial the weight of hay actually fed was checked frequently by Mr. Simms.

Weighing

Weights on three successive days were averaged for the initial and final weights. For the others, the horses were weighed bi-weekly after the day's work was done but before they were fed or watered.

Results

The results are presented below in Tables 1 and 2 with the pertinent data.

TABLE 1

Bridgeport Experiments—Naugatuck Stable

LOT I—HAY, 8 POUNDS; GRAIN, 15 POUNDS

Weighing Dates	HORSE NUMBER							Average of Lot
	No. 259	No. 258	No. 226	No. 230	No. 214	No. 200	No. 63	
1927	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Aug. 10	1410	1510	1230	1310	1420	1410	1380	1381
Aug. 25	1410	1500	1220	1315	1400	1375	1375	1371
Sept. 7	1430	1570	1275	1320	1460	1425	1420	1414
Sept. 21	1450	1550	1275	1325	1450	1420	1415	1412
Oct. 5	1450	1560	1275	1325	1435	1430	1400	1410

Difference between initial and final weights, + 29 pounds. Hay as percent of live weight, 0.58 percent.

LOT II—HAY, 12 POUNDS; GRAIN, 15 POUNDS.

Weighing Dates	HORSE NUMBER						Average of Lot
	No. 254	No. 75	No. 8	No. 85	No. 68	No. 79	
1927	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Aug. 10	1460	1500	1280	1270	1475	1435	1403
Aug. 25	1420	1465	1280	1280	1410	1410	1376
Sept. 7	1415	1480	1315	1310	1460	1470	1408
Sept. 21	1415	1480	1310	1310	1470	1470	1409
Oct. 5	1400	1500	1285	1310	1455	1435	1398

Difference between initial and final weights, — 5 pounds. Hay as percent of live weight, 0.86 percent.

LOT III—HAY, 16 POUNDS; GRAIN, 15 POUNDS

Weighing Dates	HORSE NUMBER							Average of Lot
	No. 17	F.F.S.	No. 7	No. 233	No. 22	No. 96	W.L.R.	
1927	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
Aug. 10	1220	1260	1250	1245	1350	1500	1510	1334
Aug. 25	1200	1245	1235	1235	1330	1500	1500	1321
Sept. 7	1225	1280	1245	1280	1340	1500	1500	1339
Sept. 21	1225	1275	1245	1275	1350	1500	1520	1341
Oct. 5	1250	1305	1205	1300	1335	1475	1500	1339

Difference between initial and final weights, + 5 pounds. Hay as percent of live weight, 1.2 percent.

TABLE 2

Bridgeport Experiments—Sprague Stable

LOT I—HAY, 8 POUNDS; GRAIN, 15 POUNDS

Weighing Dates	HORSE NUMBER							Average of Lot
	No. 237	No. 209	No. 18	No. 122	No. 23	No. 108	No. 109	
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Sept. 8	1200	1450	1305	1405	1435	1450	1350	1371
Sept. 22	1225	1445	1290	1375	1430	1465	1355	1369
Oct. 6	1220	1440	1295	1380	1420	1450	1350	1365
Oct. 20	1235	1430	1295	1365	1415	1445	1360	1364
Nov. 3	1205	1400	1270	1350	1400	1450	1350	1346
Nov. 17	1200	1410	1240	1375	1405	1445	1390	1352
Dec. 1	1190	1390	1250	1395	1400	1450	1400	1353
Dec. 15	1195	1375	1270	1390	1410	1450	1385	1354
Dec. 29	1200	1375	1260	1390	1430	1425	1390	1353
Jan. 12	1185	1390	1260	1375	1405	1415	1395	1347
Jan. 26	1190	1385	1265	1390	1400	1425	1385	1349
Feb. 9	1205	1395	1290	1385	1405	1400	1365	1349
Feb. 23	1210	1420	1280	1385	1400	1420	1365	1354
March 9	1195	1400	1295	1395	1410	1445	1350	1355
March 23	1225	1400	1280	1385	1400	1440	1345	1353
April 6	1250	1395	1270	1390	1410	1450	1340	1358
April 20	1265	1395	1260	1390	1400	1435	1355	1357
May 4	1220	1380	1295	1395	1420	1445	1350	1358
May 18	1235	1370	1290	1385	1410	1430	1360	1354

Difference between initial and final weights, — 17 pounds. Hay, as percent of live weight, 0.6 percent.

LOT II—HAY, 12 POUNDS; GRAIN, 15 POUNDS

Weighing Dates	HORSE NUMBER							Average of Lot
	No. 69	BH	No. 3	No. 114	No. 16	No. 56	WAK	
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Sept. 8	1350	1325	1295	1350	1690	1590	1360	1423
Sept. 22	1350	1350	1255	1340	1730	1620	1370	1430
Oct. 6	1345	1335	1270	1310	1720	1600	1365	1421
Oct. 20	1345	1350	1275	1330	1700	1610	1360	1424
Nov. 3	1360	1345	1280	1340	1685	1585	1370	1423
Nov. 17	1375	1365	1275	1365	1675	1590	1365	1430
Dec. 1	1410	1380	1255	1370	1680	1580	1370	1435
Dec. 15	1390	1375	1280	1375	1680	1565	1360	1432
Dec. 29	1395	1380	1260	1360	1695	1570	1365	1432
Jan. 12	1395	1370	1275	1355	1690	1575	1365	1432
Jan. 26	1395	1370	1265	1355	1700	1590	1360	1432
Feb. 9	1370	1395	1270	1345	1690	1605	1370	1435
Feb. 23	1380	1390	1265	1325	1685	1610	1380	1433
March 9	1375	1380	1285	1315	1690	1600	1360	1429
March 23	1370	1365	1285	1335	1695	1605	1365	1431
April 6	1370	1325	1290	1345	1695	1585	1380	1427
April 20	1340	1230	1290	1350	1695	1590	1375	1410
May 4	1335	1235	1285	1325	1690	1595	1390	1408
May 18	1340	1245	1285	1350	1700	1590	1395	1415

Difference between initial and final weights, — 8 pounds. Hay as percent of live weight, 0.84 percent.

LOT III—HAY, 16 POUNDS; GRAIN, 15 POUNDS

Weighing Dates	HORSE NUMBER					Average of Lot
	No. 120	BM	No. 240	No. 252	No. 113	
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Sept. 8	1190	1430	1275	1330	1520	1349
Sept. 22	1180	1415	1300	1380	1520	1359
Oct. 6	1185	1410	1275	1340	1515	1345
Oct. 20	1180	1420	1285	1345	1520	1350
Nov. 3	1200	1415	1265	1360	1505	1349
Nov. 17	1220	1435	1290	1355	1510	1362
Dec. 1	1245	1420	1285	1390	1500	1368
Dec. 15	1235	1405	1275	1380	1505	1360
Dec. 29	1245	1420	1255	1390	1525	1367
Jan. 12	1235	1405	1255	1385	1515	1359
Jan. 26	1240	1415	1265	1380	1520	1364
Feb. 9	1230	1420	1275	1380	1515	1364
Feb. 23	1225	1410	1265	1375	1525	1360
March 9	1230	1425	1245	1360	1520	1356
March 23	1225	1420	1260	1365	1530	1360
April 6	1230	1410	1245	1380	1550	1363
April 20	1200	1425	1265	1345	1535	1354
May 4	1210	1420	1275	1330	1540	1359
May 18	1205	1435	1265	1350	1540	1359

Difference between initial and final weights, + 10 pounds. Hay as percent of live weight, 1.2 percent.

Discussion

The Naugatuck stable trial (Table 1) was of such short duration, eight weeks, that no conclusions may be drawn safely. However, it may be pointed out that the differences are within the limits of experimental error.

At the Sprague stable (Table 2) where the trial continued for 36 weeks, we find no marked differences in the three lots. In Lot I on eight pounds of hay, Horse No. 209 lost rather steadily a total of 80 pounds. In Lot II, Horse No. BH gained for 24 weeks and then lost rather rapidly, finishing 80 pounds below the initial weight. All of the rest ran along evenly, when one considers that weights of horses may vary normally within a range of 50 pounds from day to day.

LOT I
BRIDGEPORT EXPERIMENT
SPRAGUE STABLE
HAY 8 LBS GRAIN 15 LBS PER DAY
WEIGHING DATES

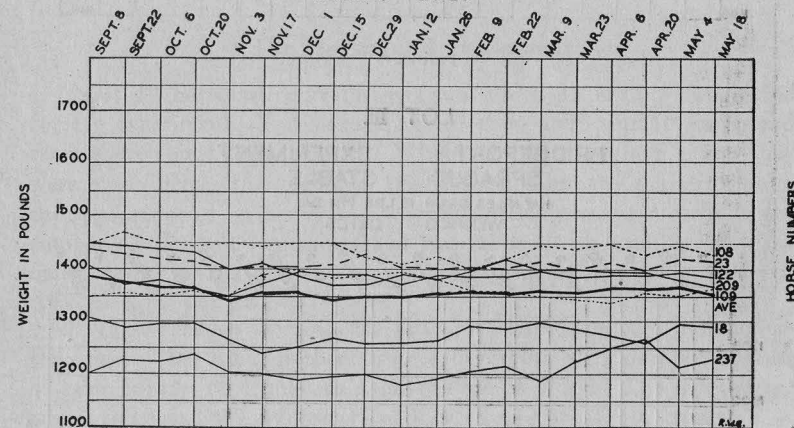


FIGURE 7

All the horses were carefully judged at the beginning and at the end of the trial by those in charge. In addition, other horse men went over the animals on several occasions. The stablemen and drivers also were asked to give their opinions. None of these could detect any differences between the lots in health, spirit, appetite, appearance, or ability to work.

However, there is a distinct trend in the data. On 8 pounds of

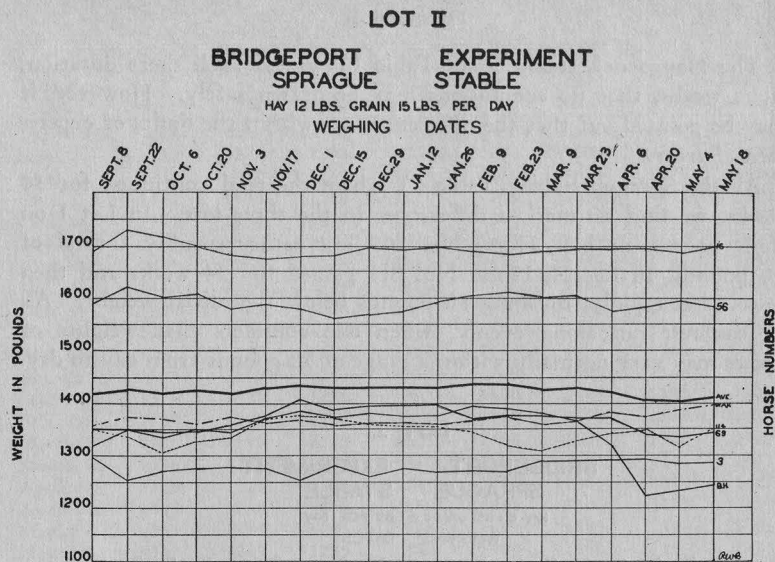


FIGURE 8

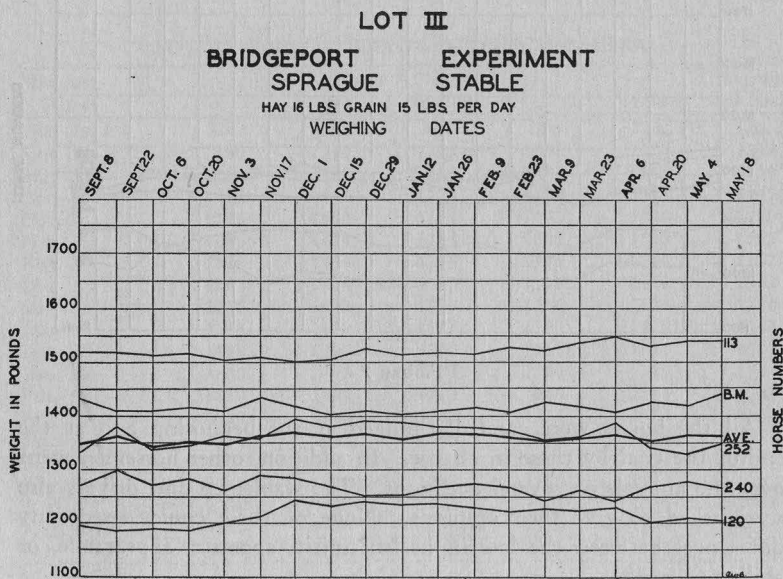


FIGURE 9

hay there was an average loss of 17 pounds, on 12 pounds a loss of 8 pounds, and on 16 pounds of hay, a gain of 10 pounds. All of the horses received 15 pounds of grain. If these differences are considered significant, then the optimum amount of hay for these conditions is about 14 pounds per horse, or one percent of the live weight.

THE WATERBURY EXPERIMENTS

(Worden Stables)

The horses at Bridgeport were on ice delivery, an enterprise that recently has undergone great changes due to the introduction of mechanical refrigeration. The regular delivery routes are being abandoned and the volume of retail business is decreasing. The one city enterprise that continues to use horses regularly is that of milk delivery. Therefore a dairy company stable was sought for more permanent and satisfactory conditions. Arrangements were made with R. H. Worden and Sons of Waterbury, who generously offered their horses and equipment for the experiments.

The Horses and Equipment

About 50 horses were available, from which 33 head were selected for the experiment. The average age of those used was 10 years, and the weight about 1300 pounds. While not of the highest grade, they were much better than average, the Worden Company taking pride in the appearance of its horses and wagons. Based on cost records in the company office, the hay ration had been about 30 pounds per day for many years. In 1925, at the suggestion of the senior author, this was reduced to 15 pounds.

Of the 33 horses starting the test, 24 finished and are included in the tables. Thus nine, or three from each group, were dropped because of sales, injury, or change to another type of work. The average age was as follows: Lot I, 12 years; Lot II, 9 years; Lot III, 10.5 years.

The wagons were all exactly the same—light, single rigs designed by Mr. Worden. They had plain axles, no tops, and weighed 975 pounds.

The Work Performed

All animals were worked single on milk delivery routes seven days per week. During the 314 days of the trial, all horses included in the tables were worked every day. Nineteen of the 24 had the same driver throughout. For the five on which drivers were changed, the data

show no significant effect. Naturally the loads varied, but the average, including wagon and driver, was about 2000 pounds. On four routes the loads varied from 2400 to 3000 pounds but the horses used suffered no loss in weight or condition. Zuntz (11) reports that the energy required to draw a load up a grade of 10.7 percent is three times that required on a level road. Waterbury is a hilly city and some of the streets are not well paved. The wagons were not equipped with brakes, so that the horses worked both up and down the hills. However, every effort was made to balance the groups in respect to hills, loads, condition of streets, and the like.

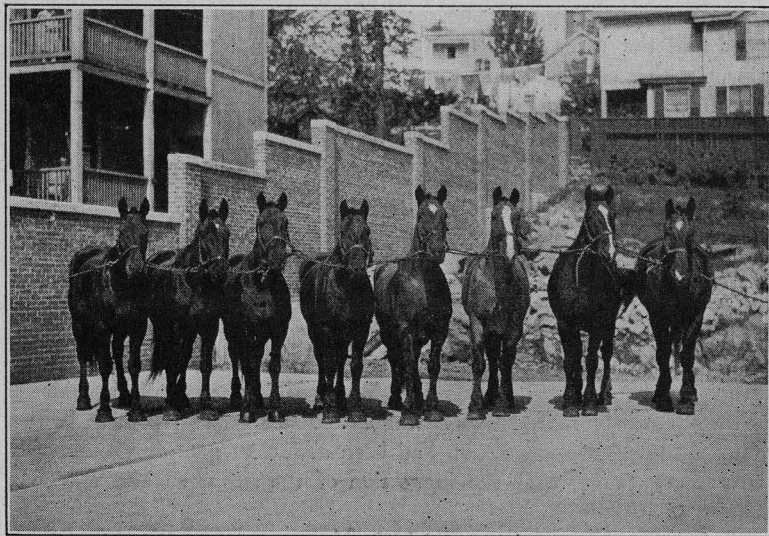


FIGURE 10. HORSES—LOT III
Worden Stables, Waterbury, Conn., June, 1928

Records were kept on temperature and precipitation during the period of the trials. Snowfall was unusually light during the winter of 1927-1928 and did not constitute a disturbing factor. During a hot week in June 1928, all of the lots lost some weight, the average being six pounds per horse.

The routes were measured by following each wagon with an automobile, this being repeated to insure accuracy. In the same manner the hills, the condition of the streets, the frequency of stopping, and the like were obtained. These with other data are presented in Table 3.

TABLE 3
Conditions Affecting Waterbury Experiments

Horse No.	Age 1927	Distance Traveled	Hills	Streets	Load	Sickness	Changed Drivers
LOT I							
4	7	4.4	None	Good	Light	None	
5	15	6.7	Many	Good	Light	None	Apr. 22
6	7	6.4	Few	Good	Light	None	
11	14	2.0	Several	Fair	Light	None	
14	18	3.3	Few	Good	Light	None	
27	9	3.6	None	Good	Light	None	Mar. 5
29	9	2.8	Many	Good	Light	None	
32	13	1.9	Very many	Fair	Light	None	
LOT II							
3	7	5.9	Many	Fair	Light	Nov. 1 slight colic	Mar. 25
9	10	8.1	Many	Good	Light	Sore withers several weeks	
10	8	9.0	Many	Fair	Heavy	None	
13	12	3.7	Some	Good	Light	None	
15	8	6.5	None	Good	Heavy	None	
22	8	4.2	Few	Good	Light	None	Jan. 16
25	9	5.9	None	Good	Heavy	None	
30	8	6.5	None	Good	Light	None	
LOT III							
2	8	7.4	Few	Good	Light	None	June 17
7	7	7.4	Very many	Poor	Light	None	
8	12	10.4	Many	Fair	Heavy	None	
12	8	8.6	Many	Fair	Light	None	
17	13	3.7	Many	Good	Light	None	
18	9	5.8	Many	Fair	Light	None	
21	14	7.1	Few	Good	Light	None	
23	8	4.5	Few	Fair	Light	None	

Plan of the Experiment

The purpose of the experiment was to determine the minimum and optimum amounts of hay required by city work horses and the relative cost of increments of feed in hay and grain. The general plan was similar to that followed at the Bridgeport stables, but greater refinements were possible. Two preliminary determinations were deemed necessary: (1) The normal weight of each animal; (2) the amount of grain necessary to maintain this weight with a minimum amount of hay. For this purpose the amount of grain normally fed each horse was determined. Then all horses were put on eight pounds of hay

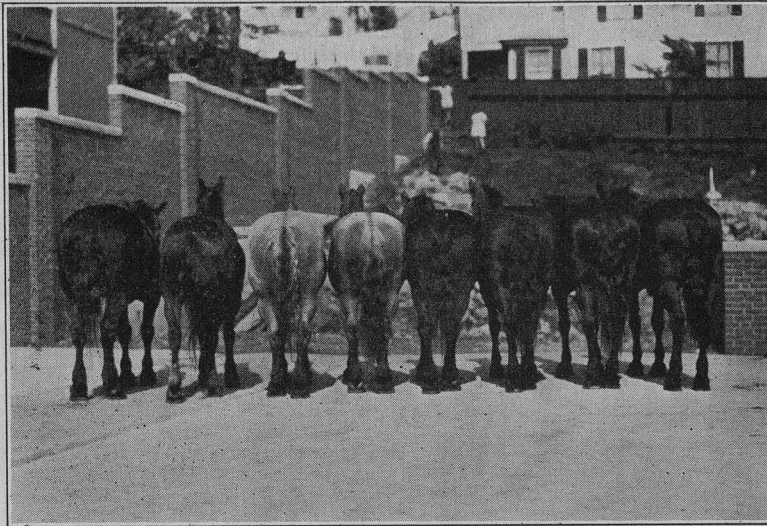


FIGURE 11. HORSES—LOT III
Worden Stables, Waterbury, Conn., June, 1928

(Sept. 21, 1927) and the grain gradually adjusted to the changing weights. By October 12 the grain requirement seemed to stabilize and no changes were made in grain or hay until January 18. October 12 to January 18, or 98 days, was the *Preliminary Period*.

On January 18, Lot II was put on 12 pounds of hay and Lot III on 16 pounds, and the grain gradually reduced for these lots. The 20 days, January 18 to February 8, were considered an *Adjustment Period*.

The *Experimental Period* began on February 8. The object was to determine the minimum amount of grain required to maintain weight and condition in Lots II and III, for which the hay was increased. This minimum seemed to have been reached by February 8 and was continued on the same level to June 27, or 139 days. The data are presented in Table 4 and represented graphically in Figures 12, 13 and 14.

Feeds and Feeding

The hay used was graded by the Bureau of Agricultural Economics, U. S. Department of Agriculture, as No. 2 timothy. The oats were purchased in the open market as No. 2 white clipped, 38 to 40 pounds per bushel.

For weighing the hay a scale with a rack was installed in the loft over the stable. The hay for each horse was weighed and placed in a pile near the chute leading down to the feed rack.

The oats were weighed into canvas bags, three for each day, and set out for the barn man to empty into the mangers. The three bags were numbered to correspond to the number of the horse for which they were used.

Weighing

A large scale was installed in a covered driveway beside the barn. Weights were taken on Monday, Wednesday and Friday of each week, the three being averaged. The dates used in Table 4 are as of the middle day, Wednesday. The horses were weighed when they came in from work, but before feeding hay and grain.

Discussion of Results

No differences were noted in the horses of the three lots in ability to perform work, in health, in appetite, or in spirit. The one case of colic reported in Lot II cannot be considered as significant. Two horses in Lot III were below the average in condition and spirit throughout the entire experiment and the change in the ration failed to show any effect on them in any way. The average variation in weight per horse during the entire experiment was 73 pounds per horse for Lot I, 72 pounds for Lot II, and 81 pounds for Lot III. This includes all of the horses.

TABLE 4
Waterbury Experiments—Worden Stable

Weighing Dates	LOT I								Average of Lot
	No. 5	No. 6	No. 27	No. 29	No. 32	No. 11	No. 4	No. 14	
PRELIMINARY PERIOD—Hay, 8 lbs.; Grain, 11.34 lbs.									
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Oct. 12	1292	1420	1256	1223	1251	1445	1342	1343	1322
Oct. 19	1288	1405	1250	1220	1253	1430	1335	1342	1315
Oct. 24	1290	1415	1247	1245	1252	1430	1328	1335	1316
Nov. 2	1285	1403	1238	1231	1257	1426	1325	1328	1312
Nov. 9	1300	1400	1229	1245	1257	1430	1325	1325	1314
Nov. 16	1300	1390	1239	1241	1260	1425	1335	1330	1315
Nov. 23	1300	1400	1239	1248	1264	1415	1334	1334	1317
Nov. 30	1300	1405	1254	1250	1258	1408	1338	1334	1318
Dec. 7	1300	1450	1257	1245	1265	1410	1335	1336	1325
Dec. 14	1302	1458	1252	1255	1263	1400	1335	1334	1325

TABLE 4—(Continued)
Waterbury Experiments—Worden Stable

Dec. 21	1320	1460	1240	1254	1275	1390	1355	1335	1329
Dec. 28	1310	1450	1254	1250	1280	1400	1335	1335	1327
Jan. 4	1314	1450	1267	1262	1281	1409	1325	1340	1328
Jan. 11	1315	1450	1246	1259	1281	1407	1330	1327	1327
Jan. 18	1318	1454	1261	1255	1280	1419	1321	1337	1331
ADJUSTMENT PERIOD—No change for Lot I									
Jan. 25	1310	1457	1250	1264	1283	1414	1320	1335	1329
Feb. 1	1310	1470	1244	1260	1271	1414	1320	1334	1328
Feb. 8	1320	1465	1248	1260	1286	1410	1320	1323	1330
EXPERIMENTAL PERIOD—No change for Lot I									
Feb. 15	1321	1462	1249	1260	1284	1410	1322	1335	1331
Feb. 22	1324	1464	1252	1250	1287	1419	1320	1338	1332
Feb. 29	1328	1458	1254	1250	1275	1417	1315	1329	1328
March 7	1333	1460	1254	1249	1280	1414	1318	1330	1330
March 14	1325	1450	1251	1249	1271	1401	1325	1325	1325
March 21	1320	1454	1249	1255	1274	1398	1329	1325	1325
March 28	1331	1453	1230	1244	1280	1400	1326	1325	1324
April 4	1325	1450	1235	1247	1271	1405	1333	1334	1325
April 11	1323	1448	1235	1251	1260	1406	1347	1327	1325
April 18	1325	1460	1245	1254	1260	1405	1330	1325	1326
April 25	1321	1463	1265	1255	1254	1415	1334	1325	1329
May 2	1326	1477	1275	1250	1253	1410	1330	1323	1330
May 9	No weights	.....	.....	.....	.....	.....	.....	.....	.....
May 16	1327	1495	1285	1255	1257	1410	1325	1315	1333
May 23	1333	1495	1283	1245	1270	1410	1303	1315	1332
May 30	1323	1490	1257	1253	1260	1410	1330	1303	1328
June 6	1325	1502	1263	1258	1270	1405	1323	1300	1331
June 13	1315	1507	1273	1250	1273	1398	1327	1283	1328
June 20	1325	1495	1265	1242	1260	1388	1327	1282	1323
June 27	1318	1493	1260	1257	1247	1387	1338	1272	1321

Hay, 0.68 Percent; Grain, 0.85 Percent of Live Weight.

LOT II

Weighing Dates	HORSE NUMBER								Average of Lot
	No. 9	No. 13	No. 30	No. 25	No. 15	No. 3	No. 22	No. 10	
PRELIMINARY PERIOD—Hay, 8 lbs.; Grain, 12.67 lbs.									
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Oct. 12	1167	1242	1258	1300	1380	1298	1249	1343	1280
Oct. 19	1168	1228	1252	1297	1375	1282	1244	1338	1273
Oct. 26	1168	1225	1255	1290	1373	1282	1250	1338	1273
Nov. 2	1168	1215	1255	1296	1368	1263	1235	1335	1266
Nov. 9	1160	1225	1255	1301	1375	1275	1227	1325	1268
Nov. 16	1160	1220	1250	1298	1385	1285	1238	1340	1272
Nov. 23	1145	1215	1246	1288	1384	1288	1241	1335	1268
Nov. 30	1143	1215	1246	1293	1392	1300	1241	1336	1271
Dec. 7	1135	1215	1244	1293	1391	1300	1248	1337	1270
Dec. 14	1136	1200	1245	1295	1383	1295	1250	1335	1267
Dec. 21	1134	1207	1250	1275	1384	1290	1250	1325	1264

TABLE 4—(Continued)
Waterbury Experiments—Worden Stable

Dec. 28	1130	1200	1245	1278	1388	1300	1250	1321	1264
Jan. 4	1127	1204	1234	1276	1375	1300	1250	1320	1261
Jan. 11	1125	1206	1225	1271	1380	1300	1255	1323	1260
Jan. 18	1120	1202	1225	1280	1380	1300	1257	1304	1259
ADJUSTMENT PERIOD—Hay, 12 lbs.; Grain, 12.67 lbs.									
Jan. 25	1114	1210	1245	1283	1379	1312	1254	1303	1261
Feb. 1	1137	1220	1255	1280	1400	1314	1250	1305	1271
Feb. 8	1137	1225	1250	1292	1400	1332	1275	1320	1279
EXPERIMENTAL PERIOD—Hay, 12 lbs.; Grain, 11.77 lbs.									
Feb. 15	1138	1235	1240	1292	1402	1335	1285	1320	1281
Feb. 22	1132	1239	1240	1283	1410	1337	1290	1300	1279
Feb. 29	1128	1235	1235	1281	1404	1335	1291	1288	1275
March 7	1125	1235	1235	1281	1412	1335	1292	1280	1275
March 14	1128	1225	1249	1300	1398	1328	1293	1295	1280
March 21	1133	1230	1251	1293	1395	1328	1290	1300	1278
March 28	1126	1230	1250	1280	1395	1325	1279	1300	1273
Apr. 4	1125	1227	1253	1287	1395	1325	1280	1300	1274
Apr. 11	1125	1235	1250	1283	1390	1325	1280	1300	1274
Apr. 18	1135	1242	1255	1285	1395	1330	1277	1305	1278
Apr. 25	1133	1250	1257	1285	1403	1330	1280	1317	1282
May 2	1137	1250	1270	1285	1405	1335	1280	1320	1283
May 9	No weights	.....	.....	.....	.....	.....	.....	.....	.....
May 16	1147	1255	1262	1285	1415	1332	1277	1315	1286
May 23	1170	1250	1268	1298	1420	1330	1283	1327	1293
May 30	1183	1248	1268	1288	1408	1310	1288	1320	1289
June 6	1192	1250	1277	1298	1413	1325	1308	1323	1298
June 13	1188	1258	1283	1317	1408	1329	1309	1323	1302
June 20	1187	1262	1268	1280	1387	1311	1310	1328	1292
June 27	1180	1255	1280	1292	1392	1290	1297	1315	1288

Hay, 0.94 Percent; Grain, 0.92 Percent of Live Weight.

LOT III

Weighing Dates	HORSE NUMBER							
	No. 12	No. 2	No. 7	No. 21	No. 23	No. 8	No. 17	No. 18
PRELIMINARY PERIOD—Hay, 8 lbs.; Grain, 15.82 lbs.								
1927-1928	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Oct. 12	1233	1277	1313	1338	1242	1215	1393	1243
Oct. 19	1224	1275	1310	1343	1248	1225	1402	1248
Oct. 26	1236	1255	1307	1348	1247	1223	1398	1252
Nov. 2	1225	1255	1297	1355	1248	1222	1390	1258
Nov. 9	1227	1250	1300	1360	1250	1225	1392	1268
Nov. 16	1235	1260	1310	1358	1267	1225	1388	1272
Nov. 23	1234	1264	1308	1361	1250	1232	1378	1275
Nov. 30	1228	1260	1308	1367	1248	1233	1377	1279
Dec. 7	1230	1265	1310	1365	1250	1245	1375	1280
Dec. 14	1225	1268	1300	1368	1255	1248	1380	1275
Dec. 21	1225	1275	1280	1352	1260	1255	1380	1275
Dec. 28	1225	1282	1292	1375	1270	1260	1375	1245

TABLE 4—(Continued)

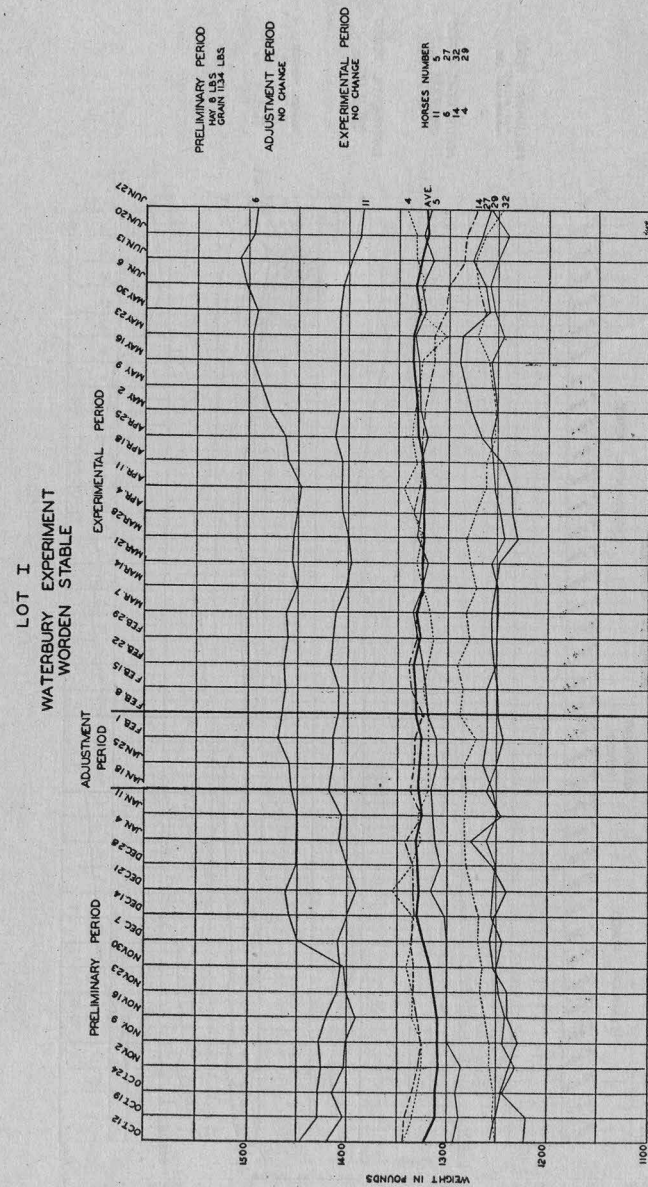
Jan. 4	1218	1283	1300	1375	1273	1270	1370	1245
Jan. 11	1220	1275	1303	1375	1260	1275	1365	1230
Jan. 18	1216	1269	1298	1365	1260	1270	1370	1233
ADJUSTMENT PERIOD—Hay, 16 lbs.; Grain, 15.82 lbs.								
Jan. 25	1221	1276	1310	1366	1275	1280	1373	1233
Feb. 1	1240	1280	1325	1388	1300	1300	1400	1252
Feb. 8	1240	1300	1320	1390	1300	1325	1385	1255
EXPERIMENTAL PERIOD—Hay, 16 lbs.; Grain, 14.32 lbs.								
Feb. 15	1233	1300	1320	1400	1295	1345	1375	1260
Feb. 22	1230	1296	1319	1392	1301	1350	1376	1260
Feb. 29	1225	1295	1321	1400	1304	1345	1377	1250
March 7	1225	1295	1315	1403	1304	1341	1372	1245
March 14	1233	1290	1300	1395	1300	1330	1375	1245
March 21	1236	1292	1300	1395	1300	1330	1375	1245
March 28	1235	1295	1307	1395	1300	1325	1380	1245
Apr. 4	1230	1300	1312	1390	1297	1320	1380	1250
Apr. 11	1235	1300	1310	1380	1295	1320	1375	1253
Apr. 18	1225	1307	1325	1395	1300	1320	1375	1272
Apr. 25	1225	1317	1340	1400	1310	1317	1355	1272
May 2	1225	1315	1345	1410	1315	1320	1355	1275
May 9	No weights							
May 16	1215	1322	1370	1410	1327	1320	1350	1280
May 23	1235	1328	1348	1405	1330	1338	1355	1255
May 30	1220	1303	1328	1408	1328	1325	1355	1258
June 6	1225	1310	1335	1405	1328	1332	1352	1252
June 13	1232	1308	1328	1407	1342	1327	1345	1247
June 20	1233	1318	1312	1395	1340	1320	1355	1238
June 27	1242	1297	1320	1393	1325	1322	1353	1238

Hay, 1.23 Percent; Grain, 1.1 Percent of Live Weight.

A study of Table 4 and Figures 12, 13 and 14 reveals the following:

	Average Weight During Preliminary Period Pounds	Gain or Loss During Experimental Period Pounds
Lot I	1321	nothing
Lot II	1267	+ 21
Lot III	1287	+ 23

For Lot I the average weight curve is very regular throughout the entire period. For Lot II a gradual rise begins when the hay is increased, and holds at a higher level throughout the greater part of the experimental period. For Lot III a rise occurs rather suddenly when the hay is increased, and this is maintained. In themselves, these small gains in weight are insignificant, but as averages and trends they would seem to indicate that the reduction in grain for Lots II and III might have been greater.



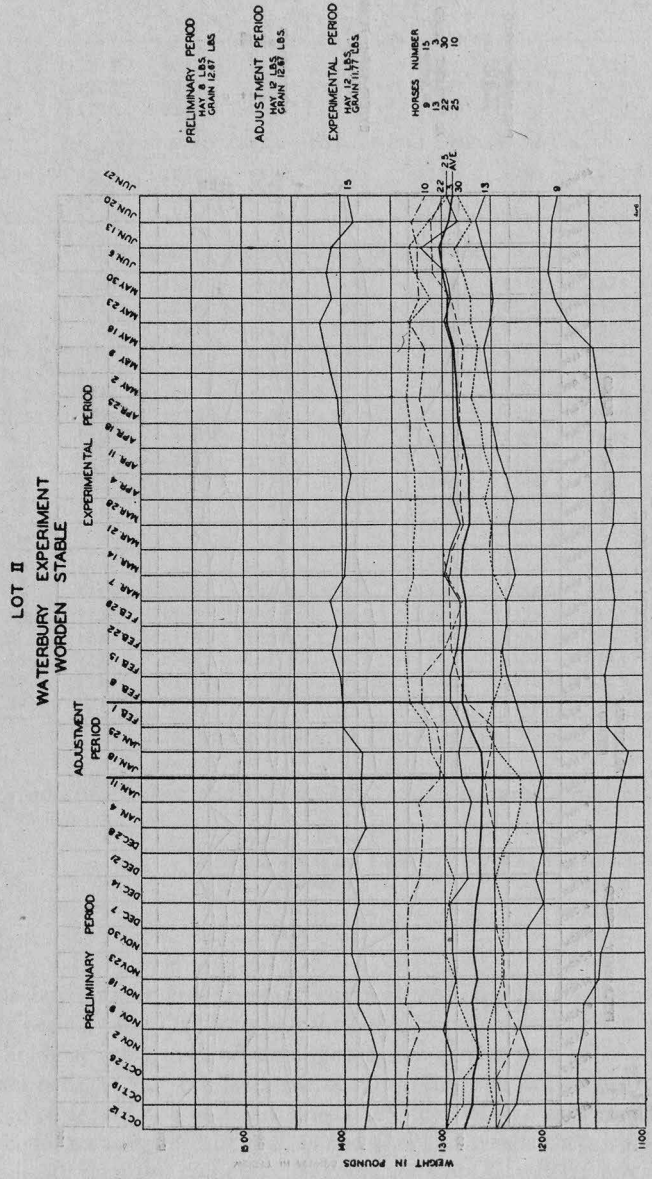


FIGURE 13

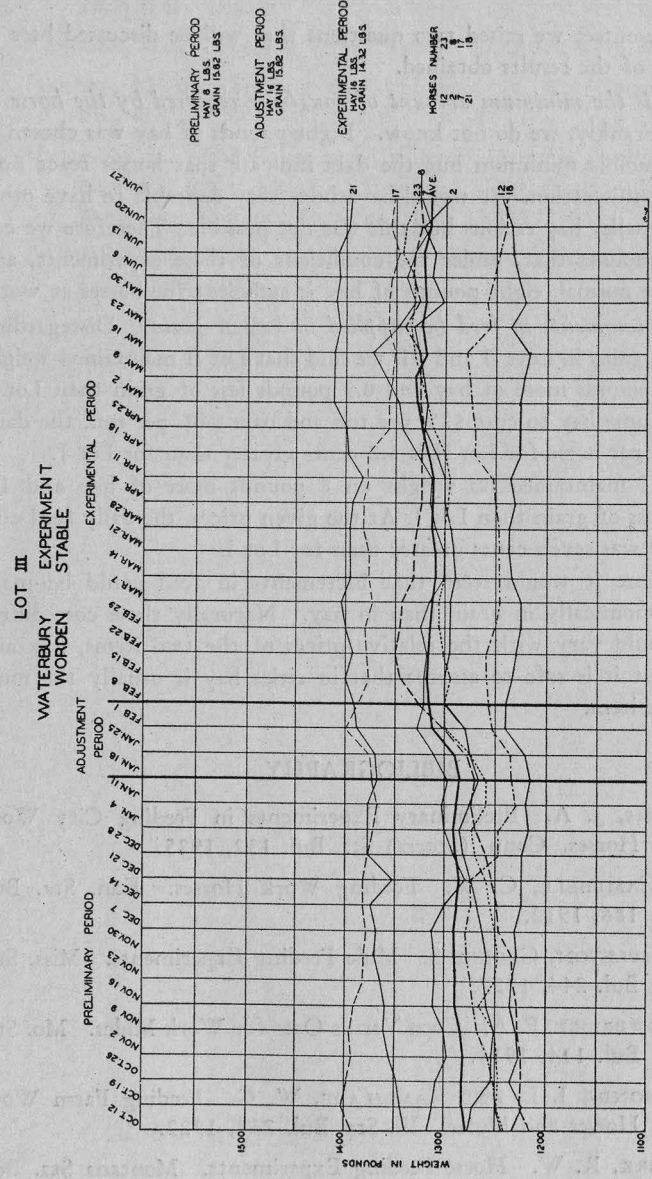


FIGURE 14

Conclusions

At the outset we raised two questions that will be discussed here in the light of the results obtained.

What is the minimum amount of roughage required by the horse at work? Frankly, we do not know. Eight pounds of hay was chosen as the irreducible minimum but the data indicate that horses react normally on this ration. It would have been very desirable to have other lots on smaller hay rations but this was not possible. Therefore we can safely conclude that, under the conditions of these experiments, and they were normal, eight pounds of hay is sufficient for horses at work.

Shall increments in feed be supplied in hay or grain? Disregarding the small gains in Lots II and III, we find that Lot II maintained weight on four pounds more of hay and 0.9 pounds less of grain than Lot I. If we assume hay to cost \$25. per ton and oats \$40. per ton, the daily feed cost per horse for Lot II is 3.2 cents greater than for Lot I.

Lot III maintained its weight on 8 pounds more of hay and 1.5 pounds less of grain than Lot I. At the given prices, the daily feed cost per horse was seven cents greater than for Lot I.

Therefore it would seem that increments in feed could be made more economically in grain than in hay. Naturally these cost differences would vary with the relative prices of the two items, hay and grain; but it is safe to assume that in cities hay is usually the more expensive item.

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