Horses with the shorter, more level backs (score of 6, 7, or 8 for top line of back) covered the 11.35-mile course in 105.9 minutes, on the average, whereas animals that were longer and lower in the back (score of 4 or 5) averaged 112.7 minutes (table 12).

Analyses of variance indicate that the scores for action at the walk and trot are significantly associated with the time required for the cross-country ride. In general, the horses given the best scores at the walk made better time than those with poorer scores (table 7). At the trot the results were inconsistent. There is no indication in the data that horses with good action at the trot performed better than those with medium action. There is, in fact, some indication that those with medium action at the trot may be the most efficient at covering ground. The two horses with poor action (score of 3) were much slower than the others.

On the average, horses with a long stride at the trot covered the distance on the cross-country ride in significantly less time than horses with a relatively short stride (table 5). Thirteen horses with strides of more than 11 feet averaged 12.4 minutes faster than ten horses with strides less than 9.0 feet

At performance at the walk, horses that were given good scores by the riders made much better time on the cross-country course than those given poor scores (table 8). Sixteen horses with a score of 5 covered the distance in an average of 104.9 minutes, whereas five horses with a score of 1 or 2 averaged 121.9 minutes.

The association of the score for slope of croup with the time required to cover the 11.35-mile course approached significance (table 12). However, the averages for the different scores did not show a trend except that the two horses having the steepest croup had very slow time.

The relationship between the atmospheric temperature and the time required for the cross-country ride also approached significance. Temperatures of 40° to 49° F. appeared to be slightly more favorable than any others for making fast time, and temperatures of 80° or above were unfavorable. However, few horses were tested at these extremes.

As would be expected, the time required for the cross-country ride was significantly correlated with the time required to walk a mile ($r=0.42$) and to trot a mile ($r=0.35$).

Endurance

At the end of the 11.35-mile course, 19 of the 68 horses were fresh with no signs of fatigue (score of 5); 42 showed slight signs (score of 4); and 7 showed marked signs (score of 3). None of the horses were recorded as exhausted (score of 2) or extremely exhausted (score of 1). Both years and sexes were significantly associated with the degree of fatigue. The horses showed less fatigue in 1943, 1946, and 1947 than in other years. The 6 stallions showed the least fatigue, the 42 mares the most, and the 20 geldings were intermediate (table 11). Neither riders, sires, nor time required for the 11.35-mile test were significantly associated with the degree of fatigue shown. The relation between this character and the others has not been studied except for the measurements of the cannon bones and the circum-

ference of the knee. No association was found between them. So few horses showed fatigue that it was clear that a more severe test would be required if the scores for this character were to be used as a measure of endurance.

Ease of Riding

Rider scores for ease of handling, performance of gait, and ease of gait to the rider were significantly associated with one another. Horses that performed the gait well were generally scored as easy to handle and had an easy gait from the standpoint of the rider (tables 8, 13, 15, and 18). In addition to these, the following associations were found: Ease of handling at the walk was significantly associated with length of stride at the walk (table 13), temperament (table 14), and general conformation (table 18). Ease of handling at the trot was significantly associated with action at the walk (table 18), temperament (table 14), and height at withers (table 18). Ease of handling at the canter was significantly associated with scores for style, head, and temperament (table 18).

Horses given the best scores for ease of handling at the walk, on the average, walked significantly faster than those given poor scores (table 13). Four horses given the highest scores on general conformation had the best average score for ease of handling at the walk, and three horses with the lowest score for general conformation had the poorest average score for ease of handling. Scores for intermediate classes, however, did not show a consistent trend. In general, horses receiving intermediate scores for temperament were the easiest to handle at the walk (table 14). The association between action at the walk and ease of handling at the walk was not quite significant (table 7). In general, horses with the best action were easier to handle than those with medium action. Horses with low scores for action were not consistent for ease of handling.

Straight, snappy action at the walk was more closely associated with easy handling at the trot than was medium action. The few horses that had the poorest action were not consistent. Horses that were easiest to handle at the trot were intermediate in height at withers. Fatigue, as measured by the score for condition at the end of the 11.35-mile test, was on the average not quite significantly associated with ease of handling at the trot. The three horses with the lowest scores on general conformation were on the average much harder to handle at the trot than the others.

Although differences in style and head were significantly associated with ease of handling at the canter, the results were not consistent. Horses with an intermediate score for temperament were most easily handled at the canter. The association of differences in general conformation and ease of handling at the canter approached significance. There was, however, no consistent trend in the means except that the 3 horses with the lowest score for general conformation were much harder to handle than the other 60 horses.

TABLE 13.—*Association of ease of handling at the walk and trot with other measures of performance, and analyses of variance*

AVERAGE PERFORMANCE

Score for ease of handling at walk [1]	Horses	Time to walk a mile	Length of stride at walk	Score for performance at walk [1]	Score for ease of walk to rider [1]	Time to cover 11.35-mile course	Score for ease of handling at trot [1]	Horses	Time to trot a mile	Length of stride at trot	Score for performance at trot [1]	Score for ease of trot to rider [1]	Time to cover 11.35-mile course
	Number	*Minutes*	*Feet*			*Minutes*		*Number*	*Minutes*	*Feet*			*Minutes*
1	3	16. 33	4. 93	2. 00	2. 67	116. 7	1	2	6. 05	8. 65	2. 00	1. 50	123. 0
2	3	15. 80	4. 77	3. 33	3. 33	105. 3	2	1	5. 50	10. 30	4. 00	4. 00	95. 0
3	7	15. 11	5. 44	3. 43	3. 71	105. 1	3	8	4. 96	10. 22	3. 62	3. 12	107. 0
4	30	15. 04	5. 43	3. 87	4. 10	111. 1	4	28	5. 47	9. 79	4. 00	3. 89	111. 0
5	25	14. 82	5. 33	4. 12	4. 56	107. 4	5	29	5. 21	10. 28	4. 41	4. 31	107. 4
Total or average	68	15. 06	5. 35	3. 81	4. 12	109. 1		68	5. 32	10. 03	4. 07	3. 91	109. 1

ANALYSES OF VARIANCE

Source of variance	Degrees of freedom	Mean squares [2]					Source of variance	Degrees of freedom	Mean squares [2]				
Between scores	4	1. 98	**0. 45	**3. 50	**3. 54	130. 9	Between scores	4	1. 03	1. 09	**3. 43	**5. 30	199. 2
Within scores	63	1. 69	. 11	. 67	. 79	97. 0	Within scores	63	. 49	1. 01	. 62	. 73	92. 7
Total	67							67					

[1] Scored by the riders on a scale of 1 to 5, 1 being the poorest and 5 the best.
[2] *=Significant; **=highly significant.

TABLE 14.—*Association of temperament with performance and analyses of variance*

AVERAGE PERFORMANCE

Score for temperament [1]	Horses	Time to walk a mile	Length of stride at walk	Score for ease of handling at walk [2]	Score for performance at walk [2]	Score for ease of walk to rider [2]	Score for action at walk [3]	Time to cover 11.35-mile course	Time to trot a mile	Length of stride at trot	Score for ease of handling at trot [2]	Score for performance at trot [2]	Score for ease of trot to rider [2]	Score for action at trot [3]
	Number	*Minutes*	*Feet*					*Minutes*	*Minutes*	*Feet*				
2	1	17. 0	5. 50	5. 00	2. 00	2. 00	3. 00	117. 0	5. 90	9. 80	5. 00	2. 00	2. 00	3. 00
3	1	16. 40	5. 60	1. 00	2. 00	4. 00	5. 00	125. 0	5. 80	9. 40	1. 00	3. 00	2. 00	7. 00
4	5	15. 08	5. 44	4. 00	4. 20	4. 60	6. 40	102. 8	5. 12	10. 60	4. 40	4. 40	4. 20	6. 40
5	18	15. 17	5. 48	4. 22	3. 78	4. 17	6. 89	111. 0	5. 29	10. 06	4. 33	4. 06	4. 00	6. 89
6	17	15. 32	5. 18	4. 12	3. 88	4. 00	6. 53	106. 5	5. 44	9. 86	4. 35	4. 18	3. 82	6. 59
7	13	14. 62	5. 36	3. 92	4. 00	4. 38	6. 69	105. 3	5. 04	10. 34	4. 00	4. 00	4. 00	7. 00
8	1	16. 00	4. 40	1. 00	1. 00	1. 00	2. 00	121. 0	6. 30	7. 90	1. 00	1. 00	1. 00	3. 00
9	1	15. 20	5. 30	5. 00	4. 00	5. 00	7. 00	103. 0	5. 50	8. 80	4. 00	3. 00	4. 00	5. 00
Total or average	57	15. 15	5. 34	4. 02	3. 79	4. 12	6. 51	108. 0	5. 30	10. 04	4. 16	3. 98	3. 84	6. 61

ANALYSES OF VARIANCE

Source of variance	Degrees of freedom	Mean squares [4]												
Between scores	7	1. 42	*0. 26	**3. 03	*2. 26	*2. 48	**5. 47	141. 7	0. 43	1. 41	**3. 21	**2. 34	*2. 33	**4. 63
Within scores	49	1. 42	. 10	. 85	. 77	. 87	1. 27	82. 3	. 43	. 94	. 51	. 62	. 92	1. 53
Total	56													

[1] 1=very sluggish; 2=sluggish; 3=somewhat sluggish; 4=moderately alert; 5=active but gentle; 6=very active, easily handled; 7=very active, difficult to handle; 8=very active, vicious; 9=very active, very vicious.

[2] Scored by the riders on a scale of 1 to 5, 1 being the poorest and 5 the best.

[3] Scored on a scale of 1 to 9, 1 being the poorest and 9 the best.

[4] *=Significant; **=highly significant.

TABLE 15.—*Association of ease of walk and trot to the rider with other measures of performance and analyses of variance*

AVERAGE PERFORMANCE

Score for ease of walk to rider [1]	Horses	Time to walk a mile	Length of stride at walk	Score for ease of handling at walk [1]	Score for performance of walk [1]	Time to cover 11.35-mile course	Score for ease of trot to rider [1]	Horses	Time to trot a mile	Length of stride at trot	Score for ease of handling at trot [1]	Score for performance of trot [1]	Time to cover 11.35-mile course
	Number	*Minutes*	*Feet*			*Minutes*		*Number*	*Minutes*	*Feet*			*Minutes*
1	1	16. 00	4. 40	1. 00	1. 00	121. 0	1	1	6. 30	7. 90	1. 00	1. 00	121. 0
2	4	16. 12	5. 02	3. 50	2. 50	109. 5	2	6	5. 82	9. 38	3. 33	3. 17	117. 0
3	10	15. 76	5. 37	3. 80	3. 20	113. 4	3	13	5. 08	10. 25	3. 85	3. 46	108. 8
4	23	14. 85	5. 32	3. 70	3. 74	110. 3	4	26	5. 37	10. 06	4. 38	4. 15	107. 8
5	30	14. 82	5. 43	4. 57	4. 33	106. 3	5	22	5. 21	10. 13	4. 55	4. 73	108. 1
Total or average	68	15. 06	5. 35	4. 04	3. 81	109. 1		68	5. 32	10. 03	4. 19	4. 07	109. 1

ANALYSES OF VARIANCE

Source of variance	Degrees of freedom	Mean squares [2]					Source of variance	Degrees of freedom	Mean squares [2]				
Between scores	4	3. 28	*0. 39	**5. 51	**6. 70	149. 5	Between scores	4	1. 14	1. 97	**4. 97	**7. 21	145. 0
Within scores	63	1. 60	. 11	. 78	. 47	95. 9	Within scores	63	. 49	1. 00	. 58	. 38	96. 1
Total	67							67					

[1] Scored by the riders on a scale of 1 to 5, 1 being the poorest and 5 the best.
[2] *=Significant; **=highly significant.

As judged by the riders, performance at the walk was significantly associated with action at the walk (table 7), speed of walk and length of stride at the walk (table 8), and the rider, scores for head, slope of croup, and temperament (table 18). Performance at the trot was significantly associated with temperament (table 14), and years and action at the walk (table 18). Performance at the canter was significantly associated with temperament (table 18).

Average scores for performance at the walk varied from 3.67 to 4.67 with riders that rode three or more horses. Horses given the best scores for performance at the walk, on the average, walked faster and had longer strides than those given poorer scores. Horses with high scores for head had the best average scores for performance at the walk. Horses with an intermediate score for slope of croup generally performed better than horses given extremely high or low scores. However, there were few horses in the extreme classes. There was considerable difference in the performance at the walk by horses of different temperaments but no consistent trend (table 14). There was a consistent trend for performance at the walk with action at the walk (table 7). The differences in the performance at the walk were highly significant when the horses were classified on action at the trot, but there was not a consistent trend.

Horses that were active but not vicious or difficult to handle performed better at the trot than either sluggish or very active vicious horses (table 14). Straight, snappy action at the walk and trot was highly associated with a good score for performance at the trot (table 7). Very active but easily handled horses performed best at the canter.

Ease of walk to the rider was significantly associated with action at the walk and at the trot (tables 7 and 18), temperament (table 14), and with riders, condition (fleshing), and type of head (table 18). Ease of trot to the rider was significantly associated with action at the walk and at the trot (tables 7 and 18), and temperament (table 14).

Average scores for ease of walk to rider varied with different riders from 3 to 5. Although the analyses showed significant differences in ease of walk for horses with different scores for conformation of head, condition or fleshing, and temperament, the results were not consistent. Horses with a straight, snappy action at the walk and trot in general had the easiest walk (table 7). Those that were given the best scores for ease of walk walked faster on the average, although the differences did not quite reach significance.

The differences in ease of trot for horses of different temperaments showed no trend (table 14). Those with a straight, snappy walk had the easiest gait at the trot. However, good action at the trot was not consistently associated with ease of trot (table 7).

Other Characters

Length of stride at the walk varied from 4.1 to 6 feet, the average being 5.4 feet. It was significantly associated with time required to walk a mile and time required to cover the 11.35-mile course (table 5), performance at the walk (table 8), temperament (table 14), ease of walk to the rider (table 15), and ease of handling at the walk (table 18).

Length of stride was not associated significantly with sex, sire, dam, year, or rider.

Horses with the best scores for performance at the walk and ease of walk to rider had the longest average strides. Although statistically significant differences were found between the average length of stride at the walk for horses with different scores for temperament, there seemed to be no obvious reason why this relationship exists as judged by the average scores. It may be due to the fact that the temperament score was based on several factors including activity, ease of handling, and viciousness or it may be that the differences are only a chance relationship. Heart girth and slope of croup were somewhat associated with length of stride at the walk but the differences were not significant (table 16). Horses with medium heart girth and medium slope of croup had the longest average strides.

TABLE 16.—*Association of heart girth and slope of croup with length of stride at the walk and analyses of variance*

AVERAGE PERFORMANCE

Heart girth (cm.)	Horses	Average length of stride at walk	Score for slope of croup [1]	Horses	Average length of stride at walk
	Number	*Feet*		*Number*	*Feet*
163–165	3	5. 3	3	2	5. 3
166–168	4	5. 5	4	4	5. 4
169–171	8	5. 3	5	15	5. 5
172–174	10	5. 2	6	21	5. 4
175–177	19	5. 5	7	15	5. 4
178–180	11	5. 4	8	6	5. 0
181–183	5	5. 0			
184–186	3	5. 2			
Total or average	63	5. 3		63	5. 3

ANALYSES OF VARIANCE

Source of variance	Degrees of freedom	Mean squares	Source of variance	Degrees of freedom	Mean squares
Between heart girth	7	0. 21	Between slope of croup.	5	0. 24
Within heart girth	55	. 10	Within slope of croup.	57	. 11
Total	62			62	

[1] 1=steep−, 2=steep, 3=steep+, 4=medium slope−, 5=medium slope, 6=medium slope+, 7=level−, 8=level, 9=level+.

Length of stride at the trot ranged from 7.9 to 12.4 feet with an average of 10 feet. It was significantly associated with sire (table 2), time required to trot a mile and to cover the 11.35-mile course (table 5), sex (table 11), general conformation and top line of back (table 17), and ease of trot to rider (table 18). Geldings had, on the average, the longest stride (10.3 feet); stallions, the shortest (9.1 feet); and mares, intermediate (10 feet). Averages for the offspring of different sires ranged from 8.8 to 10.6 feet (table 2). However, an analysis of the variance between the offspring of different sires within the same sex showed that the average difference was not significant.

Horses with different scores on general conformation differed significantly, though not consistently, in average length of stride. In general, horses with intermediate scores for conformation, as well as for top line of back and top line of withers, had the longest stride (table 17).

Action at the walk, which was significantly associated with time required to cover the 11.35-mile course, performance at the walk, and ease of walk (table 7), and with ease of handling at the trot, was not significantly associated with differences between sexes, offspring of the various sires, or the progeny of sires within sexes.

Action at the trot was significantly associated with the sire (table 2), time required to cover the 11.35-mile course, performance at the walk and trot, and ease of walk and trot to rider (table 7), and differences in the dams (table 18). Considerable spread was found in the distribution of the offspring from some of the sires (figure 4). This may indicate segregation of genetically different types.

Temperament, which was significantly associated with length of stride at the walk and all the riders' scores except for ease of canter, was not significantly associated with differences between sexes or between the progeny of sires within sexes.

Heart girth, which was somewhat associated with length of stride at the walk (table 16), was not significantly associated with differences between the offspring of the various sires when the effects of sex were removed.

General conformation, which was significantly associated with time required to trot a mile (table 10), length of stride at trot (table 17), ease of handling at walk (table 18), and sex (table 18), was not associated with differences between the offspring of the various sires. The stallions averaged the highest conformation, mares the next, and geldings the lowest.

Top line of back, which was significantly associated with the time required to cover the 11.35-mile course (table 12) and length of stride at the trot (table 17), was not significantly associated with differences between the offspring of the various sires, although the association approached significance. The averages for the different sires ranged from 4.3 (medium) for Hudson's progeny to 7.5 (short, level) for Laddie's progeny. The progeny of Goldfield and Canfield averaged medium+ (6.0 and 6.1, respectively).

TABLE 17.—*Association of general conformation, top line of back, and top line of withers with length of stride at the trot and analyses of variance*

AVERAGE PERFORMANCE

Score for general conformation [1]	Horses	Average length of stride at trot	Score for top line of back [2]	Horses	Average length of stride at trot	Score for top line of withers [3]	Horses	Average length of stride at trot
	Number	*Feet*		*Number*	*Feet*		*Number*	*Feet*
4	3	10. 4	4	7	9. 9	4	1	8. 0
5	7	10. 3	5	13	10. 1	5	10	10. 2
6	11	10. 7	6	18	10. 4	6	19	9. 7
7	26	9. 8	7	16	10. 1	7	21	10. 5
8	12	10. 3	8	9	9. 7	8	11	10. 1
9	4	9. 0				9	1	10. 2
Total or average	63	10. 1		63	10. 1		63	10. 1

ANALYSES OF VARIANCE

Source of variance	Degrees of freedom	Mean squares [4]	Source of variance	Degrees of freedom	Mean squares [4]	Source of variance	Degrees of freedom	Mean squares [4]
Between general conformation.	5	* 2. 41	Between top line of back	4	* 3. 04	Between top line of withers	5	2. 12
Within general conformation.	57	. 93	Within top line of back	58	. 92	Within top line of withers	57	. 96
Total	62			62			62	

[1] 1=poor−, 2=poor, 3=poor+, 4=medium−, 5=medium, 6=medium+, 7=good−, 8=good, 9=good+.

[2] 1=low, long−; 2=low, long; 3=low, long+; 4=medium−; 5=medium; 6=medium+; 7=short, level−; 8=short, level; 9=short, level+.

[3] 1=flat, wide−; 2=flat, wide; 3=flat, wide+; 4=medium−; 5=medium; 6=medium+; 7=sharp, well defined−; 8=sharp, well defined; 9=sharp, well defined+.

[4] *=Significant.

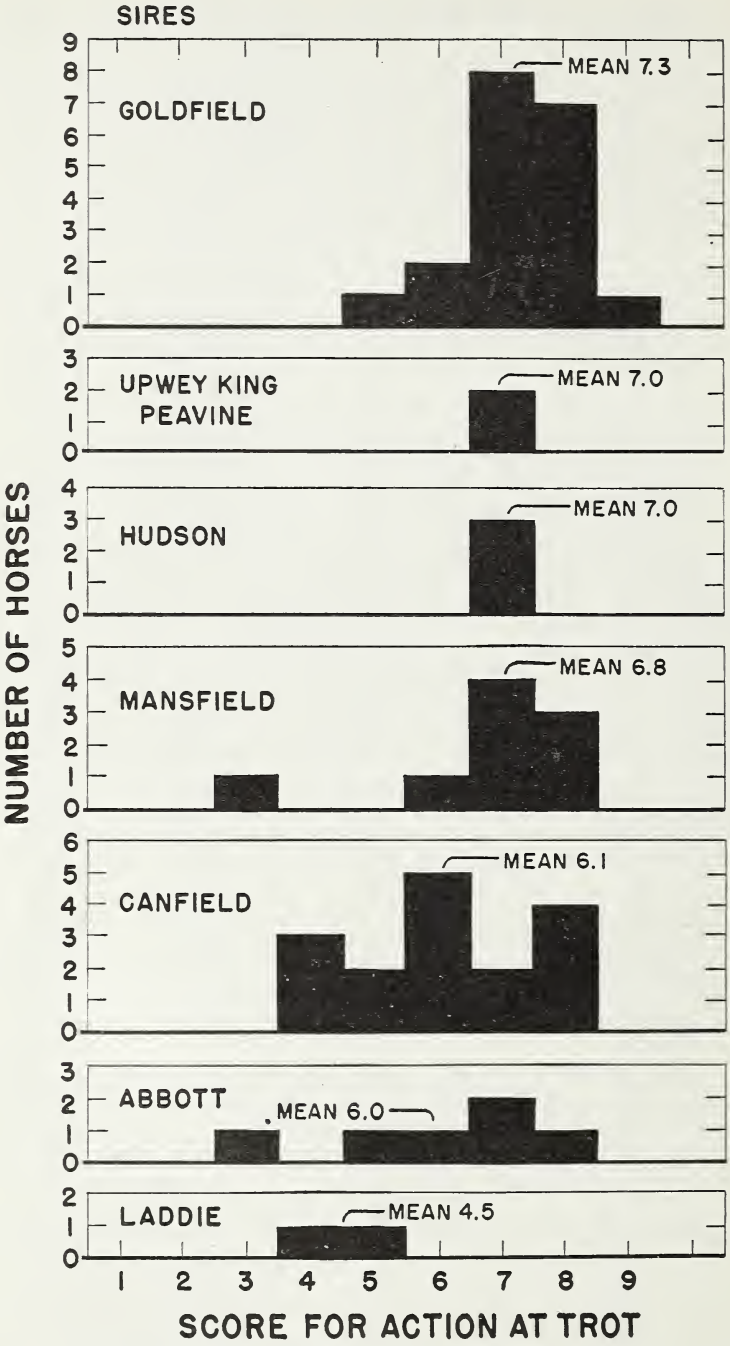

FIGURE 4.—Distribution of offspring of some of the sires for action at trot.

Slope of croup (top line of croup) was significantly associated with the riders' scores for performance at walk, approached significance for time required to cover the 11.35-mile course, the time required to trot a mile, and the length of stride at the walk, and was significantly associated with the differences between the offspring of the various sires and offspring of sires within sexes. It was not significantly associated with sex. Average scores for the progeny of different sires ranged from 5.3 for Hudson's progeny to 7.5 for those of Upwey King Peavine. Goldfield's progeny averaged 5.4.

Slope of shoulder was significantly associated with the time required to walk a mile (table 6) and with differences between sire-progeny groups within the same sex groups. It approached significance for differences between sexes and between sire-progeny groups.

Transmitting Ability of the Sires

The relative breeding value of the sires was indicated by comparing the average performance of the colts of a given sire with the average performance of colts by other sires from the same dams (table 9). In many of the comparisons the numbers were so small that only extreme differences could be shown to be significant, and it was not possible to consider the effects of years and sex. Apparently, no one stallion had superior transmitting ability in all characters. Canfield's progeny, however, made the best showing when all the characters were considered. Mansfield's progeny, on the other hand, generally did not perform so well as those of the other sires. In regard to speed, stride, and temperament, it has been assumed in comparing the sires that the faster the speed, the longer the stride, and the higher the temperament score, the better were these characters.

Style and beauty, although not directly related to performance, are generally desired in saddle horses and must be considered in selecting breeding stock. Differences between the progeny groups were found to be significant (table 18). The means for the progeny of the different stallions from highest to lowest were Mansfield, 7.7; Laddie, 7.5; Canfield, 7.2; Goldfield, 7.1; Hudson, 7.0; Upwey King Peavine, 6.5; and Abbott, 5.5. Delmont's progeny were not scored for style and beauty.

Determination of the transmitting ability of the sires is only partly covered by the tests reported in this study. Thus, Mansfield's 12 colts that were tested are only a small sample of those sired by this stallion and may not have included the best. In fact 2 of his colts that were not available for testing have won the 100-mile trail rides of the Green Mountain Horse Association, indicating they had some excellent qualities. This fact does not detract from the findings of the present study but illustrates that the ability to evaluate the sires is limited by the inadequacy of the tests and the samples tested.

TABLE 18.—*Significance of association between characters*[1] *in Morgan horses*[2]

Character	Speed and length of stride					Rider's scores									Body measurements												Miscellaneous scores								
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	44	45	46	48	50	51	52
1. Sex	−	−	−	−	*	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	*	−	−	*	**	**	+	−	+	−	−	−	−
2. Sires	+	*	**	−	*	−	−	−	−	−	−	−	−	−	−	−	−	*	**	+	−	*	−	−	−	*	−	−	*	+	**	+	−	−	−	* *
3. Sires within sexes															−	−	−	*	*	−	−	−	−	−	−	−			*	−	*	*	−	−	−	*
4. Sires within years and riders	*	−	*																																	
5. Dams	*	−	−	−	−	−	−	−	−	−	−	−	−	−													−									
6. Groups of mares mated to different sires	−	−	−	−	−	−	−	−	−	−	−	−	−	−													−							**	−	
7. Years	*	*	**	−	−	−	−	−	−	+	−	−	−	−													**									
8. Riders	−	−	**	−	−	−	−	−	*	−	−	**	−	−													−									
9. Temperature at time of test	−	−	−			−	−	−	−	−	−	−	−	−																						
10. Humidity at time of test	−	−	−			−	−	−	−	−	−	−	−	−																						
Speed and length of stride																																				
11. Time to walk a mile																																				
12. Time to trot a mile																																				
13. Time to cover 11.35-mile course																																				
14. Length of stride at walk	*		*																																	
15. Length of stride at trot		*	**																																	
Rider's scores																																				
16. Ease of handling at walk	−	−	−	**	−				**			**			−	−	−	−	−	−	−							−			−	−	−			
17. Ease of handling at trot	−	−	−	−	−					**			**		*	−	−	*	−	−	−							−			−	−	*			
18. Ease of handling at canter											**			**	−	−	−	−	−	−	−															
19. Performance at walk	**	−	*	*	−	**						**			−	+	−	−	−	−	−							−			−	−	−			
20. Performance at trot	−	−	−	−	−		**						**		−	−	−	−	−	−	−							+			−	*	−			
21. Performance at canter								**						**	−	−	−	−	−	−	−															
22. Ease of walk to rider	+	−	−	*	−	**			**						−	+	−	−	−	+	−							−			−	−	−			
23. Ease of trot to rider	−	+	−	*	−		**			**					−	−	−	−	−	−	−							−			−	−	−			
24. Ease of canter to rider			−					**			**				−	−	−	−	−	−	−							−								
Body measurements																																				
25. Weight of horse at 3 years	−	−	−	−	−	−	−	−	−	−	−	+	−	−								**	**	**	−	**										
26. Height at withers	−	−	−	−	−																	*	*	**	−	−										
27. Depth of chest	−	−	−	−	−																															
28. Width of chest	−	−	−	−	−																															
29. Height to floor of chest	−	−	−	−	−																														−	−
30. Point of shoulder to point of hip	−	−	−	−	−																	**	**	**	**	**									−	−
31. Heart girth	−	−	−	+	−																															

Character	Speed and length of stride					Rider's scores									Body measurements												Miscellaneous scores												
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	44	45	46	48	50	51	52
32. Depth of hock	−	−	−	−	−																														−	−
33. Circumference of fore cannon	−	−	−	−	−																														−	−
34. Circumference of hind cannon	−	−	−	−	−																						−		−					−	−	−
35. Circumference of knee	−	−	−	−	−																						−		−					−	−	−
36. Width of fore cannon	−	−	−	−	−																						−		−					−	−	−
37. Depth of fore cannon	−	−	−	−	−																						−		−					−	+	−
Miscellaneous scores																																				
38. Condition (fatigue) [3]			−	−	−	−	+	−	−	−	−				−	−	−	−	−	−															*	+*
39. General conformation	−	*	−	−	*	*	+	+	+	−	−	−	−	−																					+	
40. Style and beauty	−	−	−	−	−	−	−	*	−	−	−	−	−	−																						
41. Head	−	−	−	−	−	−	−	*	*	−	−	*	−	−																						
42. Neck	−	−	−	−	−	−	−	−	−	−	−	−	−	−																						
43. Top line of withers	−	−	−	−	+	−	−	−	−	−	−	−	−	−																					−	−
44. Top line of back	−	−	*	−	*	−	−	−	−	−	−	−	−	−																					−	−
45. Slope of croup (top line of croup)	−	+	+	+	−	−	−	−	*	−	−	−	−	−																					−	*
46. Slope of shoulder	•	−	−	−	−	−	−	−	−	−	−	−	−	−																					*	
47. Size and shape of feet	••	−	−	−	−	−	−	−	−	−	−	−	−	−																						
48. Quality	−	−	−	−	−	−	−	−	−	−	−	−	−	−																						
49. Condition (fleshing)	−	−	−	−	−	−	−	−	−	−	−	*	−	−																						
50. Temperament	−	−	−	*	−	**	**	**	*	**	*	*	*	−				−												−	−	+			**	**
51. Action at walk	*	−	*	−	−	+	**	−	**	**	+	**	**	−				−												−	−	++				
52. Action at trot	−	−	*	−	−	−	−	−	**	**	−	*	*	−				−												−	−	**				

[1] Numbers at top of columns correspond to numbers and description at left.
[2] Studied by analyses of variance; − = Not significant; + = approaches significance; * = significant; ** = highly significant.
[3] Scored at end of 11.35-mile test.

DISCUSSION

The results presented must be considered as only an approach to many of the problems involved. Although the number of animals was fairly large considering the relatively long interval between generations of horses and the expense of raising and training them, the number and distribution of progeny by sires or dams were not adequate to more than indicate some of the possibilities from the standpoint of inheritance. Moreover, most of the tests should be repeated several times with each horse in order to get reliable estimates of its ability. In a preliminary study, Phillips, Brier, and Lambert (*7*) found this to be true for time required to walk or trot a mile in the carriage. In repeated tests, however, with the same horses under saddle at the trot no significant differences were noted between the tests.

No check has been made of the reliability of the data obtained for the time required to walk a mile under saddle or to cover the 11.35-mile course; for the riders' scores for ease of handling, performance of gaits, and ease of gaits to riders; or for the scores given by the trained observers.

The significant differences between the progeny of different sires give strong indications that factors controlling the following characters are inherited: Speed at the walk and on the 11.35-mile course, height to floor of chest, length from point of shoulder to point of hip, style and beauty, slope of croup and shoulder, and action at the trot. Such significant differences as were found are undoubtedly due to both environmental and genetic factors. With the data available there is no way of accurately measuring all these effects. However, in the case of speed, which one would expect would be affected materially by environmental influences, the indications of the influence of inheritance are strengthened by the significant differences for speed at the walk and on the 11.35-mile course within the same years and with the same riders, the significant differences for speed at the walk between the offspring of different dams, and the significant differences between the offspring of certain sires mated to the same dams. The fact that differences in temperature and humidity at the time of the test did not, on the average, have a significant effect also tends to eliminate these environmental factors. Some of the differences that were not statistically significant, such as differences between the offspring of the different sires for speed at the trot in the same years and with the same riders, might with repeated experiments and different samples prove to be inherited to a measurable degree.

Many of the interrelationships among the characters have not been adequately studied. Some of these may be complex, as Dawson (*1*) found in studying the relationship of weight and heart girth to pulling ability in draft horses. A number of the associations found may be coincidental. For example, some of the sires might transmit both small feet and speed to their offspring, thereby making it appear that speed was dependent on the size of the feet, when actually there was no relationship other than that both characters were inherited together and the sample was not large enough to randomize such occurrences.

It should be borne in mind that the primary purpose of the breeding work at the United States Morgan Horse Farm has been to produce animals for use both under saddle and in the carriage. To qualify as good saddle horses, they should have clean gaits that are easy on the rider, be easy to handle, possess considerable endurance, and have a reasonable speed. Excessive speed, as that of race horses, is not desired or attempted.

The speed that a horse attains in a given test is due to the influence of many factors. From a breeding standpoint, the factors that appeared to be most important in this study were length of stride, temperament, action, length of leg, slope of shoulder, and slope of croup. Shape and size of feet, which were found to be associated with speed of walk, were probably coincidental combinations. The five horses with the smallest feet were by two sires, Canfield and Goldfield, which also had the fastest walking progeny. Sex undoubtedly had an influence on speed both directly and through its association with length of stride at the trot and general conformation. Unfortunately, there was not a normal distribution of sexes. The castration of most of the males and disposal of others before testing were undoubtedly factors that resulted in the elimination of certain types. The fact that the stallions, on the average, had a shorter stride at the trot than the geldings might indicate a selection for a type with a shorter stride. On the other hand, it might be due to a difference in temperament directly connected with the presence or absence of the sex glands.

At the walk, a long stride was not necessarily associated with speed since a considerable number of horses with long strides did not naturally walk fast. Speed, however, was dependent on the horses' having a reasonably long stride since none with short strides walked fast. Since straight, snappy action was associated with speed at the walk, it is evident that ability and willingness to move the feet fast in combination with ability and willingness to take a long stride are essential for a horse to make good time at the walk. Although slope of shoulder, which was found to be associated with time required to walk a mile, did not seem to be associated with length of stride, it was associated with action or willingness and ability to move the feet fast.

At the trot, none of the horses with a long stride were very slow and none with a short stride were fast. Slope of croup was also associated with speed at the trot but was not significantly associated with length of stride. The apparent lack of association where it might be expected may be partly due to the fact that medium slope of croup was found to be the most favorable. The same statement may apply also to slope of shoulder in relation to speed of walk, and to top line of back and withers where a medium condition was associated with a longer stride at the trot but not with the greatest speed at the trot. Also the lack of association may be due to the characters' being related to speed in different ways but not necessarily to one another.

On the cross-country ride, speed was an even more complicated measure since it involved three gaits and, furthermore, the long distance might involve endurance to a much greater extent than the 1-mile tests. The fact that only seven horses showed marked signs

of fatigue and that the association between speed and fatigue was not significant indicates that the test did not satisfactorily differentiate endurance between the horses. The differences between riders (environmental factors) were also associated with speed to a greater extent than on the shorter tests. This fact may in part account for the correlations between time on the cross-country test and on the shorter tests not being higher.

On the average, horses with short, level backs made the best time on the cross-country test. This may have been due to the association between top line of back and length of stride at the trot, or it may have been a coincidental association. Canfield's offspring, on the average, had relatively short backs and were also the fastest.

The riders liked a fast walk with good action and were able to recognize it, as indicated by the fact that in general they gave the best scores for performance at the walk to horses with the fastest time, longest stride, and best action. They were not, however, so consistent in scoring performance at the trot, indicating that they did not all prefer the fast trot with a long stride or that they did not recognize it. However, in scoring performance, they liked a straight, snappy action at the trot. Just why good action at the walk should have been associated with ease of trot to the rider when good action at the trot was not, is not clear to the authors. Many horsemen believe slope of shoulder is associated with ease of riding. It did not appear to be in this study.

According to Steele (*11*) the need for progeny testing has already been recognized by some light-horse breeders but more need to practice it. He says, in effect, that performance and meritorious production should be made the basis of selection and retention rather than the current use of lengthy pedigrees.

SUMMARY

This circular presents results of performance tests for speed, endurance, and ease of riding under saddle of 68 three-year-old Morgan horses raised and trained at the United States Morgan Horse Farm, Middlebury, Vt. These horses were by 8 sires and ranged from 2 to 25 offspring per sire. Tests consisted of 1 mile under saddle at the walk and 1 mile at the trot and an 11.35-mile cross-country ride at the walk, trot, and canter. On the 1-mile tests records were made of the time required for the test and the length of stride. On the 11.35-mile test records were taken of the time required; fatigue at the end of the test; and riders' scores on each horse for ease of handling at each gait, performance of gait, and ease of gait to the riders. Other measurements and scores were made on each horse.

Horses with a fast walk, on the average, had a long stride, straight snappy action, and a medium slope of shoulder. Slow horses had either a short or a long stride. None of the sires produced all progeny with both a fast walk and a long stride. Canfield had the best record, 69 percent of his progeny being in this group.

Horses with a fast trot had a relatively long stride and in general had a medium score on general conformation. Differences between the offspring of the different sires were not on the average significant when the sex of the progeny was considered.

On the cross-country ride, horses that made the fastest time had a long stride at the trot, performed the trot well in the opinion of the riders, and had relatively short, level backs.

At the end of the cross-country test, stallions showed the least fatigue and mares the most. So few horses showed fatigue that the test was not considered adequate as a measure of endurance.

The easiest horses to handle at the walk, on the average, were those with a long stride, a high score on general conformation, and a medium score on temperament. Horses that walked fast and had a long stride, high scores for head, an intermediate slope of croup, and straight snappy action generally had the best scores on performance at the walk. In general, horses with a fast walk and a straight snappy action at the walk and trot had the easiest walk for the rider.

At the trot, horses that had low or medium scores for temperament, straight snappy action at the walk, and intermediate height at the withers were, on the average, the easiest to handle. Horses that were active but not vicious or difficult to handle and had straight snappy action at the walk and trot as a rule performed best at the trot. Horses with a straight snappy walk had the easiest gait at the trot to the rider. Riders did not prefer horses with the longest stride.

At the canter, horses with intermediate scores for temperament were the easiest to handle. Horses that were very active but easily handled performed the best.

The significant differences between the progeny of different sires give strong indications that factors controlling the following characters are inherited: Speed at the walk and on the 11.35-mile course, height to floor of chest, length from point of shoulder to point of hip, style and beauty, slope of croup and shoulder, and action at the trot.

Characters that were associated with performance and that differed significantly between the sexes were length of stride at the trot and general conformation. Canfield's colts, when compared with colts by other stallions from the same dams, made the best showing on performance of any of the sire progeny. Mansfield's colts had a higher average for style and beauty than those from other stallions.

Because of the relatively few sires and inequalities of distribution of the progeny and sexes, some of the results may be due to coincidence of characters being transmitted together.

The results of this study indicate that some of the existing beliefs concerning the relation of physical characters to performance of saddle horses are not based on sound assumptions and that more comprehensive studies should be carried out to determine the relationships between form and function. Until better information is available, it is suggested that breeders select for characters shown in this study to be associated with performance and, when possible, use breeding animals with proved ability to transmit performance.

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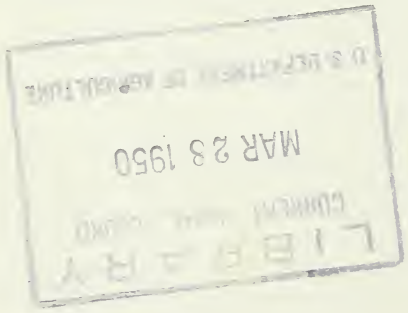

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