ANALYSIS OF QUANTITATIVE CHARACTER IN GRAZING HORSES

III. History of Breeding

By

Yutaka WATANABE and Takashi SHIMOIIZAKA

Introduction

The pedigree of the grazing horses of the stock-farm belonging to Faculty of Agriculture of Hokkaido University has been apparent since the time of the opening of the stock-farm in the begining of the Meiji era (1867–1912), and the record thereof would have been valuable to tell the history of breeding of horses for the period of 90 years, but unfortunately the material that is available at the present time is not plenty. A great number of horses of different breeds has been imported for the improvement of the native horses in this stock-farm, and it would be very interesting to trace the history and causes of the past and to study the influences brought upon the horses of the present days. Fortunately, as the measurement records of the mares as observed by MASUMURA et al. in 1920 have now been obtained, the authors have tried to review the transition in the measurements of the grazing horses from the early days of Meiji era of the said record in addition to the data of observation conducted by the present authors.

The breeding mares used in the observation have been restricted to the horses of 5 years of age and above, as these horses are of late maturity. The horses of the population have a tendency toward a certain type of body as they have been bred toward a definite form of the body, but as they are group of cross breed principally, it is not possible to discuss the general form of the horses, and only the observed measurements are described herin.

Outline of the Stock-Farm

(1) History:

The present stock-farm was opened in the *5th* year of Meiji era (1872) with the land area approximately 66,000 hectares in Niikappu, Shizunai and Saru county in recognition of the improvement of horse breeding by Mr. KURODA, then the director of Land Reclamation Commissioner, and 2,262 wild horses

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scattered in the countries of Hidaka, Hokkaido were collected, and the stock-farm was named Niikappu Grazing Land in the 10*th* year of Meiji (1877), and was completely equipped by a reclamation commissioner EDWIN DUN, an American. In the beginning, the land was under the supervision of the Office of Reclamation Commissioner and then transfered to the supervision of the Ministry of Agriculture and Commerce in the 15*th* year of Meiji (1882), and again transfered to the supervision of the Ministry of the Imperial Household in the 16*th* year of Meiji (1883), and the name of the grazing land was changed to the Imperial estate of Niikappu in the 19*th* year of Meiji (1886). In the 21*st* year of Meiji (1888), the land was again transfered to the supervision of the Bureau of Imperial Mews under the new name of the Imperial Stock-Farm of Niikappu and continued so until the 3*rd* year of Showa (1928), and the same year it was transfered to the supervision of the Imperial Forestry Bureau, and again to the supervision of the Ministry of Imperial Household. With the abolishment of the Ministry of Imperial Household in the 22*nd* year of Showa (1947) the farm was transfered to the supervision of the Ministry of Agriculture and Forestry, with the change of name to Niikappu Breeding Stock-Farm. However, at the request of the Ministry of Agriculture and Forestry the horse breeding enterprise, which had continued for the period of 80 years, was abandoned, and became a stock-farm for breeding bulls. The operation of the forest grazing land and of grazing horses, which had been improved for grazing in the forest from the beginning, was partly taken over by Hokkaido University, and it is now in operation under the supervision of the University.

(2) **Environment:**

In the forest, flourish broad-leave trees like Japanese Oak trees, Japanese Judas trees, Itaya trees, Oak trees, elm trees, yachidamo trees and the like, and the grazing horses feed on *Sasa nipponica*, mugworts, miscanthuses and the other various weeds growing under the trees throughout the seasons. The climate of the place is quite moderate and deep snow is seldom seen even in the season of severe coldness. The soil is mostly valcano ash soil and the condition of grass growth and the environment are comparatively good although the soil is not very fertile.

The values of average temperatures, maximum and minimum temperatures, rain fall, and the number of days of fair weather in the plane land for 10 years from 1946 to 1955 were as shown in the following table. The environment where the grazing horses are bred, is of course quite different from that of plane land, but the general condition of the place may be imagined.

Month	Average temperature (°C)	Max. temp. (°C)	Min. temp. (°C)	Rainfall (mm)	Rainny days (days)	Solar time (times)
January	− 5.15	0.38	− 9.79	40.64	13.40	114.33
February	− 4.16	1.02	− 8.76	28.24	9.00	144.07
March	− 0.22	3.41	− 5.41	51.50	11.90	201.45
April	5.62	10.71	− 0.60	78.07	12.20	176.15
May	10.26	16.20	5.17	92.28	11.50	184.28
June	14.47	19.33	10.94	91.93	12.20	148.68
July	19.48	22.94	15.86	125.15	15.60	144.87
August	22.21	26.23	18.24	94.51	12.40	157.90
September	17.20	22.04	12.43	136.87	14.40	161.81
October	11.12	16.39	5.87	123.95	15.40	170.60
November	4.18	8.83	− 0.73	69.76	14.70	121.64
December	1.39	2.88	− 5.93	53.51	12.40	92.00

(averages of ten years from 1946 to 1955 at Shizunai)

(3) Policy of Horse Breeding:

In the beginning of development of this stock-farm, the stallions produced in Nanbu District (a northern district of the main land of Japan) were brought in and mated with the native mare horses, and the horses thus produced were very popular on account of their larger body, stronger and healthier, than the native ones. However, as it was deemed necessary to have superior foreign stallions for the improvement of the native horses, the import of stallions from foreign countries was initiated since the 11*th* year of Meiji (1870), and those imported for the purpose were mostly American trotters.

The first foreign stallions imported as breeding horses were the trotters, Black Hawk and King Richard, by name, used in the 13*th* year of Meiji (1872), and then the Thoroughbred stallions, Karyu and Araragi, by name, in the 17*th* year (1876). The Viscount and Spney, Thoroughbred stallions, were imported in the 21*st* year (1880) and these were the beginning of Thoroughbreds in Hidaka.

Since the 22*nd* year of Meiji (1889) the yearly import of foreign breeds of stallions increased amounting to 9–10 heads a year, but the number was only one half of the stallions employed in the farm. In the 35*th* year of Meiji (1902) the fundamental policy of the operation of the farm was defined, and the policy was based on the import of mostly trotters, and some others were the breeds of Thoroughbred, Arab, Anglo-Arab, Gidlan, Thoroughbred line, Hackney, Cleveland Bay, light half-breed, middle half-breed of light line in order. In the 45*th* year of Meiji (1912) a Percheron was brought in, but

they were mostly for riding and sold off to the military and to the public. Some of the Cleveland Bay breed and those line, it is assumed, were used as the Imperial carriage horses.

Thus, the scope and system of operation of the farm had been established by the end of Meiji era and the development of the enterprise was stressed in the subsequent years, but so long as the purpose of the stock-farm was to produce a definite number of horses for the Imperial family, the rationalization of operation in the production of horses, and the furnishing of the material for the improvement of horses of the country, and the entire system and operation of the farm was pursued along this line.

Since Showa era began (1925–), the condition of the grazing horses had become too unruly and too thin bodily and in some extreme cases those that were unsuitable for grazing in the forest had increased, and too many foreign breeds had been brought in during the 7 or 8 generations, which were too excessive in general, it appeared that the stocky type of horses had been lost. But as the era was such that demanded the production of the drag horses of middle fleshy breeds more than the riding horses of light breeds, through the change in the horse breeding policy of Japan in the *8th* of Showa (1933), Percheron breed, Yuto by name, was introduced to produce middle half-breed horses, and in fact the F_1 offsprings by him were greatly superior in type and capacity.

On the otherhand, in order to produce middle sized riding and drag horses as well as small type drag horses (including the production of farm horses for Niikappu and Shimofusa), strong in stature and good in nature, mating imported Anglonorman breed or its line alone, was supplied since the *15th* of Showa (1940).

In the *17th* of Showa (1942) when farm was again transfered to the supervision of the Ministry of Imperial Household, the predetermined policy was still continued, except that it was partly changed to consider the production of Cleveland Bay breed of 40 heads as the Imperial carriage horses out of 220 head in the farm, but with the end of the War II the policy had to be changed, and the enterprise was transfered to the Hokkaido University as it remains today.

Analysis of Body Measurement

(1) Effect of Stallion:

As described above, the horse breeding policy underwent modification more or less according to different eras. However, the heads and breeds of the

horses imported for breeding purposes amounted to a quite large number, and the type of the horses was greatly influenced by the stallions supplied in the respective eras.

The original home-bred horses early in Meiji era were so-called Japan native horses of which the record of body measurement is very scanty, and

TABLE 1 Increase of withers height since 12*th* year of Meiji (1879)

Period (Meiji)	n	$\bar{x} \pm t\ .05 S_{\bar{x}}$
12 — 16	38	m 1.405±0.063
17 — 21	38	1.443±0.082
22 — 26	70	1.454±0.068
27 — 31	119	1.451±0.072
32 — 36	162	1.466±0.080

TABLE 2 Average measurement according to periods ($\bar{x} \pm t\ .05\ S_{\bar{x}}$)

	Meiji (1899–1912)	Taisho (1913–1926)	Showa (1927–1948)
Withers height	m 1.508±0.073	m 1.511±0.065	m 1.499±0.066
Croup height	1.508±0.099	1.510±0.070	1.497±0.075
Body length	1.601±0.111	1.578±0.111	1.554±0.081
Heart girth	1.791±0.111	1.781±0.124	1.790±0.085
Cannon circumference	0.187±0.000	0.190±0.000	0.189±0.000
Chest depth	0.721±0.066	0.710±0.056	0.708±0.016
Chest width	0.397±0.043	0.399±0.059	0.399±0.017

TABLE 3. Relative value

	Meiji	Taisho	Showa
Croup height	99.94	99.86	99.85
Body length	106.16	104.44	103.67
Heart girth	118.78	117.87	119.44
Cannon circumference	12.47	12.57	12.48
Chest depth	47.85	46.98	47.24
Chest width	26.30	26.41	26.64

TABLE 4. Average measurement according to sires

Name of Stallion	Breed	Used for breeding	No. of offspring	Withers height	Croup height	Body length	Heart girth	Cannon circum-ference	Chest depth	Chest breadth
				Average measuvement of offspring						
Schagya (VII-4)	Arab	1890–1895	7	1.454	1.452	1.565	1.762	0.181	0.715	0.379
Spooney II	Thoroughbred line	1893–1914	15	1.488	1.485	1.564	1.773	0.185	0.713	0.386
Morioka	Middle half	1898–1906	7	1.510	1.521	1.578	1.817	0.193	0.716	0.402
Vodka	Trotter	1899–1914	10	1.489	1.508	1.588	1.777	0.189	0.721	0.405
Handy	Trotter	1902–1914	23	1.515	1.515	1.622	1.793	0.189	0.719	0.403
Yad	Anglo-Arab	1902–1921	20	1.511	1.504	1.589	1.757	0.187	0.708	0.392
Unsei	Middle half	1904–1908	13	1.518	1.524	1.612	1.811	0.188	0.729	0.399
Hokucho II	Heavy half	1904–1914	12	1.547	1.536	1.646	1.861	0.194	0.741	0.416
Forestview IV	Middle half	1904–1922	25	1.521	1.513	1.603	1.823	0.185	0.728	0.430
William	Thoroughbred	1906–1916	9	1.521	1.522	1.593	1.816	0.187	0.727	0.404
Shagya (VII 4) II	Light half	1907–1915	11	1.494	1.500	1.569	1.794	0.185	0.712	0.394
Woodland Pride	Cleveland bay	1908–1916	16	1.526	1.516	1.622	1.815	0.193	0.727	0.397
Speciallite	Cleveland bay	1908–1917	12	1.533	1.515	1.642	1.804	0.193	0.727	0.393
Bowland Pride	Cleveland bay	1908–1923	26	1.512	1.518	1.609	1.887	0.193	0.710	0.392
Yad IV	Anglo-Arab	1909–1923	32	1.500	1.504	1.574	1.764	0.188	0.704	0.440

Average measuvement of offspring

Name of stallion	Breed	Used for breeding	No. of offspring	Withers height	Croup height	Body length	Heart girth	Cannon circum-ference	Chest depth	Chest breadth
Gidran XLI-3	Gidran	Urakawa	9	1.508	1.515	1.576	1.776	0.188	0.713	0.408
Portland Bay	Thoroughbred	Urakawa	7	1.525	1.526	1.573	1.801	0.194	0.717	0.421
View Light	Middle half	1910-1915	16	1.506	1.508	1.561	1.781	0.187	0.703	0.388
Hero	Middle half	1910-1915	15	1.481	1.496	1.551	1.745	0.183	0.702	0.393
Vodka VI	Middle half	1916-1917	7	1.517	1.511	1.558	1.798	0.195	0.717	0.383
Ruadhogeir III	Thoroughbred	1913-1935	26	1.520	1.523	1.588	1.782	0.192	0.718	0.396
Blacksmith	Thoroughbred	1919-1933	25	1.523	1.536	1.573	1.791	0.189	0.724	0.393
Capenor Killala	Hackney	1920-1931	12	1.498	1.494	1.565	1.769	0.192	0.705	0.387
Massbort	Arab	1922-1929	13	1.458	1.459	1.504	1.688	0.178	0.663	0.398
Supper Dance III	Anglo-Arab	1922-1929	21	1.499	1.510	1.566	1.754	0.184	0.706	0.380
Thunderland Peter	Hackney	1923-1931	32	1.515	1.505	1.577	1.772	0.190	0.706	0.390
Kalpa	Trotter	1925-1938	25	1.496	1.495	1.551	1.774	0.185	0.698	0.384
Ajax	Trotter	1925-1938	28	1.506	1.514	1.543	1.779	0.187	0.702	0.398
Yuto	Percheron	1933-1944	19	1.490	1.480	1.588	1.811	0.191	0.712	0.411
Horen	Anglonorman line	Urakawa	7	1.470	1.475	1.540	1.749	0.188	0.691	0.402

their withers height, about 140 cm. were taller than present Hokkaido native ponies. Some of them were bred by foreign stallions since the 12*nd* year of Meiji (1879), the withers height became taller gradually, according to the increase of foreign stallions and came to the withers height of the present grazing horses in the 32*nd* of Meiji (1899), a period of about 30 years.

When the types of horses after 1899 are compared by having the period

TABLE 5. Analysis of Variance in Withers Height

Source of variation	Degrees of freedom	Mean square	Expected value of mean square	Variance component
Between sires	29	0.524*	A+kB	0.014
Within sires	470	0.296	A	0.296
Period	2	0.059		
Discrepancy	468	0.296		

* 1% significant $r=0.045$ $g^2=0.180$

TABLE 6. Analysis of Variance in Croup Height

Source of variation	Degrees of freedom	Mean square	Expected value of mean square	Variwnce component
Between sires	29	0.362*	A+kB	0.012
Within sires	470	0.161	A	0.161
Period	2	0.494		
Discrepancy	468	0.161		

* 1% significant $r=0.069$ $g^2=0.276$

TABLE 7. Analysis of Variance in Body Length

Source of variation	Degrees of freedom	Mean square	Expected value of mean square	Variance component
Between sires	29	0.970*	A+kB	0.042
Within sires	470	0.272	A	0.272
Period	2	1.501*		
Discrepancy	468	0.267		

* 1% significant $r=0.131$ $g^2=0.524$

divided into 3 eras, Meiji, Taisho and Showa, for convenience's sake, they are as shown as in Table 2 and 3, and when the 7 body measurements are observed in the offsprings by various stallions, each of which had a comparative large number of offsprings, they are shown in the Table 4. It is presumable that the measurements were not influenced much by the time of impregnation.

Of course, the record of the offsprings of those stallions is only a part

TABLE 8. Analysis of Variance in Heart Girth

Source of variation	Degrees of freedom	Mean square	Expected value of mean square	Variance component
Between sires	29	0.870*	A+kB	0.031
Within sires	470	0.364	A	0.364
Period	2	0.967		
Discrepancy	468	0.360		

* 1% significant $r=0.079$ $g^2=0.316$

TABLE 9. Analysis of Variance in Chest Depth

Source of variation	Degrees of freedom	Mean square	Expected value of mean square	Variance component
Between sires	29	0.292*	A+kB	0.013
Within sires	470	0.074	A	0.074
Period	2	1.689*		
Discrepancy	468	0.054		

* 1% significant $r=0.150$ $g^2=0.600$

TABLE 10. Analysis of Variance in Chest Width

Source of variation	Degrees of freedom	Mean square	Expected value of mean square	Variance component
Between sires	29	0.493*	A+kB	0.016
Within sires	470	0.221	A	0.221
Period	0	0.367		
Discrepancy	468	0.221		

* 1% significant $r=0.067$ $g^2=0.268$

of the whole and it is improper to make the average values obtained thereby represent the body measurements of the limited number of the offsprings of those stallions, but it is tabulated as, only a means of examining the influence of stallions. However, analyzed by different stallions and different eras for studying the statistical meaning of them, they are as shown in Tables 5–10.

According to the Tables of analysis of variance, throughout each of the measurements the effect by the stallions appears to be significant, and it is assumed that the supplied stallions were varied by the modification of the horse breeding policy in each era and the effect thereof has appeared significantly on the offsprings. In observing the differences due to respective era, no significant difference is seen in withers height (Table 4), croup height (Table 5), heart girth (Table 7), and chest width (Table 9), and these are possibly due to comparatively small change inherently. It is also presumable that due to the fact that, as the result of efforts for the production of a definite type of horses to a certain extent for a long duration, though they are cross-bred horses the factors relating to the body measurement have become more or less fixed, and their change is small, and that in consequence the heritability is so small as 0.180, 0.276, 0.316 and 0.278, respectively. It is also presumable that the influence of the environment was easy to have an effect on them. It is interesting that these heritabilities are much smaller than those of animals in a stable (Holstein cow) calculated by Touchberry, R. W. (1951) or Weber, F. (1957). On the contrary, the body length (Table 6) and the depth of chest (Table 8) were greatly influenced by the stallions, and changes are seen significant in respective eras and the difference according to the era and the result of analysis of variance are quite significant, and in consequence the heritability thereof has appeared greater. When these facts are observed in relation to the withers height, the croup height has decreased in recent years and the heart girth and chest width have become greater also in recent years, and that shows that the horses have changed to the horses of broad and low body as demanded for small type drag horses for the farm.

(2) Correlation in the Character of Body

It is a well known fact that the selection of one particular character has an influence on the improvement of other characters. Even if breeders try to improve one particular character of a horse, other characters are also affected to a certain extent. It may be said similar phenomena will happen in the measurement of each part of the body as the correlation between respective part exists. The reasons for such phenomena may be considered as the following:

a. It will be taken up first whether one gene is working on more than tow characters of horse (pleiotropic gene action in a broad sense) or the genes are in linkage. It also might have been caused by the characters having been conducted into the whole population commonly in the recent generation and/or by the mating system employed.

b. The phenotypic correlation, in which some of the influence of internal and external environments act similarly on both of the characters, includes both genetic correlation and environment correlation. The former means the correlation of sets of genes acting on the character of the same body to the extent of accumulation of the effect on the character by the same genes for a long duration, and the latter the measurement of the effect of the common environment. The contents of the meanings are extremely complicated and there are often cases wherein entirely opposite results come out in different groups. Especially, in the place like this stock-farm, where there are many

TABLE 10. The phenotypic (top figure) and the genetic (bottom figure) correlation between the seven characteristics

	Croup height	Body length	Heart girth	Cannon circum-ference	Chest depth	Chest width	Hip width
Withers height	0.816 0.981	0.423 0.507	0.636 0.118	0.584 0.850	0.614 0.178	0.391 −0.266	0.308 −0.150
Croup height		0.411 0.493	0.481 0.068	0.615 0.552	0.489 −0.095	0.348 −0.344	0.326 −0.313
Body length			0.506 −0.218	0.364 0.527	0.332 0.604	0.212 0.261	0.254 −0.310
Heart girth				0.525 0.257	0.471 0.866	0.421 0.540	0.413 −0.659
Cannon circum-ference					0.411 0.139	0.361 0.315	0.197 −0.187
Chest depth						0.605 0.836	0.479 −0.485
Chest width							0.411 −0.170

cross-bred horses from various breeds, the correlations may happen only temporarily. The individual body of animal is a physiological constituent unit and each part thereof is in a balanced state, and when the influence of environment works on one part, the secondary effect works on other parts.

Genetic correlation can be calculated from phenotypic correlation between related individuals, Hazel, L. N. (1943) derived next formula:

$$r_{G_i G_j} = \sqrt{\frac{r_{I_2 J_1} \cdot r_{J_2 I_1}}{r_{J_2 I_1} \cdot r_{J_2 I_1}}}$$

G_i = Genotype of character 1.
G_j = Genotype of character 2.
I_1 = Phenotype of character 1 in animal 1 (mother).
I_2 = Phenotype of character 2 in animal 2 (daughter).
J_1 = Phenotype of character 2 in animal 1 (mother).
J_2 = Phenotype of character 1 in animal 2 (daughter).

When one figure in the numerator was negative and the other positive, the arithmetic mean of the two figures in the numerator was used in place of their geometric mean to avoid the difficulty of the square root of a negative number. When both figures in the numerator were negative, the geometric mean was used just as when all the figures were positive except, of course, the genetic correlation was given a negative. The withers height and the croup height have the same genetic basis. All of correlations between hip width and other measurements are negative, and we are afraid that any errors should be included in them, for measurement of hip width is sometimes accompanied by human error.

Summary

The transition of the type of the breeding mares produced in the old Imperial Stock-Farm of Niikappu since the Meiji era has been analyzed herein above. As the result of grazing and rearing throughout all seasons for the long period since the beginning of the stock-farm with the native breed as its basic breed, the horses, assimilated to the land and climate, light in steps, endurable of plain feed, good endurance, practicable and healthy, were produced to 7 to 8 generations and these became varied in the type and breed as light, medium, and heavy, and most of the horses were of the riding type horses. However, in the begining of Showa era the horse breeding policy was modified according to the demand of the time. Small type riding and dragging horses, healthy and strong, and of good character, were intended to be produced.
Looking at the relation shown in the figures representing the existing conditions of the duration, no significant differences are noted in the withers height, the croup height, the heart girth, chest width of the horses, and the heritability is small, being 0.180, 0.276, 0.316, and 0.278, respectively, but quite periodical variation was observed in the body length and chest depth. In recent years, however, they have a tendency of getting small gradually, and the heritability

also are getting greater like 0.524, 0.660. Looking at the relative value of the withers height, the height has decreased with somewhat larger heart girth and chest width in quite recent years. It is apparent that the horses are advancing toward the formation of the so-called small type drag horses with broad body and low height. Significant differences due to the stallions are noted in each measurement and the influence of the stallions on their offsprings is quite apparent.

The influence of foreign stallions on the size is clear in unimproved native breed to certain point, thereafter the change is comparatively small. This may be explained from the point of adaptability of the cross-bred population or of genetic homeostasis and so on.

As it is one of the important matters to know the correlation between the characters of horses in selecting the character among several breeds in actual breeding, phenotypic and genetic correlations have been calculated on 8 body measurements. It will be known there is difficulty in breeding by the type of body through these correlations, as certain measurements changed. The genetic value of each part is coexistent with others, and especially it may be known that the withers height and the croup height have the same genetic basis.

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