POPULATION SIZE OF NATIVE LIVESTOCK IN JAPAN AND ITS ADJACENT LOCALITIES*

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Synopsis. Results of population size estimation of the native livestock—cattle, horses, swine, and goats—in Japan and its adjacent localities are summarized. They are accompanied by short remarks on the origin and present status of each stock. Brief discussion was also made on measures to protect the inbreeding depression and extinction of these native stocks.

Introduction

In the present article, the author summarizes the results of population size estimation of the native livestock maintained in Japan and its adjacent localities at as recent date as possible. The description of the results is accompanied by short remarks on the origin and present status of that native stock. Materials include native cattle, horses, swine, and goats kept in Japan, Ryukyu (Okinawa) Island, Korea, and Taiwan (Formosa). In these areas a number of native stocks of dogs and fowls are kept mainly for hunting use and as fancy animals. A survey of them is now in progress. So the results of estimation of their population sizes will be given later. It would be desirable that the effective population size in the sense of WRIGHT is calculated precisely in every case, but when calculation was difficult to be accomplished for various reasons, the census number alone was given here.

Materials and Methods

Materials used for the present work were collected mainly in field investigation made by the Research Group on Native Livestock in Eastern Asia over a period from 1961 to date. The general description of this field investigation is given in the official reports of the Research Group (No. 1 in 1964, No. 2 in 1967, and succeeding numbers to be published). The results of a field survey on Kiso native horses (NOZAWA et al., 1962) and those of a pedigree analysis on Japanese “Wagyu” cattle (NAGAMI, 1968) were used as other sources of materials. The locations of the native livestock dealt with in the present paper are indicated in Figure 1.

The census number of native animals with a fairly large population size could be obtained from statistical records kept by the competent authorities of the national and local governments, for which the author wishes to express his thanks to the officers in charge of these governments. In case such records were not available, direct counting or estimation was made during the exploration activities of the Research Group.

For the estimation of effective population size the following three methods were employed. (1) When the number of male parents (N_m) and that of female parents (N_f) in the breeding population were known, the effective population size (N*) could be calculated from the formula N* = 4N_mN_f/(N_m + N_f). This formula was simplified as N* = 4N_m, since N_m < N_f ordinarily in farm animals (WRIGHT, 1938). (2) When the insemination records of breeding sires were maintained, the effective size (N**) could be calculated from the formula N** = 4N_m/(V_km^2 + 1), in which V_km was the coefficient of variability between the progeny numbers of these male parents (NOZAWA, 1958). (3) On an animal breed the herdbook of which had been published periodically by an authorized association for registration, pedigree analysis could be made by using WRIGHT and McPhee’s method (1925). In this case, the effective population size (N***) could be estimated from the formula N***/ = 1/JR, where
$\Delta R$ was the increment per generation of the mean relationship coefficient between individuals in the population. Of the three methods mentioned above, the exactness of estimation was considered to be the lowest in the first ($N^*$) and the highest in the third ($N^{**}$) method. In addition, it should be remembered that among the values obtained by these methods there usually exists an order, census number $N^* > N^{**} > N^{***}$, when the size of the same animal population is estimated by the methods described above.

**Results**

1. Native cattle

**Mishima cattle:** On Mishima Island which is northwest of Hagi City, Yamaguchi Prefecture, Japan, a native breed of cattle has been raised by farmers. Since the breed has had no experience of being hybridized with any improved breed, its population is considered to represent the ancestral type of Japanese "Wagyu" cattle. The Mishima cattle were proved to be much smaller in body size than the modern Japanese "Wagyu" cattle. The blood-group studies revealed that the fre-
quency of antigenic factor Z' was about 65 percent in the Mishima cattle, or the highest that ever observed among the cattle breeds in the world (Kihara et al., 1965). The census number of the population was 220 in August, 1964. The effective population size was calculated as $N** = \text{ca. 10}$ at the same time. Since then, however, the population size has been decreasing. In 1967, the census number was reduced to about 150, including only one breeding sire. So that the effective size was calculated as $N** = \text{ca. 4}$. The cattle population on Mishima Island was designated as a natural monument of the nation by the Japanese Government in 1928, but in recent years a number of general farmers raising these cattle have come to request a cancellation of the designation on account of economic reasons. If such request is accepted, it will be feared that the hybridization of the population which has hitherto been prohibited by law may be made among the Mishima cattle.

**Kuchinoshima cattle:** A population of native cattle which had been breeding naturally was found in the mountain range on Kuchinoshima Island of the Tokara Archipelago belonging to Kagoshima Prefecture, Japan. These cattle are descendants of a small population which was introduced from Suwanosejima Island of the same archipelago in 1918. They can also be considered to belong to the ancestral type of the modern Japanese “Wagyu” cattle. The population could not be counted precisely, but an estimation of 30 to 100 was considered as a first approximation in 1961. Description remains to be made on the gene constitution of this population.

**Japanese “Wagyu” cattle:** Modern Japanese “Wagyu” cattle, which totaled about 1,900,000 all over the country in 1965, can hardly be considered as a native breed, because they have been improved by an intensive artificial selection from the hybrid population between Japanese indigenous stock and imported European breeds, such as Devon, Shorthorn, Jersey, Guernsey, Simmenthal, Ayrshire, and Brown Swiss (Uesaka, 1958). It would be adequate, however, to point out that some “Tsuru” strains (excellent families) established and maintained in the western part of Honshu, Japan, have long been used as the cores of breeding of Japanese “Wagyu” cattle and that they are highly inbred lines with an effective population size, $N** = 6$ to 8, according to the results of pedigree analyses covering a period from 1952 through 1962 (Nagami, 1968).

**Korean native cattle:** Korean native cattle which have been bred and raised all over Korea for meat and draft numbered about 1,300,000, including about 8,000 breeding bulls, in 1967. From that figure the effective population size may roughly be calculated as $N = 32,000$ for whole Korea, probably with some subdivision within the population. Because those cattle have no experience of hybridization with any imported stock in their breeding history, they have been regarded as a pure native breed. According to the result of blood-type studies, the Korean cattle population is considered to have a gene constitution similar to that of Mishima cattle, suggesting a common origin of Korean and Japanese native cattle.

**Taiwan yellow cattle:** Taiwan yellow cattle which have been bred all over Taiwan almost exclusively as draft animals totaled about 100,000 in 1967. Originally, they are descendants of native cattle of Kwangtung and Fukien Provinces in the southeastern part of China Proper. While Taiwan was under the rule of Japan from 1895 through 1945, they were hybridized frequently with some Indian cattle breeds, such as Sindhi and Kankrej, with the aim of increasing their body size. The exploration activities conducted by the Research Group in 1967 revealed that pure Taiwan yellow cattle remaining numbered less than 1,000 and that they were distributed sparsely throughout Taiwan, showing a comparatively high density in Pingtung and Miaoli Prefectures in the southern and western regions of the country. From the results of blood-type studies, it was presumed that the yellow cattle might have a fairly close phylogenetic relationship with the Indian breeds.

2. **Native horses**

**Hokkaido native horses:** The Hokkaido native horse is a representative of the native Japanese horses 130~135 cm in withers height. Hokkaido native horses consist of the descendants of a horse population which were raised in the northeastern part of Honshu, Japan, in
and prior to the 19th century. This history made it possible to presume that the majority of the genes harbored by Hokkaido native horses might be of Mongolian origin. In 1966, about 500 Hokkaido native horses were kept almost exclusively for transportation in the mountain ranges of the southern region of Hokkaido. The stock farm attached to the Hokkaido University has been carrying on a program for the maintenance of this horse breed, the population of which consisted of 4 males and 20 females in 1966. On the basis of the breeding records kept by the farm over a period from 1950 through 1965, the mean effective population size for this period was calculated as $N_{e}^* = 6.19$.

**Kiso horses**: So-called Kiso horses native to Nishi-Chikuma County, Nagano Prefecture, Japan, have been considered to be of Asian continental origin, like Hokkaido native horses. They were hybridized during World War II for military purposes. Since the end of the war they formed a single and closed breeding unit. Almost all the male parents, the pedigree of which are connected with one another, have been supplied from the villages of Shinkai and Kaida in the same county. The census number was about 2,000 and the average effective population size was calculated as $N_{e}^* = 90.39$ for a period from 1955 through 1961 (Nozawa et al., 1962). This value was confirmed by the result of effective size estimation from the random fluctuation of frequencies of genes controlling the coat color and blood-types (Nozawa et al., 1965). Since then, however, the population of Kiso horses has been decreasing in size year after year on account of diminution in demand for horses. In 1967, the census number was about 470, including 8 breeding males. So the effective population size was calculated as $N_{e}^* = ca. 30$.

**Misaki horses**: A population of native horses 130~135 cm in withers height has been keeping natural reproduction for hundreds of years on a woodland pasture at the Misaki Cape, Miyazaki Prefecture, Japan. In 1960, the population size was about 80, including 3 reproductive males. So the effective population size was calculated as $N_{e}^* = ca. 10$. Judging from their small population size, Misaki horses may have undergone much more intensive inbreeding than Hokkaido native horses or Kiso horses.

**Tokara horses**: Tokara horses, as well as Ryukyu and Tsushima native horses, are 110~120 cm in withers height. They have been assumed to be originated from an ancestry different from that of Hokkaido, Kiso, or Misaki horses mentioned above. This assumption was based on the fact that the former three populations, Tokara, Ryukyu and Tsushima, commonly had such constitution of genes controlling the coat color and blood-types as quite different from that of the latter three, Hokkaido, Kiso, and Misaki. Therefore, the former were classified into a group of island-type native horses (Nozawa et al., 1965). Archeologically, these horses are considered to belong to the oldest type of native horses in Japan and its adjacent localities (Hayashida and Yamauchi, 1956). It should be noted that Tokara native horses have disappeared almost completely from the original place of production; that is, Takarajima Island, Kagoshima Prefecture, Japan. Only one or more Tokara horses are now being raised as specimens in some of zoological gardens in the Japanese inland without any definite plan of reproduction. An exceptional, fortunate case is seen in a park at the foot of Mt. Kaimon, Kagoshima Prefecture, where a population of Tokara horses has been maintained. In 1967, the population consisted of 10 breeding male, 10 breeding females, and 16 young (Hayashida, personal communication). Therefore, the effective size was calculated as $N_{e}^* = 3.6$.

**Ryukyu native horses**: In the Ryukyu Archipelago, a stock of island-type horses has been maintained in pure form on Yonaguni Island, and a small number of them kept on Hateruma Island. These two islands are located very far from the main islands. The draft horses used in most part of the Ryukyu Islands are hybrids of varying grades between native stock and improved one introduced from the Japanese inland and U.S.A. The number of purely native horses was about 100 on Yonaguni and about 10 on Hateruma Islands in 1963. Yonaguni Island kept 43 male and 35 female native horses at the end of 1967,
when the breeding males numbered 5 or 6 and the effective size (N*) was considered to be 20 at the largest. Since many improved draft horses have been raised on these islands, there is a danger for the native stock to undergo hybridization.

Tsushima native horses: On the Tsushima Islands, Nagasaki Prefecture, Japan, island-type horses have been raised by general farmers and used for transportation in the mountain range of the islands. Recently, however, their population has been hybridized and decreasing in size. Thus only one of the seven males used for insemination in 1962 was of purely native kind and was stationed in a village southern-most of the islands. At that time, the census number of horses all over the Tsushima Islands was about 1,800.

Cheju horses: Cheju Island, located south of the Korean Peninsula, has long been famous for its horse production. In 1967, the census number was about 20,000 there. It produces about 3,000 colts annually by approximately random mating in the population. Then the effective population size was very roughly estimated as N*=400～600. The majority of male young produced have been shipped to the Korean Peninsula and used as draft animals in urban areas. In 1966, about 200 Cheju horses were imported into Japan for the purposes of amusement. Cheju horses are of pony size 110～120 cm in withers height. So, they have been considered to belong to a breed of such island-type native horses as Tokara and Ryukyu native horses. Investigation on the coat-color frequencies and blood-types, however, has raised a doubt about this point. The present author is in the opinion that Cheju horses may have a common origin with such continental-type native horses as Hokkaido native horses and Misaki horses, and that otherwise they have, at least, been influenced markedly by the continental-type native horses in lineage, even though they have a body size much closer to that of the island-type horse. Genetical and biometrical discussion is now being made on this point.

3. Native swine

South-China type swine in Taiwan: In Taiwan, native swine of South-China type have been raised. They are characterized by wrinkles of the skin on the face and body. They are descendants of swine introduced from China Proper mainly by the people of Kwangtung Province. Their population was about 140,000, including 451 breeding males, in 1966. The effective size was then calculated as N*=ca. 1,800. They are composed of three local breeds, the Taoyuan (Taoyuan Prefecture), the Meinung (Kaohsiung Prefecture), and the Tingshuanghsi breed (Taipei Prefecture). Each local breed has its own peculiarities in appearance distinctive from any other breed. In 1966, 95 percent, or about 3 million head, of the swine raised by general farmers all over Taiwan were hybrids of varying grades between native stock and imported European one. Of the three local breeds, the Taoyuan breed is predominant in number (presumably more than 100,000 head), with the most scattered distribution and, therefore, with some genetic differentiation throughout the country. Since it has been used extensively as parents for the production of cross-bred commercial hogs, there is no worrying about extinction of the Taoyuan breed at present.

Taiwan "short-ear" breed: The aborigines of Taiwan, who live in the mountain range of this island at present, have raised swine of different lineage from the South-China type native swine described above. The breed of those swine was called the "short-ear" one on account of their physical characteristic. It may be of Southeast-Asian origin and have a common ancestry with Philippine, Indonesian, Melanesian, and Polynesian native swine. Its population number has been unknown. The Field Research Unit on Taiwan Native Livestock, to which the author belonged, could find a small number of swine of this breed in the mountain range of Nantou and Kaohsiung Prefectures. It is the author's impression that the substitution of the "short-ear" breed by the South-China type or some hybrid swine has been in progress with the advance in economic development of the mountain range.

4. Native goats

Native goats in the Southwestern Islands and eastern Taiwan: Along the island chain from Tokara through Amami and Ryukyu Archi-
pelagoes to the eastern part of Taiwan, large numbers of goats are raised exclusively for meat. The round census numbers obtained were as follows: 200 in the Tokara Archipelago in 1960, 9,000 in the Amami Archipelago in 1960, 56,000 in the Ryukyu Archipelago at the end of 1962, and 10,000 in the three eastern prefectures of Taiwan at the end of 1965. In Ryukyu Islands, goat meat is comparable with pork in the importance as animal–protein source for the inhabitants. The original phenotype of them have a brown body color with a black stripe on the back, and horns, but not wattles (SUZUKI et al., 1967). They show a strong resistance to lumbar paralysis Filariasis cerebrospinalis). Moreover, they can be reproduced all the year round. From these characteristics it would be clear that they are native goats different in ancestry from any European dairy breed. The population of those goats, however, has been hybridized by the dairy Saanen breed with an aim of increasing the body size. Consequently, there seems to be a difference in gene constitution between the island populations on account of variation in the intensity of hybridization and of random genetic drift. There is, however, a tendency that the remoter the locality of a population from any developed area, the higher the frequency of native genes is maintained. Thus, on Takarajima Island of the Tokara Archipelago, on Onaguni Island of Ryukyu, and in the regions along the southern sea-coast of Taitung Prefecture, Taiwan, the goat population was observed to retain a comparatively high grade of purity as native breed. In Iso Park in Kagoshima City, Japan, a population of native goats consisting of 12 males and 8 females (therefore N* = 19.2) is maintained at present. These individuals are descendants of a mating pair of goats introduced from Takarajima Island in 1960 (HAYASHIDA, personal communication).

Native goats in Korea and western Taiwan: Meat goats have also been raised in the agricultural areas of southern Korean and western Taiwan. The census numbers of

<table>
<thead>
<tr>
<th>Species</th>
<th>Code number</th>
<th>Name or location of native livestock</th>
<th>Year of population size estimation</th>
<th>Census number</th>
<th>Effective population size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>1</td>
<td>Mishima cattle (Japan)</td>
<td>1964</td>
<td>220</td>
<td>N** = ca. 10</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Kuchinoshima cattle (Japan)</td>
<td>1967</td>
<td>ca. 150</td>
<td>N** = ca. 4</td>
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<tr>
<td></td>
<td>3</td>
<td>“Wagyu” cattle (Japan)</td>
<td>1961</td>
<td>30~100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>“Tsuru” strains of “Wagyu” cattle (Japan)</td>
<td>1965</td>
<td>1,900,000</td>
<td>N*** = 6~8*</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Korean native cattle</td>
<td>1967</td>
<td>1,300,000</td>
<td>N* = ca. 32,000</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Taiwain yellow cattle</td>
<td>1967</td>
<td>&lt;1,000</td>
<td></td>
</tr>
<tr>
<td>Horse</td>
<td>6</td>
<td>Hokkaido native horse (Japan)</td>
<td>1966</td>
<td>ca. 500</td>
<td>N** = 6.19</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Hokkaido University stock (Japan)</td>
<td>1950~1965</td>
<td>ca. 2,000</td>
<td>N** = 90.39</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Kiso horse (Japan)</td>
<td>1955~1961</td>
<td>ca. 470</td>
<td>N** = ca. 30</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Misaki horse (Japan)</td>
<td>1967</td>
<td>ca. 80</td>
<td>N** = ca. 10</td>
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<tr>
<td></td>
<td>10</td>
<td>Tokara horse (Japan)</td>
<td>1967</td>
<td>27</td>
<td>N* = 3.6</td>
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<td></td>
<td>11</td>
<td>Ryukyu native horse on Yonaguni Island (Japan)</td>
<td>1967</td>
<td>78</td>
<td>N* = &lt;20</td>
</tr>
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<td></td>
<td>12</td>
<td>Tsushima native horse (Japan)</td>
<td>1962</td>
<td>1,800</td>
<td>N* = ca. 4</td>
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<td></td>
<td>13</td>
<td>Cheju horse (Korea)</td>
<td>1967</td>
<td>20</td>
<td>N* = 400~600</td>
</tr>
<tr>
<td>Swine</td>
<td>13</td>
<td>South China type (Taiwan)</td>
<td>1966</td>
<td>ca. 140,000</td>
<td>N* = ca. 1.800</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>“Short ear” breed (Taiwan)</td>
<td>1966~1967</td>
<td>Small number</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>15</td>
<td>Southwestern Islands and eastern Taiwan (Iso Park, Kagoshima city, stock) (Japan)</td>
<td>1960~1965</td>
<td>ca. 70,000</td>
<td>N* = 19.2</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Korea</td>
<td>1965</td>
<td>ca. 180,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Western Taiwan</td>
<td>1965</td>
<td>ca. 150,000</td>
<td></td>
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</table>
them were about 180,000 in Korea and about 150,000 in western Taiwan at the end of 1965. These goats have the same morphological and physiological characteristics as the native goats in the Southwestern Islands and eastern Taiwan, except that they are monotonously black in coat color. The goat populations of those countries have also been hybridized by the Saanen breed; consequently, the pure stock are being extinguished. In 1967, the Research Group found several regions in Kyungsang–Nam Prefecture, Korea, and in Nantou and Yunlin Prefectures, Taiwan, where populations of this type of native goats had been maintained with a comparatively high grade of purity.

The results of estimation of the population size of native livestock maintained in Japan and its adjacent localities described so far are summarized in Table 1.

Discussion

Of the native livestock described in the present article, the following three stocks may be those in which a sufficient number of individuals have been maintained: Korean native cattle, Cheju horses in Korea, and South–China type native swine in Taiwan. In order to protect the population from inbreeding depression and to suppress the character fluctuation, it is desirable for the population size to be as large as possible. It is a breeding plan for these purposes that the population is maintained by splitting it into a number of subpopulations. This plan may be workable for the three native stocks mentioned above, provided that it is given enough financial support by governmental or private organizations.

For any other native livestock, it is an urgent problem of importance to protect the stock from extinction. There are two processes of extinction for native livestock. One is the extinction through contraction of the population size without hybridization. This process is observed in Mishima cattle and Tokara horses. The other is the reduction of stock purity through hybridization with an improved breed. This is shown in Taiwan yellow cattle, Kiso horses, Tsushima native horses, the "short–ear" breed of swine in Taiwan, and the native goats. In the latter process, there is a possibility that a "pocket" of hybridization may remain in which stock purity is maintained on account of difficulty in communication in that region or by chance, if the range of distribution be sufficiently wide.

In most of the native livestock now present in eastern Asia, the maintenance of the population depends solely on the expense of general farmers. This would be the most regrettable situation. Under such circumstances, a periodical census and survey on population characteristics should be made as minimum requirement for protection of livestock from extinction in the case that any financial aid is not provided. In this way, it is possible to grasp the current status of that native stock and maintain and promote the owner's interest. When a risk of extinction is felt for all such efforts, the whole population of the native stock should be transferred to the management of some public organization as scientific material. Mishima cattle, Tokara horses, and the native goats are undoubtedly considered to be in such condition.

Summary

The population size of native livestock—cattle, horses, swine, and goats—maintained in Japan and its adjacent localities at present was estimated. In almost every case, estimation was also made on the effective population size in the sense of Wright. The results are summarized in Table 1. Of the stocks studied, the Korean native cattle, Cheju horses in Korea, and South–China type native swine in Taiwan were regarded to have a sufficient number of breeding individuals to warrant the existence as purely native breeds. As for any other native stock, it was considered to be an urgent problem of importance to protect the stock from extinction. It is the most regrettable thing for the maintenance of native livestock as breeding and scientific material in those areas that the business of maintenance depends almost solely on the expense of general farmers, and that the financial support from public organizations is extremely small in amount at the time when the native stock
is reduced in agricultural and economic usefulness.

Acknowledgements

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Literature Cited


日本とその周辺地域における在来諸家畜の集団の大きさ

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現在、本邦とその周辺地域に保存されている在来諸家畜（牛、馬、豚および羊）の集団の大きさに関する調査結果を総括した。大部分の場合は、Wright の意味の有効な大きさの推定も併せてなされた（Table 1）。これらの場合、純種種として充分の個体数が現存し、絶滅の危険が感じられないのは韓国在来牛、済州島馬および台湾における南支型在来豚の 3 種に過ぎず、他は集団サイズの縮小によってか、または種類による過疎状態によってstock消滅の途を歩んでいるとみなされる。

この地域における在来家畜のstockを育種種材、または学術的研究材料として保存しようとする場合、最も重大な問題点は、経済的動物としての需要が減少した場合においても、それらの保存が一般農家の負担にほとんど完全に依存しており、国の他の公共機関からの財政的補助が極めて少ないことにあると考えられる。