THE RELATIONSHIP BETWEEN INDIGENOUS ANIMALS AND HUMANS IN APEC REGION

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THE RELATIONSHIP BETWEEN INDIGENOUS ANIMALS AND HUMANS IN APEC REGION

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Preface

The APEC-ATC Sub-Group on Conservation and Utilization of Plant and Animal Genetic Resources has held four Workshops since its initiation in 1995. The second workshop, namely *Workshop on Conservation and Utilization of Farm Animal and Aquatic Genetic Resources*, was held in November 1998 in Tainan, Chinese Taipei emphasizing more on animal genetic resources. The objectives of the Workshop were to discuss the cultural, social and economic value and importance of animal genetic resources; to exchange the expertise on conservation and utilization measures and technologies among member economies; to share information on genetic resources collections; and to formulate future collaboration plans. In addition to status reports from member economies, several prominent experts were invited to deliver lectures related to the workshop themes.

Following by one of the workshop recommendations submitted to the ATC Working Group, an APEC booklet focusing on the relationship between indigenous animals and human with local agricultural implications was scheduled and entrusted later to the Chinese Society of Animal Science by Council of Agriculture, Chinese Taipei. The objectives of the Society are to promote research and education in bringing together scientists and educators in farm animal agriculture, facilitating the dissemination of scientific and technical information through publications and scientific meetings, and conducting a scientific liaison and outreach program in support of farm animal agriculture. Therefore, we hope that this publication will assist not only in sharing expertise and experience with friends, but also promoting international cooperation among economies of the Asia-Pacific region.

I would like to express my sincere gratitude to the researcher involved in this project, and particularly to Drs. Hsiu-Luan Chang and Yu-Chia Huang, Researchers of Livestock Research Institute, Dr. Yung-Yi Sung, Emeritus Professor of Animal Science Department, National Taiwan University, and Dr. Su-San Chang, Chief of International Organization Division, International Cooperation Department, COA, for the time and effort they have spent in making this booklet possible. I also extend my gratitude to the generous grant from Council of Agriculture, Chinese Taipei, for this publication.

Cheng-Taung Wang, Ph. D.
President
The Chinese Society of Animal Science

Letter from Editors

Animal genetic resources have been contributing to both food and agriculture for more than 12,000 years, providing meat, milk products, eggs, fibre, fertilizer for crops, manure for fuel and draught power. It is estimated that, directly and indirectly, domestic animals supply about 30 percent of total human requirements for food and agriculture. However, the value of animals for the human beings went far beyond its mere economic role. The human have gained into the temperament of these animals including an inspiration in culture and the arts expressed among literature, religious customs, legends, and the oral and written language. Therefore, the animals have been the source of a multitude of creative inspirations for the human – literature, mythology, legends, maxims – they all contain clear reflection of the animal.

The purpose of this booklet is to communicate the relationship between local livestock and human, especially to recognize the role domestic animals play in agriculture vs. non-agriculture and/or socioeconomic vs. cultural function, e.g. the value of livestock to households in member economies of APEC region. However, this requires fully support from all member economies because the value and importance of the animals will vary between different types of system. In the non-commercial systems the animals, having a value within the family economy, also have a socio-cultural significance, which are difficult to evaluate in economic terms. It is also clearly the animals kept in certain conditions or households in developing member economies were used for multiple purposes and their importance to the families was immense.

Buffalo, cattle, chicken, pig and quail species from economies are reported in this booklet, an effort of international communication. The editors wish to express our grateful appreciation to the authors for their contributions. In addition, some of scientists helped to contact with authors, and review, edit and critique all the material presented in the booklet. Their contributions are gratefully appreciated. Particular thanks are due to Su-San Chang, Wu-Li Chang, Der-Cheng Chou, Tin-Chin Chou, Yung-Yu Lai, Yung-Yi Sung, Tracy Tung and Ming-Che Wu. The administrative and financial assistance of Breeding and Genetics Division, Livestock Research Institute, Council of Agriculture, towards the printing of color plates is also gratefully acknowledged.

Hsiu-Luan Chang, Ph. D.
Yu-Chia Huang, Ph. D.
October 2003

Buffalo

水牛

ASIA-PACIFIC ECONOMIC COOPERATION

AGRICULTURAL TECHNICAL COOPERATION WORKING GROUP

Thai Swamp Buffalo General Information

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Introduction

Before 1971 the buffalo was a very important domestic animal in Thailand. Statistics from the Thailand agricultural statistical center showed that Thailand had about 5.5 – 6.5 million buffalo during 1971 and 1981. The buffalo population declined to 1.8 million in 1999. Buffalo could be extinct from Thailand in 20 years, if no considerable public attention was received. There are several reasons for the reduction in the number of Thai swamp buffalo:

1. the reduction in the rice producing areas,
2. the replacement of buffalo by farm engines,
3. the castration of good male buffalo,
4. the industry invasion into the Thai rural areas, and *etc.*

From 1953 to 1971 the Thai rural areas were covered with buffalo because most of the rural families had 2 – 4 buffalo each. According the Thailand agricultural statistical center (1971 – 1981), Thailand owned the largest buffalo population and was the buffalo champion in South East Asian countries. Today, one would have to drive a car for a long distance to find one buffalo.

Types of buffalo in Thailand

There are three types of buffalo in the world, the swamp buffalo (Fig. 1), the river buffalo and Mediterranean buffalo. The swamp buffalo is the indigenous buffalo in Thailand. The Department of Animal Science, Kasetsart University, was the first official unit that introduced river buffalo into Thailand during 1957 and 1978. Most of the swamp buffalo in Thailand are completely black in color. Only a few of them are white in color. The white buffalo are not albino but the color is due to uncertain genetic effects. The dark color makes the buffalo's look scary and most ladies are afraid of the buffalo (Fig. 2). The dark color also makes buffalo heat intolerant, which is why it must stay near the swamps (Fig. 3, 4). On average, mature male buffalo weigh 450 – 600 kg in weight. The mature females weigh 350 – 450 kg in average (Fig. 5). Thai buffalo is longevity and prolificacy; female buffalo could have healthy offspring even elder than 20 years old (Fig. 6, 7, 8).

Thai swamp buffalo as a royal worker

The Thai swamp buffalo is called “Ai Tui” in the Thai language which means, “it is an honest royal worker” that is very important for Thai farmer life. The buffalo was considered a royal worker because no comparable animals or machines could do the work as well as the buffalo. Because it has big feet and is good at pulling with slow walking steps, Thai farmers use them to pull rice-digging instruments for preparing the land to grow rice. The buffalo was also used as a transportation animal (horses are rarely used in Thailand up to today). Because of its long terrible looking horn (Fig. 9) that sometimes becomes as long as 3 meters across both horns, the buffalo was also used in war. However, most of today’s buffalo have short horns (Fig. 10).

The Thai swamp buffalo can be used to work up to 14 years old without problems. That is very long royal worker life compared to other animals. On average, the buffalo works 5 hours a day. In one year a buffalo can help to grow 9.7 to 13.4 Rai of rice (1 Rai in Thai is equivalent to 1600 m^2). The buffalo is used 122 days a year. In the past, most Thai farmers grew only one rice crop in a year. Today in the machine era, we can have 3 rice seasons in Thailand each year. After they are 14 years old the “royal worker” are sent to the slaughterhouse. A buffalo carcass will contain 40.8 to 46.4% based on live weight. Buffalo carcass quality is inferior compared to cattle i.e. less in lean cut percentage, less in dressing percentage, highe, the “royal worker” are sent to the slaughterhouse. is may be the reason why farmers today prefer to raise beef cattle.

Buffalo husbandry

Both male and female buffalo were used as draft animals. Thai children perform the buffalo husbandry duties and thus the “royal worker” is also a friend to Thai kids. Because of the deep friendship between the buffalo and kids, the buffalo becomes very healthy and in good condition. The pasture quality in Thailand is poor and barren (Fig. 11) but the buffalo is well adapted to this condition. It is able to eat everything refused by cattle. The weeds in the swamp areas along the roads are a good source of food for buffalo (Fig. 12). The buffalo is not only a “royal worker” but also our weed controller and an ecological maintenance animal (Fig. 13). The buffalo is also a fertilizer maker because it produces an abundance of feces that is fertile for the land. More important than fertilizer, buffalo’s feces is free of the toxic chemical residues found in commercial fertilizers that is harmful to the ecological system.

Unlike river buffalo, Thai swamp buffalo are very low in milk production. Buffalo are never milked for human food (even it was said that buffalo milk is very high in quality with 12% white fat). Buffalo meat in Thailand is a by-product because there is no buffalo meat production in Thailand. For this reason there is a lack of meat production data for the buffalo in Thailand.

Relationship between Thai farmers and buffalo

Thirty to fifty years ago was the “buffalo golden age” in Thailand. During that time 90% of the Thai population were farmers and they all had buffalo. Thai people have deep relationship with the buffalo in the life. Several Thai songs mentioned the relationship between farmers and buffaloes. The buffalo era changed into the meat cattle era. This change occurred very fast and made the buffalo an endangered animal. Now, Thai custom compares a stupid person to a buffalo. Because they think the buffalo are stupid animals instead of an honest and royal animal. If it is said in Thai “You are a stupid buffalo” most Thais will become angry.

Most Thai farmers today that still have buffalo are not rich (Fig. 14). Their home conditions are shown in Fig. 15. Big farms belong to companies and raise beef cattle instead of buffalo (Fig. 16). Thai farmers still keep their “royal animals” next to their homes. In the first Thai song that included at the end of this paper ”the buffalo sleeps near the farmer during the night”. The major food for Thais’ “royal animal” is rice straw (Fig. 17). This is the by-product produced by the buffalo itself. Of the buffalo produces the rice that is Thais’ food (the rice grain) and eats the part that the human are unable to eat (the rice straw). Do we abuse or take advantage of the “royal animal”?

Thai swamp buffalo and the Thai cultures

Because 30-50 years ago there were a lot of buffalo in Thailand, the buffalo related deeply to Thais' life and became part of the Thai culture. There were several Thai songs that talk about buffaloes and showed as examples in Tables 1 and 2.

Table 1. Smell of mud and buffalo song (composed by Mr. Paiboon Butrakhan)

กลิ่นโคลน-สาบควาย
ไพบูลย์ บุตรขัน

อย่าดูหมิ่นชาวนาเหมือนดังตาสี เอาพื้นนาเป็นที่พำนักพักพิงร่างกาย
ชีวิตเอยไม่เคยสบาย ฝ่าเปลวแดดแผดร้อนแทบตาย ไล่ควายไถนาป่าดอน
เหงื่อรินหยดหลังลงลดแผ่นดินไทย จนผิวดำเกรียมไหม้แดดเผามิได้อุทธรณ์
เพิงพักกายมีควายเคียงนอนสาบควายกลิ่นโคลนเคล้าโชยอ่อน ยามนอนหลับแล้วใฝ่ฝัน
กลิ่นโคลนสาบควายเคล้ากายหนุ่มสาวแห่งชาวบ้านนา ไม่ลอยเลิศฟ้าเหมือนชาวสวรรค์
หอมกลิ่นน้ำปรุงฟุ้งอยู่ทุกวัน กลิ่นกระแจะจันทร์ หอมเอยทุกวันนั้นต่างชาวนา
อย่าดูถูกชาวนาเห็นว่าอับเฉา มือถือเคียว ขันเข่า เกี่ยวข้าวเลี้ยงเราผ่านมา
ชีวิตคนนั้นมีราคา ต่างกันแต่ชีวิตชาวนา บูชากลิ่นโคลนสาบควาย

We should not look down on our Thai farmers. Their life was hinged on rice growing in rural areas. Thai life was tough and the farmers worked under the strong sunshine. Their skin was burned and became dark in color. However, they never complained about that. Near their homes the buffalo slept and a muddy smell always reached their noses. However, they slept in a good dream. The young male and female farmers were also covered with the muddy smell from the buffalo. Conversely, the Bankokian who lived like in heaven always had the smell of good perfume. That is a big difference from the Thai farmers. Please don't look down on the Thai farmers. Their hands are always busy with a tool to cut the rice grain to feed us. Life is always a valuable thing, because the farmer worships on the muddy buffalo smell.

Table 2. Bringing buffalo to their place song (all right reserved by Kasetsart University, Thailand)

ต้อนกระบือ มหาวิทยาลัยเกษตรศาสตร์ ชาวใดใจกล้า เหมือนชาวนางานเก่ง ยากไม่เกรง หนักหามทน ถึงเราจนเราชาวนาไม่กลัว หาเลี้ยงตัวเลี้ยงครอบครัวเอย (หากินกันกลางด้าวดิน หากินกันมาแต่งาย ฮี่ยๆๆ ค่ำแล้วควาย กลับคอกที เร็วเถิดซิเฮ้ยอย่าเชือน เร็วเถิดซิเฮ้ยอย่าช้า กลับถิ่นหาแหล่งควายเอย ๆ ทำงานวันยังค่ำ ไถทำไปจนหง่อม ทรัพย์ได้ออม หว่านไถเป็น ถึงลำเค็ญ เราชาวนาไม่กลัว หาเลี้ยงตัวเลี้ยงครอบครัวเอย) ซ้ำ
No one is as brave as the farmer. They are never afraid of hard work. They are very durable and patient with their hard work. Although they are not rich they are never afraid of that. They always earn money for their family. They start to work on the ground before sunrise and stop their work after sunset. After sunset they shout "Huei Huei Huei Huei", the magic words to bring their buffalo home. They want the buffalo to move fast but the buffalo keep moving slowly and clumsily. They repeat the same job everyday since they were young until they become very old. They deposit their income on their land. They are able to grow rice by keeping on practicing. Their life is tough but they are never afraid of that. They always have to earn money for their family.

The story about the Bangkokian (a Thais who lived in Bangkok), afraid of the buffalo when they visit a rural area, is repeated in Thai movies. The Bangkokian always wears colorful cloth. When they meet the buffalo face to face, the Thai words "berng" is used to describe this situation. It means that the buffalo and human are looking face-to-face and eyes-to-eyes (Fig. 18). Most of the time the Bangkokian will be frightened because they are always thinking that the buffalo will become angry with them. So they run away. Actually, no one knows what the buffalo really thinks. The buffalo is colorblind. So, there is difference in color of the clothes that the farmer wears or the clothes that the Bankokian wear for the buffalo. Perhaps, the reason the buffalo keeps on looking at the Bangkokian is their strange behavior. Who knows? This phenomenon might also occur in other countries. However, it occurred so often in Thailand that it became part of Thai culture.

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Fig. 1. Typical short horn buffalo

Fig. 2. Long horn and dark color buffalo

Fig. 3. Cows near swamp but buffalo in the swamp

Fig. 4. Buffalo loves playing in swamp

Fig. 5. How heavy are they?

Fig. 6. A 21-year-old long horn buffalo with healthy buffalo kid

Fig. 7. Back view of old long horn female buffalo and buffalo kid

Fig. 8. A Thai buffalo kid

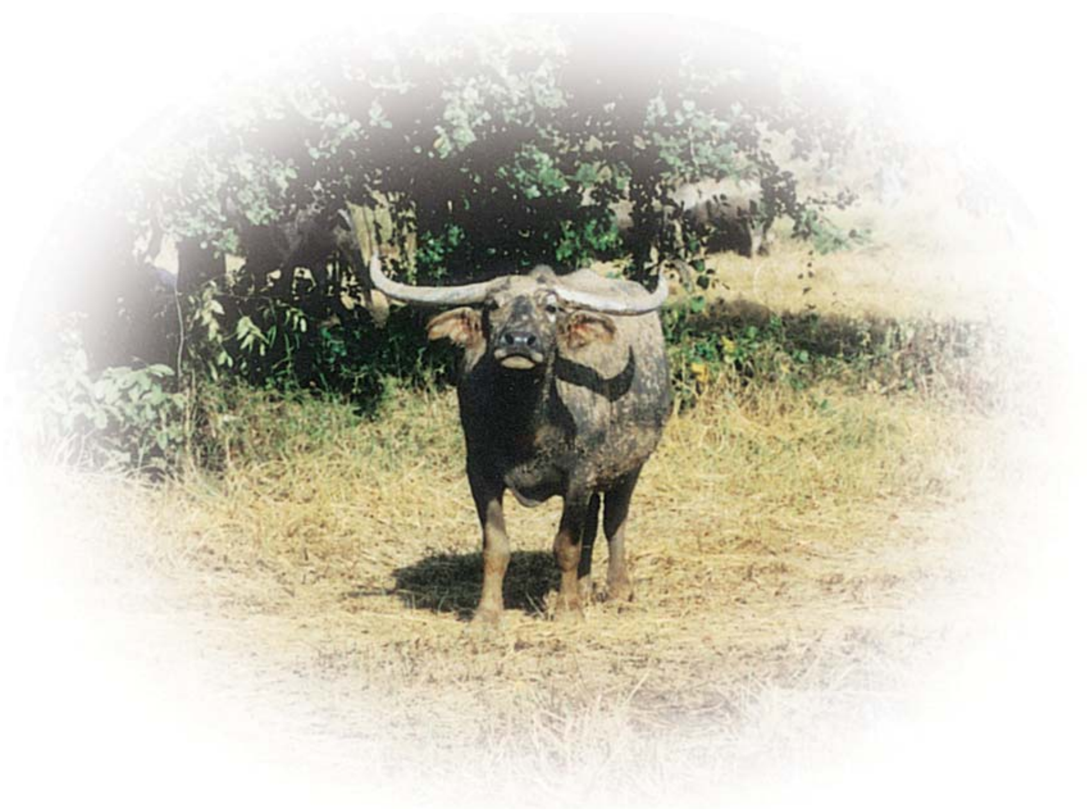

Fig. 9. Thai long horn buffalo

Fig. 10. Short horn buffalo resting under tree

Fig. 11. The buffalo is adapted to low quality pasture as well

Fig. 12. Buffalo along the road near Srakaew province

Fig. 13. A natural weed mower, buffalo, in mango garden

Fig. 14. Healthy and smiley buffalo owner

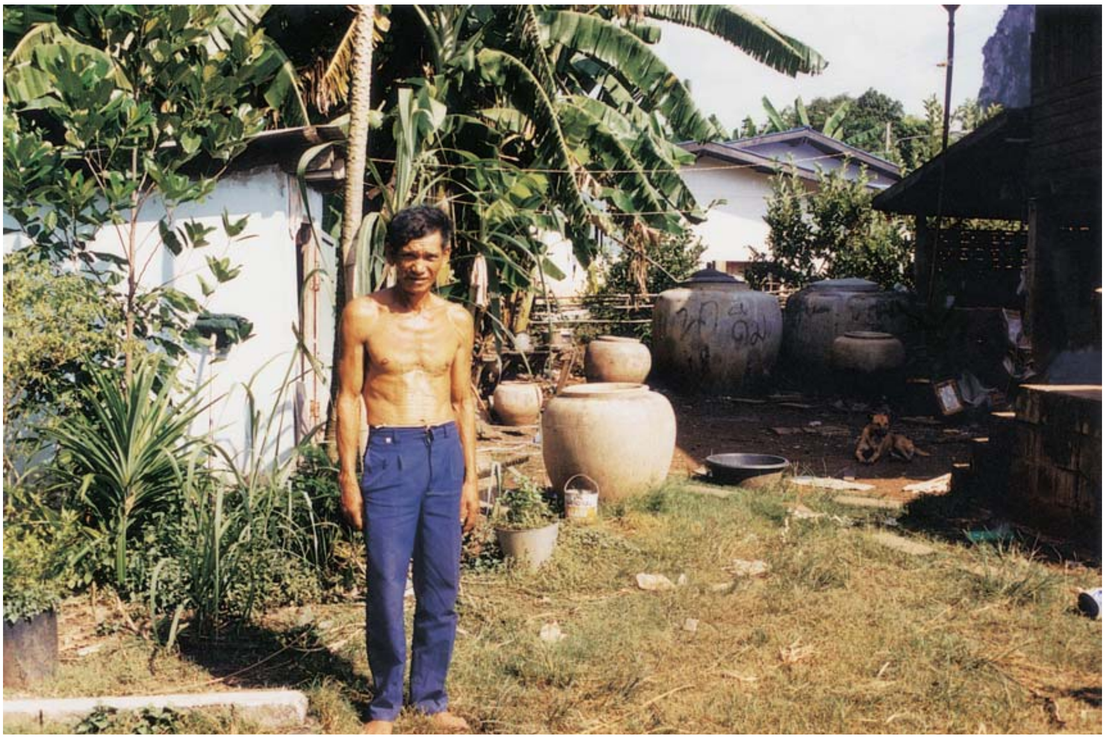

Fig. 15. Buffalo owner’s home

Fig. 16. Large-scale beef cattle farm in the central Thailand

Fig. 17. Rice straw heap, low is nutrients but the buffalo can thrive on it

Fig. 18. Look out. Is the buffalo going to attack a colorful dressed person?

Cattle

牛

ASIA-PACIFIC ECONOMIC COOPERATION

AGRICULTURAL TECHNICAL COOPERATION WORKING GROUP

Indigenous Bali Cattle: The Best Suited Cattle Breed for Sustainable Small Farms in Indonesia

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Introduction

Indonesia has a total population of around 206 million with 4.5 million households keeping livestock. About half of the cattle farmers are small farmers. The Indonesian archipelago is a land area of 1.8 million km^2 consisting of over 13,000 islands stretching from the Western tip of Sumatra to the Eastern border of Papua. The largest island, Kalimantan (Borneo), covers 28% of the total land area. Java, with only 6 – 7% of the total land area, is inhabited by around 60% of the total population and is the most densely populated island. The agro-ecological zones vary from the humid coastal wetland swamps in Sumatra, Java, South Sulawesi and Bali, to the sub-humid and semiarid dry land in the eastern part of Java, Sulawesi and most of the Nusa Tenggara islands. There is a wetter to a drier climate from the west to the east. Approximately 60% of the archipelago has about 7 – 9 consecutive months of rain in the wet season and less than two months with no rain in the dry season. The eastern islands have the lowest rainfall with the dry season varying from 3 to 8 months. The average temperature stays within a constant range differing in only a few degrees centigrade between the hot and cool months. The farming systems are regulated more by rainfall than temperature. The plantations and food crop areas are located primarily in the western wetter regions. Extensive marginal grasslands are in the drier eastern islands. Rain forest areas are found in Sumatera, Kalimantan and Papua, with limited areas on Java, Madura, Bali and Sulawesi. An alarming deforestation process is still occurring caused the illegal logging activities.

The soil fertility varies greatly, strongly affected by the climate and active volcanoes found in many of the large and small islands. The heavy rainfall causes soil erosion and high temperatures resulting in chemical weathering.

The eastern islands generally have very poor soils that prevent intensive farming. The animal production systems involve both ruminants and non-ruminants. Crops and animals are integrated with the benefits associated with the complementary interactions between these products. The economic benefits of these integrated systems contribute to their sustainability (Devendra, 1993).

Animal production systems

Only three major cattle production systems will be described (Devendra *et al.*, 1997).

1. The extensive grazing systems

   These are primarily low-input-low-output systems with less opportunity for improvement through the application of new technologies:

   - Native grassland grazing
   - Upland forest and forest margin grazing

2. Arable crop land and pasture combination systems

   The interactions between crops and animals are important in these systems, and the opportunities for interventions are significant:

   - Roadside and communal grazing combined with stubble grazing
   - Animals tethered or allowed free access
   - Grasses, crop residues and agro-industrial by-products stall-feeding

3. Systems integrated with perennial tree crops

   - Grazing under coconut, rubber, oil palm and fruit trees

In the first major system, the farmers are primarily small landholders with occasional tribal herds of a few hundred head owned by a tribal-head. In the second system, nearly all participants are small landholders. In the third system, the oldest traditional system, traditional small coconut plantation grazing is practiced. The third system is a relatively new effort, still being tried, to integrate large commercial plantations (rubber, oil-palm and fruit trees) with small landholder animal production (small and large ruminants).

Feed resources

In the Eastern islands, Nusa Tenggara Barat (NTB) and Nusa Tenggara Timur (NTT), large areas of native grasslands occur, and are grazed continuously throughout the year by buffalo, cattle and goats. These grazing areas are communal and no one is held responsible for the land maintenance. Most of these areas currently have fast growing weed infestation problems, namely *Chromolaena odorata*. Latest unofficial observations stated that about 80% of the edible native vegetation in the grazing lands in the NTT are covered by weeds, creating serious feed resource problems for the cattle and other ruminants.

The overall availability of feed for the ruminants is probably adequate, however the problem is unequal distribution. Sumatera is over-supplied, while deficiencies can be found in Java, Madura, the eastern Islands and Papua. Trials on forage integration with perennial tree crops such as the oil palm, rubber and fruit trees are in progress.

Most cattle feed on the native forages on wastelands, roadsides, unplanted land and crop-stubble. Cattle are stall-fed year-round in systems that are more intensive. In extensive systems, cattle are herded or let out to graze in the natural common grazing areas during the day and corralled at night.

The Bali cattle breed

The Bali breed is one of the four existing indigenous cattle breeds (Aceh, Pesisir, Madura and Bali) in Indonesia. The Sumban-Ongole and Javan-Ongole may also be considered local breeds. Although no official historical records exists, it is generally accepted that the Bali cattle is the domesticated direct descendant of the wild Banteng still surviving as an endangered species in three National Wild Reservation Parks (Ujung Kulon, Baluran and Blambangan) in Java.

Taxonomy of the Banteng / Bali cattle

Many taxonomical names have been given to the Banteng/Bali cattle. Some of these names are, *Bos sondaicus, Bos sundaicus, Bos javanicus, Bos bantinger, Bos banten, Bos bantinger, Bibos banteng and Bibos sondaicus* (Merkens, 1926). The last two names using Bibos are based on the opinion that the

Banteng belongs to a separate species (Bibos) from the other cattle groups (Bos). The Banteng are more closely related to the Gaur and Gayal. The earliest documented report on the Banteng was by Schlegel and Muller in 1836 (Merkens, 1926). They stated that the Banteng was found wild in small herds with a single bull and several cows and calves in the forests of Java and Kalimantan (Borneo). The Banteng is a large animal according to this report. The bulls have a withers height of 1.76 meters. The t'Hoen has a smaller wither height of 1.4 to 1.5 meters, and a chest girth of 2.0 to 2.1 meters. There is no recent report on the measurements of Bantengs still surviving in the Wild Reservation areas. This is because of the difficulty in catching these animals in the wild. The few samples in the Zoos in Java have no authentic records of their origin and dates of capture, casting doubt on whether they were actually wild Bantengs or just domesticated Bali cattle. The distinguishing difference between the Banteng and Bali cattle is the size and some behavioral traits.

The more recent taxonomical names adopted by the IUCN/SSC Asian Wild Cattle Specialist Group (Byers *et al.*, 1995), naming three subspecies of wild Banteng are the Burma banteng *(Bos javanicus birmanicus),* the Javan banteng *(Bos javanicus javanicus),* and the Kalimantan (Borneo) banteng *(Bos javanicus lowii).* How many subspecies should be recognized and included in captive breeding programs remains an unresolved problem. There is a need to further assess the genetic and phenotypic variations within the global population of wild Banteng utilizing new DNA technologies to determine the validity of the above three traditionally recognized subspecies.

Additionally, there are unresolved questions about the purity of the genetic status of the captive population. Many founder animals for the captive populations were Bali cattle, which is the domesticated form of the wild Banteng. Because Banteng can interbreed with common cattle, there exists the possibility that zoo populations may contain genetic material from Bali cattle X *Bos taurus* crosses. Domestic and feral Bali and other breeds of cattle are also a threat to the genetic integrity of wild Banteng populations in the National Wild Reserves in Java.

Conservation

Both the IUCN Red Data List and the U.S. Endangered Species Act classify the Banteng as endangered. This is based on an overall decline of at least 20%

over the last three generations. The Banteng is not currently listed by CITES, although the IUCN/SSC Asian Wild Cattle Specialist Group (Byers *et al.*, 1995) is seeking to have them listed as Appendix I.

There is no immediate concern for the Bali cattle considering the current total population estimate of 2.3 million head. There is some concern about the purity because of intensive crossbreeding programs using natural mating and AI using exotic breeds that may cause extinction because of indiscriminate crossing.

Current population estimates and distribution

The Banteng

No subpopulations of more than 500 Banteng are known and only six to eight subpopulations of more than 50 Banteng are known to remain (five or six on Java). The population trend on Borneo is unknown. The Banteng populations on Java are relatively stable, although there are threats due to illegal hunting, habitat destruction and diseases from domestic livestock.

The Bali cattle

The current population estimates (of 2000) for the Bali cattle in the five major resource areas are as follows (Talib *et al.*, 2002):

Resource area	Estimate of population size (in 2000), head
Bali	529,000
NTB	377,000
NTT	443,000
South Sulawesi	718,000
Lampung	255,000 (recently added resource)

There are other provinces with fast growing population numbers managed by small landholders. One of the most promising provinces is Southeast Sulawesi with a recent population of 300,000 head. These herds were started using small numbers of imported Bali cattle in 1923 and larger numbers during the five-year plans. Propagation was conducted through governmental owned cattle distribution to participating farmers and redistribution of the offspring to a growing number of participating farmers. This is another example of the superior quality of Bali cattle as a pioneer breed for the farming system in many new cattle production areas (transmigration projects).

There is however some concern for the negative population growth trend of 12.3% on average in due to extraction during the monetary crisis years. Measures to halt this negative trend have been taken by local governments. The total populations of the major local breeds are as follows:

Breed	Population size, head
Ongole	1,033,000
Bali	2,632,000
Madura	1,131,000
others	4,980,000 (including exotic and crossbreds)

The Bali cattle have the largest number, showing it as the local cattle breed most suitable for small landholder cattle farming.

Characteristics

The Banteng is considered one of the most beautiful of all wild cattle species. They are most likely the ancestors of the domestic cattle of Southeast Asia. The Banteng are a sexually dimorphic species, with mature males being dark bluish black and cows and juveniles reddish brown. Both sexes have white rump patches and stockings. Both sexes carry horns, although they are much heavier and larger in the males. The Banteng are smaller and have a more even temperament than the gaur. There is a well-defined narrow dark stripe along the backbone, only seen in the calves and females. In bulls, the red hair on the body begins to darken at 12 – 18 months of age and by maturity, the animal becomes almost black. In castrated bulls, the black hair on the body changes to red again within a few months of castration. The body is relatively large-framed and well muscled. Adult males weigh between 600 – 800 kg, whiles adult females weigh between 500 – 650 kg. Their average lifespan in the wild is 11 years, although they can live to 20 – 25 years of age. It is very common for captive Banteng to live into their late teens or mid-twenties (Byers *et al*., 1995). These are humpless cattle.

Productivity traits of the Bali cattle

The Bali cattle are similar to the Banteng, differing only in size and temperament. Domestication has brought about smaller, easier to handle and docile animals. The average production traits of the Bali cattle females under the extensive farming system showed in Table 1 (Talib *et al.*, 2002)

Table 1. Production traits of the Bali cattle females

Trait	Bali	NTT	NTB	South Sulawesi
Birth weight, kg	16.8	11.9	12.7	12.3
Weaning weight, kg	82.9	79.2	83.9	64.4
Yearling weight, kg	127.5	100.3	129.7	99.2
Weight at puberty, kg	170.4	179.8	182.6	225.2
Mature cows weight, kg	303.3	221.5	241.9	211.0

Average mature bull weights for NTB, NTT and South Sulawesi range 335 – 363 kg and the corresponding weight for the Bali is 395 kg (Talib *et al.*, 2002). Table 2 shows the reproductive performance and milk production of the Bali cattle (Talib *et al.*, 2002).

Table 2. Reproductive performance and milk production of the Bali cattle

Trait	Bali	NTT	NTB	South Sulawesi
Age at puberty, yr.	2.0	2.5	2.0	2.5
Calving age, month	32	41	36	36
Calving interval, month	14	15.4	16	15.7
Calving rate, %	66.3	66.6	51.7	60.4
Calf mortality, %	8.5	48	15	8
Milk prod., kg/6 month	274.5	165	--	164

Those average figures for the cows are considered low compared to figures from the *Bos taurus* cattle in the intensive production systems in temperate zones. However, these figures are the highest among the indigenous cattle breeds in Indonesia, especially the calving rates. The figures in tables 1 and 2 were cited from the latest article presented in an ACIAR-CRIAS organized Bali Cattle Workshop held in 2002 (ACIAR-CRIAS, 2002). The data was based on field observations and measurements in four areas from a limited number of animals. The measurements are likely influenced by the differences in environmental and management systems, thus making comparisons between these performances may not valid.

The Unique pioneering traits

A harsher environment induces smaller/lower performance in several traits such as lower calf birth weight, low milk production, lower calf growth rate and earlier calf age at foraging as well as cattle health resilience. A herd will also show lower birth rate (calving percentage/crop) and higher calf mortality under stressful climatic conditions. The smaller average growth rate and weight at different ages are also a herd survival adaptation. If necessary, a herd could revert to its wild ancestor feral/wild animal traits to survive in the wild without any human intervention. The proof of this can be seen in the feral Bali cattle populations in several small-uninhabited islands in Indonesia. The most extreme example of feral Bali cattle is the thriving population on the Coburg peninsula in Northern Australia.

The Bali cattle are a species that has the ability to show different phenotypes under different circumstances, also known as phenotypic plasticity. This ability may not be beneficial for intensive management systems. However, it is favorable for the small landholder system.

Genetic improvement (Breeding programs)

Pure breeding, cross breeding and selection programs was applied utilizing local and exotic breeds in Indonesia. The following is a concise report on the efforts started in the early 19th century (Merkens, 1926; Fordyce *et al.*, 2002; Martojo, 2002).

Ongole and Hissar breeds

Local breeds (Aceh, Pesisir, Madura, Bali, Javan-Ongole and Sumban-Ongole) were improved using Ongole bull from India. This was recorded in the 19th century using Ongole bulls and small sized local Javan-breeds (now considered extinct) in East Java. Ongole bull imports by several private plantation companies to produce larger draught cattle continued in small numbers. This was terminated at the end of the century due to rinderpest disease outbreaks in India. Massive Ongole cattle importation from India continued until 1920 on

Sumba island. In 1923, the number amounted to about 1,500 head. Sumba has been a source of breeding stock for other regions since then. The Hisar breed was also imported and used in Sumatra and Northern Sulawesi.

Madura breed

Starting early in the 20th century the Madura breed was maintained pure in Madura by closing the Madura from other breeds. Trials were started to propagate Madura cattle in Java and Flores Island. However, these cattle did not thrive and a gradual change was made to the Bali breed.

The Bali breed

In 1926 the Bali breed numbered 275,000 head in Bali and 125,000 in the Lombok islands. The Bali breed was then distributed to Timor, South Sulawesi and other regions in the eastern islands. After a century of effort, the highest population among the other breeds (local and exotic) totaled 9.8 million head of cattle consisting of 2.6 million head of the Bali breed. This has proven the superiority of the Bali breed for most agro-ecological zones in Indonesia. Most of theses cattle are in the hands of small farmers. The Bali breed is the best for small landholders.

Exotic breeds

Beginning with the second five-year plan in the 1970's, frozen semen from exotic cattle breeds was imported. Many crossbreeding programs using exotic bulls (*Bos taurus, Bos Indicus* and *Bos indicus* derivatives) or frozen semen (artificial breeding) in these regions were failed to yield desirable results. Success occurred only where zebu or zebu derivative crossbreeding was utilized. It is likely that such programs will never succeed in the harsh zones unless adequate fodder availability is assured and the farmers can afford the feed and concentrates required by the crossbred cattle. Most of the eastern island regions have plenty of grazing lands, but such lands are communal and not properly managed. Grazing on these lands is uncontrolled, leading to poor land productivity. Fodder cultivation is not in practice in these regions. The local Bali cattle survive primarily on fodder trees; grasses cut from forests, or graze in nearby forests. Fodder cultivation is not a priority for the small, marginal farmers that are the majority in the eastern regions.

Breeding programs for the small landholder farming system

The unique conditions in the small landholder cattle farming system has drawn special attention because efforts to improve productivity by introducing new technologies developed in the developed world ended in failure. New breeding approaches (Martojo, 2002; Talib *et al*., 2002), nutrition (Bamualim and Wirdahayati, 2002) and management programs (Fordyce *et al*., 2002) were suggested in the ACIAR worshop.

The most current recommendation was the “Contribution to sustainable livelihood and development; Realising Sustainable Breeding Programs in Livestock Production” (INRA and CIRAD, 2002). This recommendation is based on the presence of three production levels: Level 1 – Subsistence-based Production, Level 2 – Market-based Production and Level 3 – High-input Production. The small landholder system fits in Level 1 and requires a special method for the planning and application of various improvement efforts.

Disease resistance

It is also a known fact that exotic and crossbred cattle are less resistant to parasitic infestation and diseases in comparison to local cattle. Poor transportation, communication, and marketing infrastructure make these regions inaccessible. Extension services are therefore poorly equipped to meet the requirements for the efficient technology transfer needed for most input-intensive improved breeds. Thus, after several five-year trials plans the government of Indonesia should have been able to determine a best breeding policy for the best suited cattle breed for the small landholders system. The Aceh breed for Aceh province, Pesisir for West Sumatra, Javan-Ongole for provinces in Java, Madura for Madura province and most importantly the Bali cattle for the other provinces and the Eastern Islands and Kalimantan were considered (Borneo).

Weaknesses of the Bali cattle

Despite it’s superior qualities as a pioneer breed, this breed has weakness. The Bali breed has a unique susceptibility to the Malignant Catarrhal Fever, which is contracted through sheep as a vector. In provinces with a high sheep population, such as West Java, the Bali cattle cannot survive. Another disease unique to the Bali cattle is the Jembrana disease. This disease also has a high morbidity rate. No economically effective vaccines have been developed for these diseases. Only Bali cattle originating from Bali island (which may have a higher rate of inbreeding as a result of decades of isolation due to conservation) and non-Bali cattle from the other areas (NTT, NTB and South Sulawesi) have this susceptibility. This major weakness has not influenced the government against using the Bali breed to improve existing populations or start new cattle populations utilizing the Bali breed.

Role of the Bali cattle in small landholder livelihood

Under harsh environmental conditions indigenous animals performed much better than the improved stock. It would not be a sustainable practice to improve the genetic potential of this breed by breeding under artificially improved conditions for higher production. Scientists and decision-makers in the regional and central government have underestimated Bali cattle. Local Bali cattle have been acclimatized over the years in these regions and have been integrated into the rural small landholder economy in marginal areas for various reasons. The important contribution of these cattle has been studied and reported as follows:

- As source of progeny (calves)
- Weight gain
- As a safe deposit (source of cash in emergencies)
- Insurance for crop harvest failures
- Draught animal in tillage work and hauling farm products
- Manure for fertilizer

The first two roles are biological production traits most studied and given the highest attention. However, the second trait may not be important in a harsh environment where survival is most important and faster growing animals may have a reduced chance for survival. In the grassland areas where crop planting is minimal, only the first and third traits are important.

Organic farming system

Environmental issues are becoming increasingly important internationally. The indigenous cattle are an important and integral component of the small landholder cattle production system. This cattle production system is essentially “organic” in nature and the most sustainable system. The farmers also prefer indigenous cattle because they are less demanding and less prone to the problems usually associated with most of the 'improved' and/or crossbred cattle.

Ecological or organic farming is seen as an alternative to chemical intensive agriculture. One of the important points in this direction would be the development of indigenous technologies for ecological and economical farming methods. It has not been argued here that crossbreeding or external genetic interventions are non-sustainable. However, the rural small landholder regions in Indonesia cannot sustain these interventions because the agricultural production method in these regions is essentially low external input in nature. Thus, any external intervention calling for input-intensiveness would cause ecological imbalances that damage the long-term sustainability. Policies re-oriented towards maintaining the indigenous Bali breed and improving their efficiency, not through external genetic intervention, but through within breed genetic improvement are required. Effectively harnessing locally available resources is also an essential requirement.

Conclusions

Based on the facts discussed in this work, the Bali cattle can be considered the most suitable indigenous cattle breed for the low-input, high stress production system still practiced by millions of families in Indonesia.

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Fig. 1. A traditional Bali cattle market near Kupang, the capital of Nusa Tenggara Timur Province

Fig. 2. An adult Bali cattle

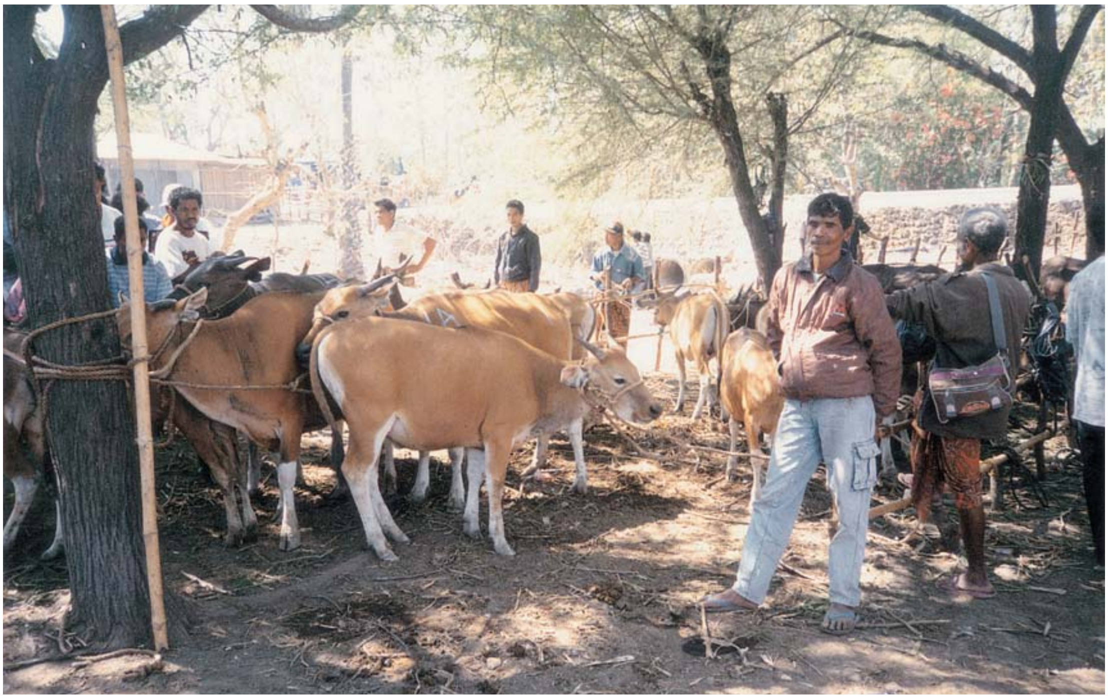

Fig. 3. Bali heifers in the foreground and young bulls are the ones with darker brown coats

Fig. 4. Cattle market and yellow trucks, transportation tools, in Kupang traditional Bali cattle market

Image of Taiwan Cattle

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Introduction

Water buffalo and cattle might look slightly differ in their appearance or in biology classifications, but Taiwanese did not consider any culture difference between them seriously. Cattle and buffalo share the same character, "牛", in Han dictionary. Therefore, in the following paragraph, "cattle" were used as "牛", if not be referred intentionally. Cattle played an important role in the traditional village life in Taiwan society and had a substantial function, economic value, culture and historic meaning. Cattle carts were used by farmers to transport goods, as a vehicle, and the cattle were even sometimes straddled and ridden like a horse. Prior to the emergence of the farming tractor commonly named as "iron cattle", cattle were indispensable laborers in the paddy fields and sugarcane orchards. Cattle, in addition to their intrinsic value were essential players in a family's livelihood. Taiwan's development progressed from south to north, and was cultivated from the west to the east. As the cultivated land increased, the number of cattle increased rapidly from a few thousand to more than 200 thousand. On the Taiwan map made by Ching Dynasty, cattle were drawn with the homes that represented villages to indicate the developed areas. Cattle were therefore used as an index in the developed history of Taiwan and were internalized as a part of Taiwan culture and history. Taiwanese farmers used tilling cattle for three hundred years. Proverbs were written detailing the intimate life relationship and feelings between farmers and their cattle. Taiwanese farmers often referred themselves as cattle, thereby indicating the fundamental character of the farmer. The Taiwan Governor Headquarters looked upon the buffalo as the Taiwan image used in paying tribute to the Japanese Royalty during the Japanese Reign. A stage photograph of a Taiwan entertainment troupe performing in Japan shows the cowboy striding the ox as "coming from Taiwan". The cowboys astride the ox and cattle carts were sighted everywhere in the village forming a particular spectacle in Taiwanese villages. Cattle's place in the village life of Taiwan was an index that could never be overemphasized. Cattle were not used merely for labor in the traditional village. They were livelihood animals closely related to the farmer's life. The Taiwan cattle (Fig. 1) have become a totem for Taiwanese.

Netherlander herding cattle

Netherlanders migrated from the Peng-Hu Archipelago to Taiwan in 1624. The Netherlanders occupied Taiwan as a stronghold for trade in the Eastern Hemisphere. Later on, Taiwan was discovered as a productive and potential virgin land for development. Cultivation was begun in southwest Taiwan. The Netherlanders began with livestock breeding, ushering in numerous cattle and establishing the Department of Cattle Husbandry. Then cattle were pastured to make profits in southern Taiwan (today Kaohsiung and Tainan areas). Picture was painted by a Spaniard in 1626, with two head of cattle bearing testimony to Netherlanders raising cattle in the City of Pu-Luo-Min-Che (today Chih-Kan, Tainan, Fig. 2).

Buffalo

The Taiwanese have a legend for why the buffalo and yellow cattle differed externally. The legend has it that once upon a time a buffalo and a yellow ox were taking a bath in a brook. They suddenly heard the sound of a tiger while bathing. They both hurried ashore to put on their garments to escape. Out of impatience, the yellow ox put on the buffalo's garment and scurried. Because the buffalo's garment was larger, a spare piece of cloth hung around the yellow ox's neck. This is the reason why there is a dewlap around the yellow ox's neck. However, the sluggish buffalo is larger than the yellow ox in stature and could not fit the small garment left by yellow ox. The buffalo put it on, leaving his neck uncovered. The Kuan Yin Buddha saw and took apart her puttee near the hem (customarily called Chiao Pai) to patch the buffalo's uncovered neck. This is why there is white skin surrounding the buffalo's neck. When the tiger moved away, the buffalo came back the brook and waited for the yellow ox to return. The yellow ox did not return so the buffalo shouted, "Change! Change!" ("Huan" is the word "change" in Taiwanese). The yellow ox cried, "No! No!" ("Mun" is the word "No" in Taiwanese). To this day the buffalo is still shouting, "Huan! Huan!" and the yellow ox is still crying back "Mun! Mun!". The buffalo was once the major draft animal used by farmers to cultivate rice and greatly appreciated by Taiwanese before the "iron cattle" (farming tractor) arrived (Fig. 3).

Yellow ox

The yellow ox is strong in body and docile in nature. It is light brown or brown in color (Fig. 4). The male yellow ox is rather stout at the shoulder and rhombic muscle whereas the female has a slender rhombic muscle. The adult male yellow ox weighs about 340 kg. The adult female weighs about 250 kg. The yellow ox can plough non-irrigated fields 20 to 25 acres per 4-hour working period.

Ploughing the field

Four procedures are used in soil preparation; ploughing the field (Fig. 5), rough raking the field, fine raking the field and final mixing. The plough is the first-stage tool for scarifying the soil. Because rice must grow in soft soil saturated with water, the soil must be prepared after cultivation. Ploughing the field involves turning the soil in the lower earth levels and covering the surface soil used in the last season. By doing so, the surface soil used in the last season can recover and the rice straw and green manure are simultaneously merged into the soil to become fertilizer.

Procedure for raking the field

After the field soil is rough raked, fertilizer is sprayed once into the soil. Fine raking is then performed (Fig. 6). The farm implement used for raking the field is a rake shaped like the Chinese word "而". The farmers in Taiwan call this rake the "hand raker". This rake is more than 0.6 meter high, 1.2 meters wide, with 7 – 11 iron teeth. The number of teeth in the rake is increased or decreased according to the size of the farmland. There are two straight posts above the rake. Across these posts is a handle that the farmer holds. The farmer draws this tool with the ox. In doing so, the soil in the field can be raked into smaller fragments. The rake teeth collect weeds while fragmenting the soil. A piece of board is placed horizontally ahead of the rake in some districts. This board allows raking the soil and mixing the field simultaneously, saving the job of final mixing.

Cattle bamboo muzzle

The cattle muzzle used in Taiwan is made of bamboo strips or iron lines (Fig. 7). Muzzling can prevent the cattle from grazing on the crops ahead, ignoring tilling the soil or eating the green crops cultivated by the next-door neighbor. To extend in meaning, people call gluttonous children "cattle with no muzzle" in idioms.

Old picture of a cattle cart

The Cattle Cart has been available in Taiwan for more than 300 years. Taiwanese depended on it no less than the cars used in modern life (Fig. 8). In addition to tilling the soil and towing heavy objects, people "take cattle carts at any moment" for traveling, watching operas and so on.

Board wheel cattle cart

The greatest feature of the cattle cart was the wheels made of boards. This wheel consisted of three pieces of solid board with no distinction between the axle and the spoke (Fig. 9). The board wheel was some 5-6 feet high (the diameter of board wheel is 150-170 cm). A cattle cart with a high wheel makes much noise when the cart is traveling on bumpy roads. Uncomfortable hubbub, sounded like turning a wheel without oil, would keep going as the cart moved.

Iron leather wheel cattle cart

Improvement in the roads, the two-wheeled cattle cart was replaced by a four-wheeled cart with spoke wheels covered with an iron hoop (Fig. 10). The improved four-wheeled cattle cart could "carry more" than two-wheeled carts. However, it was no faster than two-wheeled carts on jolting roads.

Rubber wheeled cattle cart

The rubber wheeled cattle cart appeared post World War II, replacing the iron leather wheel cart (Fig. 11). The rubber wheeled cattle cart is still in use in the Taiwan countryside today.

Cattle cart and children

Not many modern Taiwanese children had the opportunity to ride in cattle carts as their parents had (Fig. 12).

Sugar refining

The stone-grinding wheel was the major equipment for old sugar refining (simple factory of making sugar). The grinding wheel was placed in the center of a house covered with cogon grass (Fig. 13). The grinding wheel was made of two parts, a “male and female stone” over a stone floor. Large-scale sugar refineries used three grinding wheels made of granite. The grinding wheel was operated using a cow drawing the wheel. Because turning grinding wheels required a large amount of strength, several cows turn doing the chore. Sugarcane with the tails removed was placed into the space between the two wheels while the cow turned the top wheel. Sugarcane juice was squeezed out, treated and processed.

The farmer’s cattle market at Shanhua, Tainan

The “farmer’s cattle market” is an open temporary market for the regular buying and selling of cattle. There were more than 80 farmer’s cattle markets during the Japanese reign. Today only the Pei-Kang and Shanhua farmer’s cattle markets exist (Fig. 14). The fixed dates for transactions at the Pei-Kang farmer’s market in Chia-Yi are on the 3^{rd}, 6^{th}, 9^{th} of each month. At the Shanhua farmer’s market in Tainan the transaction dates fall on the 2^{nd}, 5^{th} and 8^{th}. The main purpose of purchasing cattle in early times was for tilling and cultivating farmland. Four steps were involved prior to selecting tilling cattle to determine if a given cow was suitable for tilling and cultivating farmland. The four steps were touching the cow’s teeth, testing the cow’s steps, having the cow pull a cart and having the cow pull a plough.

Touching teeth

Adult cattle normally have 8 front teeth in the lower jaw. A cow with less than 8 teeth is considered too young or unhealthy. The purchaser identifies the cattle’s healthy condition by counting the teeth, observing the color of the teeth and the degree of wear on the teeth to discern the cow’s age (Fig. 15).

Dragging carts

Dragging carts could be a formidable challenge for a cow. Two or three cattle carts are generally joined together in a test of cart pulling. The front wheels of the carts are tied firmly with hemp rope. The cow is then whipped to make it drag the carts without the wheels moving. The buffalo drags the carts painstakingly with its' head nearly touching the ground (Fig. 16). The cattle harness is stuck deeply into the cows flesh. Only cattle with sufficient strength are able to drag carts with locked wheels.

Testing the cow's steps

Specialists observe the step test. Laymen only watch this exciting "hustle and bustle". The ox in the picture is having its steps tested. The owner leads the ox to circle around two or three times at the farmer's market. An experienced cattle dealer or farmer will probably judge whether this ox is docile or hardworking and assiduous. If it is a lazy ox it will "conceal itself behind the plough". If it is untamed, it will pay no attention to the owner's commands. After observing the ox's stride and appearance, the purchaser arrives at a decision regarding buying this ox or not (Fig. 17).

Negotiating a price and make the deal

After the procedures above, the buying and selling negotiation begins (Fig. 18). More often than not, a professional "cattle umpire" will initiate a compromise bargain on the scene. In early times, farmers went to the farmer's market to purchase cattle for tilling fields and hauling carts. Today the purchasers are butchers who buy cattle for meat sales. After the transaction, mark was made on the back of "sold cattle" (Fig. 19). As shown in figure, there seems an innocent look on the buffalo "man as cutting-tool, cattle as beef".

Cattle license during the Japanese occupation era

The farmer had to take his "Cattle license" card, an identification card for cattle, while leading the cattle into the farmer's cattle market in early times. During the Japanese Occupation Era, it was stipulated that each animal must receive a cattle license identification card (Fig. 20, 21). The front side of the card showed the registered owner's name, address and four drawings of the front, back, left and right of the cow or buffalo's conformation. The hair whirl shape of the cattle was stamped to display the characteristics of the cattle. The overleaf side of cattle license showed the names and addresses of the previous cattle owners. The owner of the cattle had to have the cattle license with him at any time for immediate examination during the Japanese Occupation Era.

Taiwan cattle identification card after World War II

Cattle registration remained in effect long after World War II. The new cattle identification card is not different from the cattle license implemented during the Japanese occupation era (Fig. 22). Later on, the "iron cattle" (farming tractor) replaced ordinary farming cattle. Farming cattle gradually became unnecessary. The cattle identification card system was abolished in 1967.

Buffalo bath

The buffalo is heat intolerant by nature. Its temperature rises 2.7 degrees centigrade, pulse increases 131 times and respiration increases 27 times after being exposed to the sun. The buffalo must be coated with mud or sprinkled with water to survive high heat conditions. The effects of being sprinkled with water last for 20 minutes. A mud coating could last for more than 2 hours. The buffalo takes baths to reduce heat exposure while the farmer is herding it during leisure hours (Fig. 23). Fig. 23 shows two buffaloes gossiping while taking a bath.

Black Drongo riding the Buffalo

When cattle are pastured, the Black Drongo (the name of a bird) often saddles the cattle to eat insects and other parasites on the cattle (Fig. 24). Taiwanese liken the "Black Drongo riding on cattle" to a match between "a husband of small build to a wife of giant stature".

Racing cattle

Modern juveniles enjoy motorcycle drag racing. In past times "village cowboys" "raced cattle" for pleasure. "Driving the buffalo" was considered a matter of great fun! In the Ching Dynasty, riding male yellow cattle (stout yellow cattle) came into vogue. The back of the yellow ox is equipped with an ox saddle. One "could ride hundreds of miles (1 Chinese mile ≈ 0.6 km) a day" on the saddled back of yellow cattle, which was equivalent to 20 – 30 Chinese miles per hour. When riding cattle, one hand controls the halter and the other hand brandishes a whip or something to coach the animal on. The children driving the buffalo in Fig. 25 is an example.

Fig. 1. Taiwan cattle (photo at the Tong Hai University neighborhood in 1991)

Fig. 2. Netherlander herding cattle (from the cover of *Early History of Taiwan* by Yung Ho Tsao, Lenking Publishing Corporation)

Fig. 3. Buffalo (photo at Men-Li village, Niao-Sung Town, Kaohsiung in 1990)

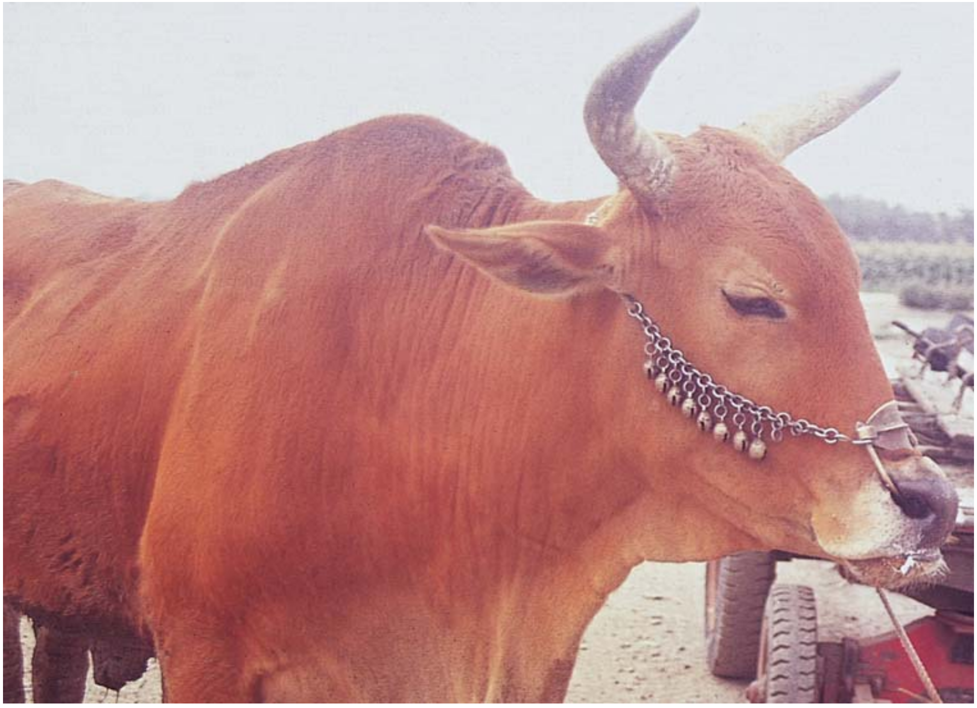


Fig. 4. Yellow ox (photo at Yuan Chang Town, Yun Lin County in 1999)

Fig. 5. Ploughing the field (photo at Tung Hai University neighborhood in 1999)

Fig. 6. Raking the field (photo at Kao Tan village, Jen Wu Town, Kaohsiung in 1990)

Fig. 7. Cattle bamboo muzzle (photo at Tung Hai University neighborhood in 1991)

Fig. 8. Cattle cart board wheel on an old painting (Photo from *Map of Taiwan* by Shu-Ching Huang during the reign of Emperor Kang - Hsi, Ching Dynasty)

Fig. 9. Board wheel cattle cart (photo at National Taiwan Museum in 1996)

Fig. 10. Iron leather wheel cattle cart (photo at the farmer's cattle market in Pei-Kang)

Fig. 11. Rubber wheel cattle cart (photo in Yuan-Chang Town, Yun-Lin County in 1999)

Fig. 12. Cattle cart and kids (photo at Tung-Hai University neighborhood in 1990)

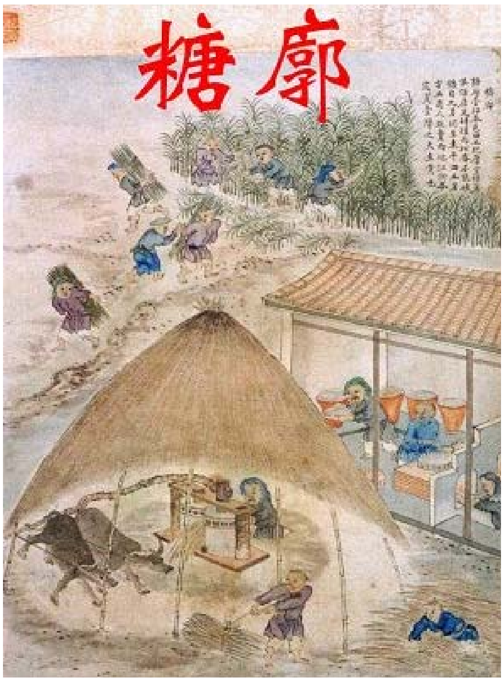


Fig. 13. Sugar refinery (*Fan She Tu Kao, History paintings of Natives)*

Fig. 14. The farmer cattle market at Shanhua, Tainan (photo by author in 1994)

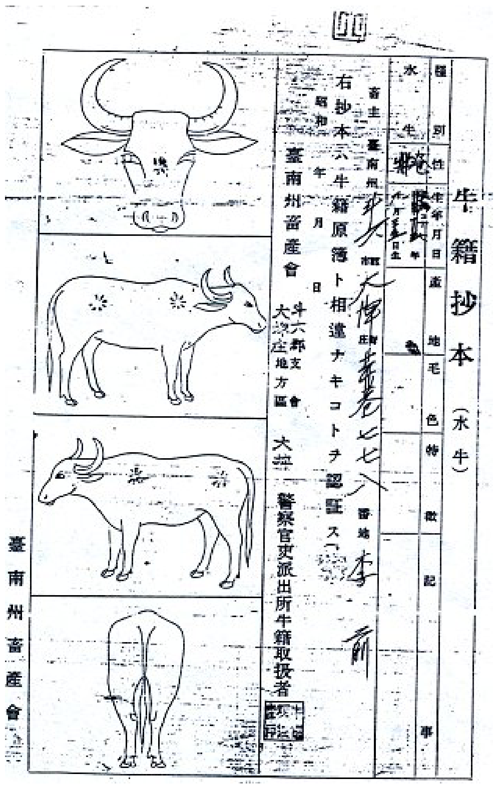
Fig. 15. Touching teeth to judge the cow's age (photo at the Pei-Kang farmer cattle market in 1992)

Fig. 16. Dragging carts (photo at the farmer cattle market in Pei-Kang in 1992)

Fig. 17. Testing steps (photo at the farmer cattle market in Pei-Kang in 1992)

Fig. 18. Negotiating a price (photo at the farmer cattle market in Pei-Kang in 1992)

Fig. 19. Red paint marked a “sold buffalo“ (photo at the farmer cattle market in Pei-Kang in 1992)



牛籍抄本（水牛）

種別 水牛

性

生年月日 年 月 日生

産地

毛色

特徴

記事

畜主 臺南州 郡 街庄 番地

右抄本ハ牛籍原簿ト相違ナキコトヲ認証ス

昭和 年 月 日

臺南州畜産會 斗六郡支會 大埤庄地方區會

大埤 警察官吏派出所牛籍取扱者

臺南州畜産會

Fig. 20. Cattle license (front view) during the Japanese Occupation Era

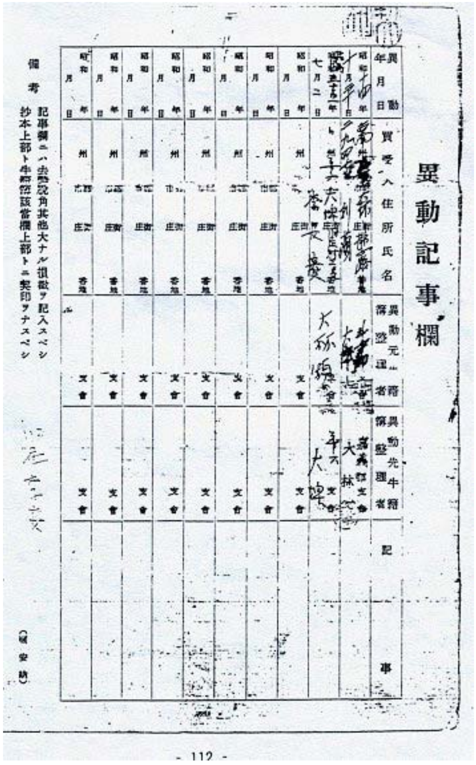


Fig. 21. Cattle license (overleaf) during the Japanese Occupation Era

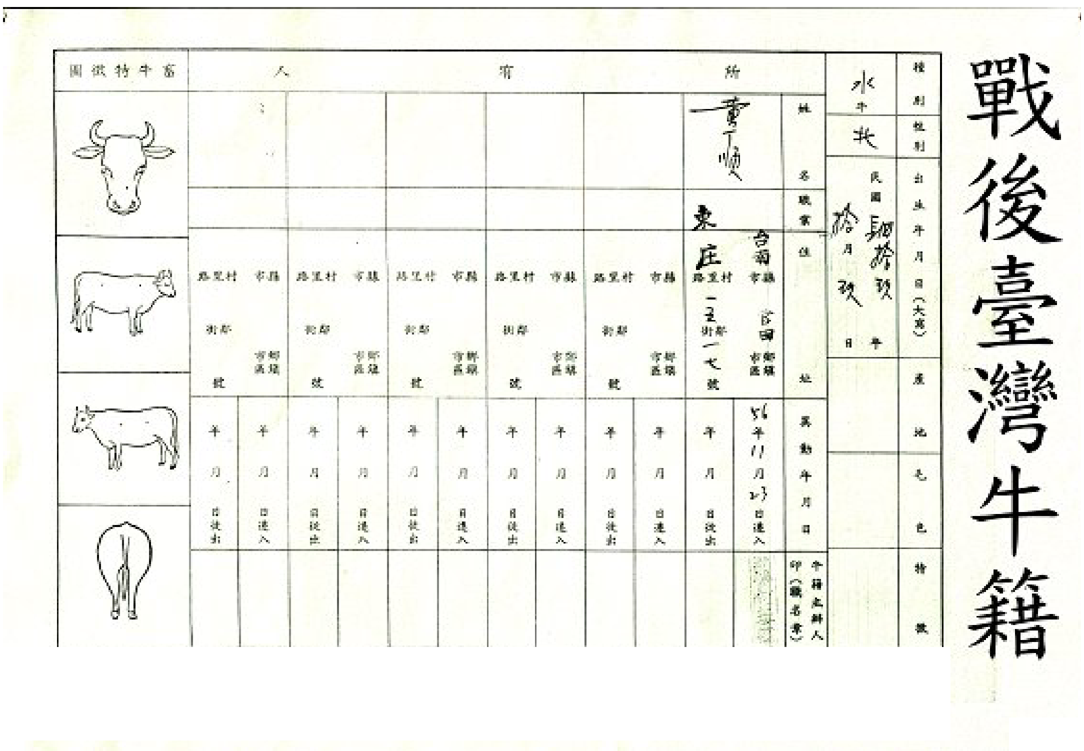


Fig. 22. Taiwan cattle identification card after World War II

Fig. 23. Spa or tub bath? (photo at Ta An Town in Taichung County in 1990)

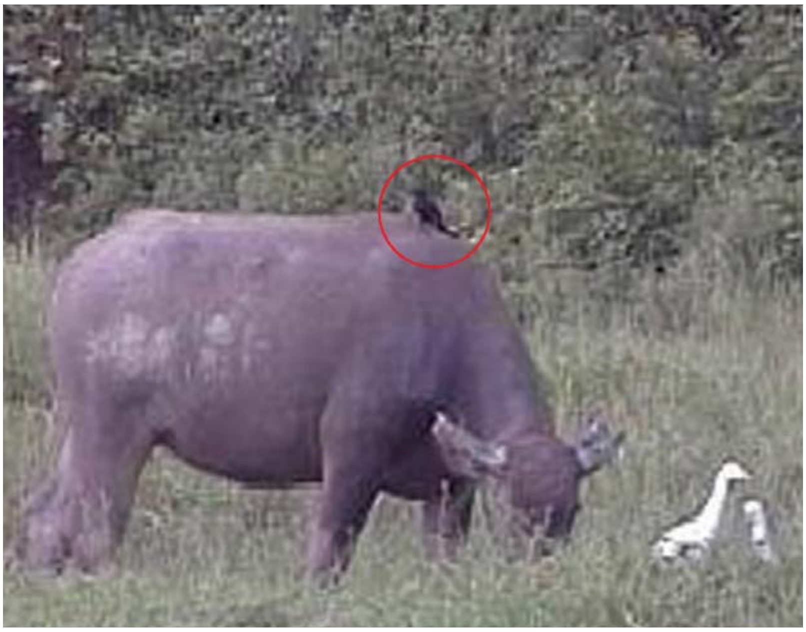


Fig. 24. Black drongo riding a buffalo (photo in Pei-Tou Town in Chang-Hua County in 1993)

Fig. 25. Racing buffalo (from Yuan-Hui Chiu. 1997. Taiwan Cattle. Yuan-Liu Publishing Corporation)

Like Cattle, Like Industrial Culture

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Different breeds of cattle are suitable for different environments and thus results diversified cultures. Agricultural development manifests the social and cultural changes within a country and can result in multiple cattle breeds.

I. Taiwan Buffalo

There are two cattle breeds in Taiwan – buffalo and cattle. Both categories are not in the same genus, the genus *Bubalus* and genus *Bos*. These two genuses, therefore, cannot mate with each other. Buffalo genus is comprised of the Indian and African buffalo. The Indian buffalo consist of swamp and river buffalo with distinctive heads and appearances. The swamp type buffalo are distributed over Southeast Asia and are used to till farmland. The river type buffalo are popular in India, Italy and the Middle East for dairy purposes.

The Dutch brought the swamp buffalo from Java to Taiwan in 1624, whereas Chinese ancestors also introduced buffalo from Mainland China to Taiwan too. The buffalo in Taiwan are all swamp type buffalo. In the 1630s, between the end of the Ming Dynasty and early Ching Dynasty, the Chinese Emperor encouraged the Fukienses refugees from Fukien Province to immigrate to Taiwan with three taels of sliver for each refugee and one buffalo for every three refugees as incentive. This was known as the "one buffalo, three taels of sliver system". These swamp buffalo then became the Taiwan buffalo (Fig. 1). These Chinese ancestors worked with their buffalo and contributed to Taiwan’s agricultural development, and thus brought changes to the aboriginal culture.

Buffalo domestication started in 2000 B.C. in China. Buffalo are adapted to water and are tolerant to heat. With large hoofs, mighty joints and steady steps, buffalo can move around easily in muddy soil and paddy fields. Buffalo are excellent helpers in the rice paddies and, therefore, are perfect for Taiwan. The aboriginal Taiwanese used to grow calla taro as their staple food. Buffalo were used successfully to help farmers transformed the calla taro paddies into rice paddies. Without the buffalo the Han people would have to live the same way as the aboriginal Taiwanese. The buffalo were used to help farmers carry rice, sugar cane and sweet potatoes, in addition to tilling the rice paddies and breaking the soil. The farmers also used buffalo to crush sugar cane, peanuts and sesame seeds. Buffalo were also used to the mix soil for producing brick at brick furnaces.

By the time the Japanese occupied Taiwan in 1895, the number of buffalo had grown to more than double that of the Taiwan Yellow cattle (Fig. 2). From this agricultural development the number of buffalo continued to grow. The number of buffalo grew to more than several times that of the Taiwan Yellow cattle. According to Fig. 2, the number of buffalo was 6 – 7 times greater than the Taiwan Yellow cattle in Taiwan before the end of the Second World War. According to Fig. 3, the Taiwan Yellow cattle were sacrificed for food purposes due to the food shortages during the war but not buffalo. After the war was over, the number of buffalo and Taiwan Yellow cattle increased as agricultural development resumed. In October 1959, 3 male and 4 female Murrah – the river type buffalo used for dairy purposes, were brought from the Philippine to Taiwan by the government to attempt to cross them with local buffalo to upgrade the dairy productivity of local buffalo. However, the Murrah were quite different from the local buffalo in appearance, and thus farmers were reluctant to see their buffalo change (Fig. 4). The government plan eventually failed. Tractors replaced buffalo in the rice fields, as mechanical mobility became popular in the rural areas in the 1960s. The buffalo were gradually retired after they made remarkable contributions to Taiwan culture and economic development (Fig. 1). The 1st January 1985, All Taiwan Buffalo Show was resuscitated and held in Meilun, Hualien. However, which was the last buffalo show even summon up a lot of people in crowd to met buffalo and fling round with gratitude sign (Fig. 5) but means Taiwan buffalo no more were a work stock with Taiwanese like a family again.

The number of buffalo dropped significantly and only a few can be seen in Taiwan now. The Hualien Animal Propagation Station, Livestock Research Institute, Council of Agriculture, Chinese Taipei maintains buffalo (Fig. 6) for the research and work with zoos around Taiwan to prevent the ancestors' friends from disappearing.

II. Taiwan Yellow Cattle

In addition to the Taiwan buffalo, there are Indian cattle (hump cattle; zebu; *Bos indicus*) and European cattle (*Bos taurus*) that originate from the northern and southern hemisphere. The Indian and European cattle are different with respect to their function and appearance. With large humps and dewlap, the Indian cattle are suitable for tilling and tolerant to heat with less succulent and rough taste in meat quality but less cooking loss. Imported European cattle were raised for dairy or beef purposes and commonly referred to as "cattle" with the features of tender and juicy meat. In the western world “cattle” is the collective term for livestock. The word cattle has the same origin as chattel and capital. In English, the first alphabet "A" is a hieroglyphic standing for ox head. In Greek, the first alphabet "α" originated from the "*Alef*" meaning “cattle” in the Semitic language. Both allusions stress the importance of cattle in ancient western culture. In Taiwan cattle represents the big animals and the person that becomes the “ox head” is a leader with great activity. In Taiwanese culture this would be stated, as “I would rather be a cock head than an ox’s tail”.

II-1. Crossing with various cattle species for improvement

Most Taiwan native cattle known as Taiwan Yellows belong to the same genus of Indian cattle, *Bos indicus*. The appearance of these cattle is similar to the British dairy cow Jersey breed (*Bos taurus*) (Fig. 7, 10). Results of blood typing indicated that Taiwan Yellows shared some genealogy with European cattle. Furthermore, Taiwan Yellows have tastier meat than that of the Indian cattle and thus many noodle shops in Chinese Taipei claim "Genuine Taiwan Yellow Meat" serving.

The Taiwan Yellow belongs to the same genus “zebu” as the cattle in the Philippines, Thailand, Vietnam, Cambodia and China' Yunlan Province. Taiwan Yellows were in Taiwan before the Chinese ancestors immigrated and thus recognized as the orthodox cattle in Taiwan compared to the buffalo. When the Dutch occupied Taiwan in 1624, there were more Taiwan Yellow cattle than buffalo. However, the Taiwan Yellows were crossed with various cattle breeds over the last 300 years. Therefore, both the appearance and function of these cattle have changed drastically.

Now Taiwan Yellows have changed completely from what they were a long time ago. Farmers in Taiwan were reluctant to cross buffalo with others and, therefore, the buffalo have remained unchanged. Evidence showed that the selfish Han race thought that the buffalo belonged to their ancestors and the orthodox Taiwan Yellows not. The Taiwan Yellows therefore faced various hybridizing attempts and appearance changed.

Changes in Taiwan Yellows reflect the evolution of agriculture in Taiwan. When the Dutch occupied Taiwan in the 17th century, many Indian cattle were brought to Taiwan from Indonesia in an effort to improve the cargo delivery efficiency. Indian cattle were then crossed with the Taiwan Yellows. The Brown Swiss, an improved breed of European dairy cattle, was brought to Taiwan together with dairy and beef dual-purpose breed known as the Devon in 1896 while Taiwan was under Japanese rule. Shorthorn cattle were also brought to Taiwan in 1906 and crossed with the Taiwan Yellows to improve the dairy productivity of the latter. However, this plan failed. The Indian zebu, Kankrej and Sindhi cattle, with large body size, humps and dewlaps were introduced to Taiwan and crossed with Taiwan Yellows. As a result, both the body size and hump of the Taiwan Yellows became stronger and larger and thus the agricultural efficiency improved. Since then, Taiwan Yellows have only served in agricultural purposes and helped farmers with tilling and shipping agricultural products (Fig. 10). The meat characteristics of Taiwan Yellows became more and more different from that of the European cattle, and thus, were no longer suitable for beefsteak production. However, it is perfect for stewing and braising of the Chinese cooking style. To cope with a severe food shortage, Taiwan Yellows were sacrificed for food in the last few years before World War II over (Fig. 3). After World War II, the ratio of the numbers of the Taiwan Yellows to the buffalo dropped to 1:7, a historic low (Fig. 2). The number of dairy Holstein cattle also decreased tremendously as the Japanese moved out of Taiwan after World War II. However, in the Taiwan recovery period after World War II, the number of buffalo and Taiwan Yellows increased greater than that of dairy cattle did (Fig. 2).

In 1962, the Hengchun Branch, Livestock Research Institute, Council of Agriculture, Chinese Taipei brought Santa Gertrudis, American beef cattle, to Taiwan for crossing with Taiwan Yellows. The plan worked successfully and Taiwan Yellows were successfully transformed into beef cattle (Fig. 8). These cattle are no longer considered “work stock” only. Taiwan Yellows, in addition to conservation purpose and maintained in the Hengchun Branch, Livestock Research Institute (Fig. 9), was kept in rural areas for either beef or tilling purposes (Fig. 10).

II-2. All dairy cattle are artificially inseminated in Taiwan

Taiwan was developed based on agriculture but not livestock. Cattle were originally used for tilling purposes. Farmers used pig's excreta as fertilizer for farming. No farmers in Taiwan ever raised cattle for dairy purposes. In 1897, the Japanese brought the first dairy cattle to Taiwan and produced milk in the suburbs of Taipei. The scale of production was rather limited and far away from an industrial scale. Before World War II, the Taipei Emperor University's Ranch (now the Experimental Farm, National Taiwan University) kept a top milking record cow in Taiwan. The 5,003 kg milk with 3.15% fat was produced in 263 days. The highest daily production was 33.4 kg. In 1943, there were 75 dairy farms and 1,706 dairy cattle. This was the peak milk production period during the Japanese colonial period. Farmers lost their dairy cattle as World War II continued. By the end of World War II, there were only 47 dairy farms and 873 dairy cattle in Taiwan. The annual milk production amounted to 1,075 tons. Taiwan's dairy industry declined as the Japanese moved out of Taiwan. The US Relief Agency shipped 75 dairy cattle to Taiwan in 1947 and distributed to National Taiwan University and various agricultural improvement stations around Taiwan. Most of the 75 dairy cattle were Holsteins, with a few Ayrshire, dairy Shorthorn, Guernsey and Jersey. Later on dairy cattle donated by the USA were mated with Holstein bulls because no bulls of the same breed were available. As a result, all cows were up graded using Holstein bulls. In the 1950s, Taiwan's economy started recovering from the shadows of World War II. Taiwan's dairy industry resumed in 1957. The government assisted farmers in developing dairy production in addition to the traditional agriculture to cope with the increasing demand for dairy products.

On April 7, 1960, an artificial insemination research team led by Professor Teng-Yen Lee from National Taiwan University successfully inseminated a Holstein cow with frozen semen from the USA. Lee's achievement set a milestone for the dairy industry using 100% artificial insemination with frozen Holstein semen in Taiwan. Taiwan's economy boomed and the national income started increasing from 1961. The people's living standard increased and, as a result, the demand for milk and beef increased tremendously. At the same time, mechanical mobility became more and more popular in the rural areas. Consequently, cattle were needed less for tilling and were raised for both meat and dairy purposes. The number of Taiwan Yellows decreased and the buffalo (Fig. 1) were no longer needed for tilling or work stock. However, beef consumption increased. With its milk production capability and tasty meat, Holsteins replaced the Taiwan Yellow cattle. Taiwan Yellows, buffalo and Holsteins reflect the changes in Taiwan local culture. With the growing popularity of Holsteins (Fig. 2), Taiwan is developing in a manner similar to European countries. The Holstein has replaced Taiwan Yellows and buffalo (Fig. 2). This speaks for the prosperity of Taiwan rural areas.

Fig.1. Taiwan Buffalo

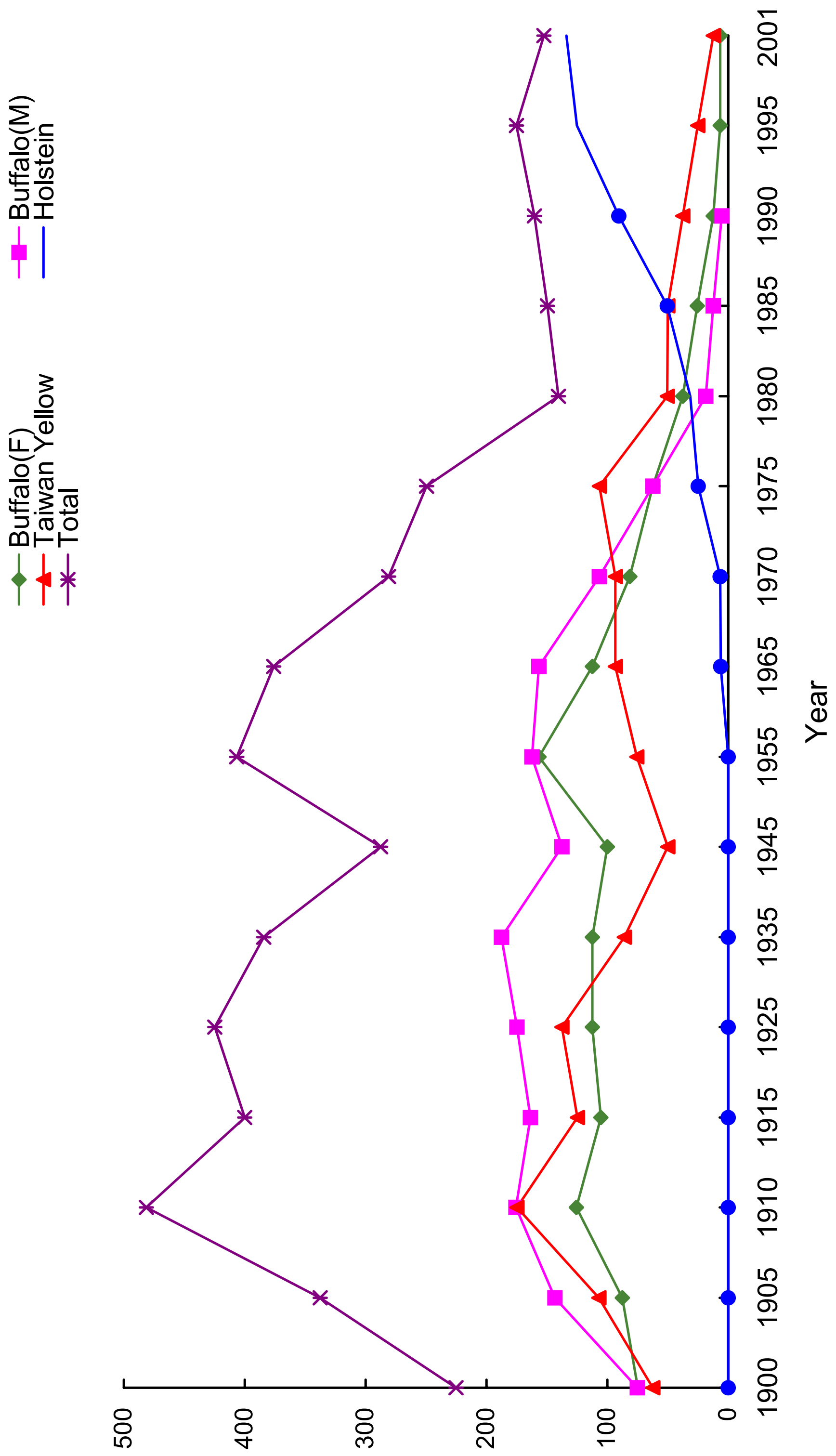

Fig. 2. Cattle inventory changes on farms over the last century in Taiwan

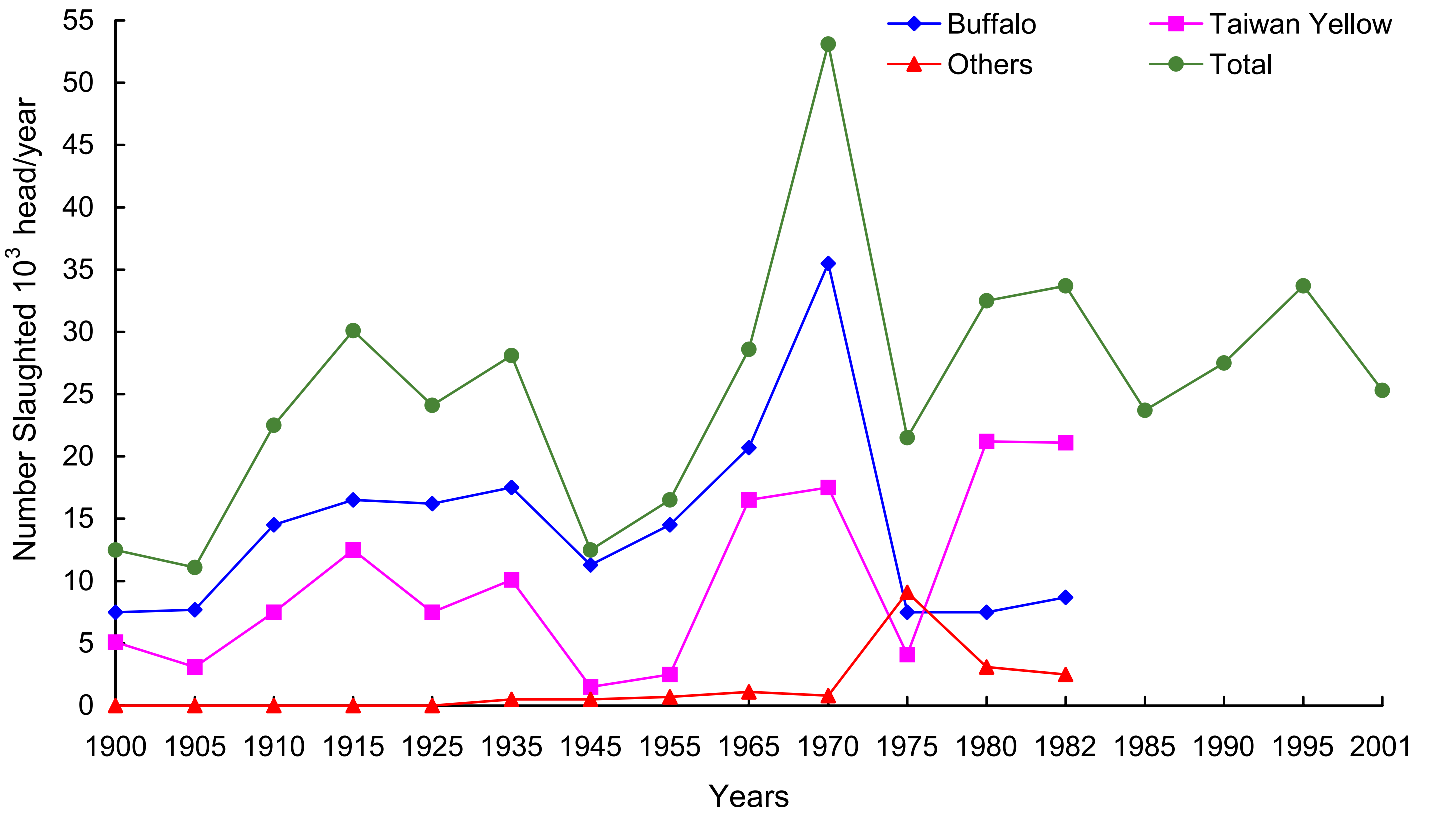

Fig. 3. Changes in the number of cattle slaughtered over the last century in Taiwan

Fig. 4. Murrah river buffalo

Fig. 5. All Taiwan Buffalo Show was held on 1st January 1985 in Meilun, Hualien

Fig. 6. Buffalo stock conserved at Hualien Animal Propagation Station, Livestock Research Institute, Council of Agriculture, Chinese Taipei

Fig. 7. Taiwan Yellows and Jersey Cattle

Fig. 8. Santa Gertrudis used in upgrading breeding system

Fig. 9. Taiwan Yellow Stock conserved at Hengchun Branch, Livestock Research Institute, Council of Agriculture, Chinese Taipei

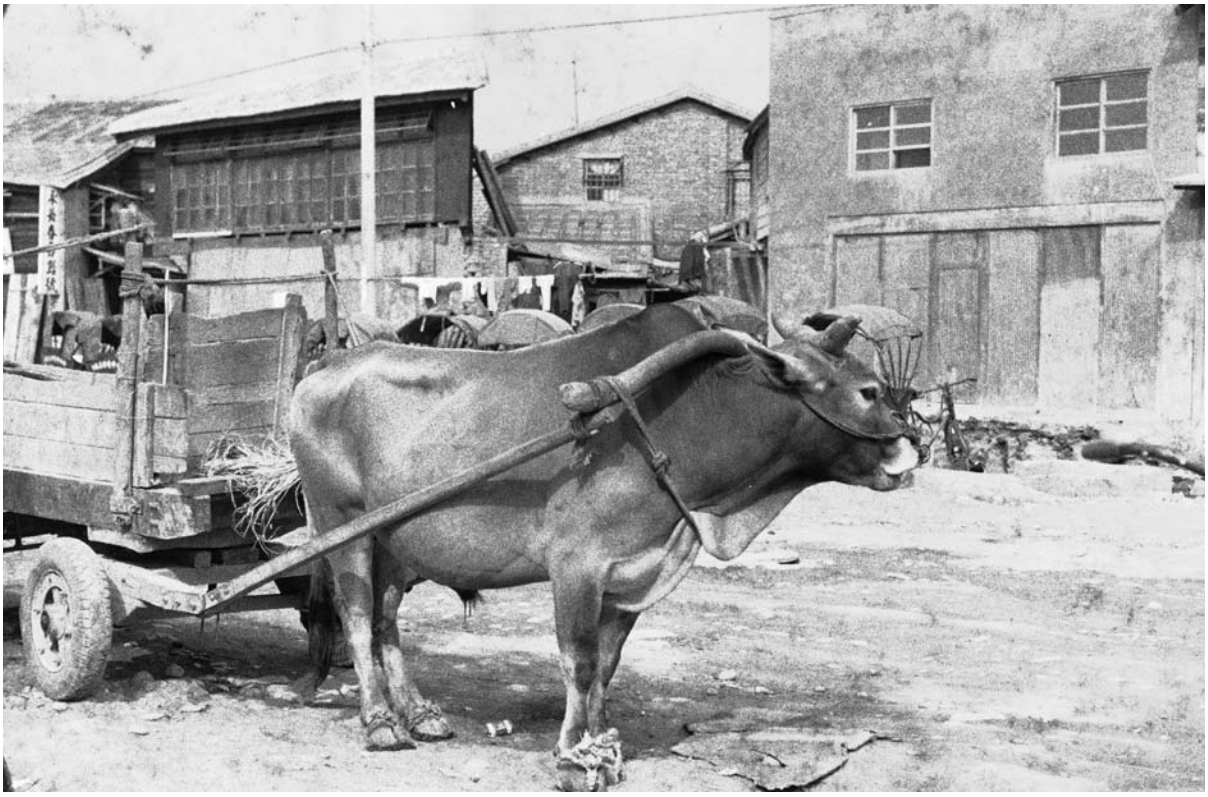

Fig. 10. Taiwan Yellow used as working stock

Cattle Genetic Resources in Japan: One Successful Crossbreeding Story and Genetic Diversity Erosion

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I. Beef cattle production background

I-1. Historical features influencing cattle production

Besides pigs and ducks, *Sus scrofa* and *Anas sp.,* no ancestral domesticated animals naturally inhabited Japan. Domestic animals, such as pigs, cattle and chickens were introduced in the late Jomon (~ B.C. 500) to Yayoi Eras (B.C. 500 – A.D. 300). A Chinese historical book (~ A.D. 250) described that there were no cattle, horses or sheep in Japan. Because no descriptions of pigs and chickens were found in the book, the possibility of their existence could not be denied.

Several books written in the mid 7th century referred to cow's milk. Engishiki (A.D. 927), written in the Heian Era, is a description of the milk product, "So", surmised as condensed milk for medical purposes. A reference to a presentation of "So" to the government is made in this book. However, this habit was abolished at the beginning of the 12th century. The government banned the slaughtering of animals, cattle, horses, dogs, monkeys and chickens in A.D. 675. Cattle and horse slaughtering were abolished again in A.D. 742. This suggested that the people of this period ate meat.

After the prohibitory edict, meat and milk became less common. A pictorial book, written around A.D. 1700, introduced dairy products. However, the main use of domestic animals was for transportation of goods, farming, or military power. Some agricultural books introduced a feeding system aimed at manure production.

The history of domestic animals for practical food production in Japan is extremely short compared to most other countries. This seems due to two reasons. First, the climatic conditions in Japan are suitable for grain cultivation and the only purpose for cattle was to assist in rice cultivation. Second, for a long time Buddhism was predominant in Japan and prohibited the eating of meats; especially from four legged animals. The utilization of animal products did not become popular until the Meiji era; especially in the central region of Japan. Meat has been consumed in Japan for only about 130 years, the beginning of the Meiji era. Meat eating has only reached widespread popularity in the last 30 years. Therefore, Japanese cattle were not subject to improvement techniques for milk and meat production before the mid 1950's. The "Law for Improvement and Increased Livestock Production" was enacted in 1950. The law stipulated that the government was required to establish the goal of improving and propagating livestock, stating, "The minister of Agriculture, Forestry and Fisheries shall set specific goals by species concerning the improvement and propagation of livestock including cattle, horses, sheep, goats, pigs and other livestock stipulated according to the related ordinances and publicize each goal".

In the Meiji era, many foreign cattle were introduced to Japan and initially extensively crossbred with the native cattle under the leadership of the government. Through this, the gene pool for Japanese cattle were diluted and greatly expanded. After the initial frenzy of crossbreeding was over, cattle breeders began to improve and promote their own breeds without crossbreeding within prefectures. The unique characteristics of Japanese cattle were then established as found today. However, followed by the introduction and breeding efforts made in each region, most of genuine Japanese native cattle diminished and only Mishima and Kuchinoshima cattle remained in two islands, Yamaguchi and Kagoshima Prefectures, respectively (Fig. 1).

I-2. Domestic Animals in Japanese daily life

There are many traditional events related to a variety of livestock that are still held, particularly in relation to cattle and horses. These include "*ushioni*" at the Warei shrine, the cattle festival at Uzumasa, and sacred rites relating to fieldwork (Tsuda, 2001) in rural Japan. At these events, living farm animals play a leading role, but unimproved indigenous livestock rarely appear. However, improved breeds are now being utilized even at these traditional events and festivals (Fig. 2).

Livestock production now takes place on a large scale. The presence and awareness of farm animals has gradually faded from ordinary life. Only a few species have been bred for specific purposes, such as cattle for bullfights, and Shamo, Onagadori and Naganakidori as fighting cocks and pet animals. Dishes using goat and pig meat in Okinawa Prefecture and "*kiritanpo-nabe*" using Hinaidori in Akita Prefecture are the forms of traditional cuisine utilizing traditional Japanese breeds. Most non-native species have already become familiar in ordinary Japanese life. With the exception of chickens, the handing down of these traditional recipes and breeds does not seem to have led to the protection of native animals.

II. Japanese native cattle breeds' description

In 2000, there were a total of 2,824,000 beef cattle and 1,764,000 dairy cattle in Japan. The beef cattle can be classified into two categories, indigenous and non-indigenous cattle. The former includes 1,700,000 Japanese beef cattle, named Wagyu, and the latter involves 461,000 non-indigenous dairy cattle and 663,000 corresponding crossbred animal. Wagyu includes four breeds, Japanese Black (93.9%), Japanese Brown (4.2%), Japanese Poll (trace), and Japanese Shorthorn cattle (1.0%). Each breed that developed its own history and distinct characteristics will be described follows. However, exotic cattle breeds contribute most milk production and more than 99% of the dairy cattle are Holsteins. Production from the two genuine Japanese native cattle is in trace proportions (Statistical Data Related to Livestock Improvement, 2001).

II-1 Mishima cattle (Fig. 3)

Mishima Island is situated at latitude 34°46' N and longitude 131°8' E with an area of 7.8 km^2 in the Sea of Japan. Mishima Island is small and with a restricted flat area. The rice fields are therefore small and terraced. Mishima cattle are suitable for small landholding farmers because of its small body size and good temperament. The first official record indicated that 350 cattle were annihilated for rinderpests in 1672. After that, a new herd was established. Four hundred thirty-three cattle were recorded in

1739 and about 400 cattle had been kept up to the Meiji Restoration in 1868. Mishima cattle can be thought of as the original type of Japanese Black cattle. They were designated a natural monument in Japan in 1928. After this designation, Mishima cattle have been kept as farm animals and for *in situ* conservation. More than 300 female Mishima cattle were kept up to 1961. The number decreased after that and only 33 females remained in the middle of the 1970s (Furukawa *et al*., 1997). The number of females has gradually increased to nearly 100 in 2002.

Mishima is classified as late maturing cattle with dark brown coat color and small horns as well as narrower body compared to the modern Japanese Black. The average wither height, chest girth and body weight of a mature Mishima female (60 months old) are 112.8 cm, 152.1 cm and 261.1 kg, respectively (Harada *et al*., 1996).

II-2. Kuchinoshima feral cattle (Fig. 4)

Kuchinoshima island is situated at latitude 29°58' N and longitude 129°55' E with an area of 13.3 km^2 at the north end of Tokara Isles 200 km south from Kyushu.

A record, written in 1727, indicated the existence of domesticated cattle in Kuchinoshima (Tomita, 1996). However, Hayashida and Nozawa (1964) suggested that these feral cattle were descendent from cattle of Kagoshima during 1918 and 1919 and that had escaped from pasturage.

The population size of Kuchinoshima feral cattle was 44 – 66 individuals in 1999. However, there were two Kuchinoshima cattle populations with 20 and 24 animals in 2001, respectively, conserved at Kagoshima University and Nagoya University. The body size of the Kuchinoshima cattle is smaller than the Mishima cattle. The average wither height and body length of a mature female are about 110 cm and 120 cm, respectively. The coat color is mainly black with a white spot in the belly and/or four limbs with brown color occasionally occurred.

II-3. Japanese Black (Fig. 5)

Most Japanese Black cattle were crossbred, producing a modern type of this breed. In the Chugoku district, several pre-crossbred strains (Tsuru) were developed during the Edo era (1600 – 1876). The primary function of these cattle was carrying firewood for steel production and used as draft animals. After the Meiji restoration in 1867, the government encouraged the introduction of foreign cattle breeds for crossbreeding with native cattle to improve body size and milk production. As shown in Table I, various breeds were introduced and crossbred with regional native cattle. In consequence, the genetic diversity of the indigenous cattle was greatly expanded.

After the mid 1950’s, agricultural machinery predominated and chemical fertilizer was more popular in agriculture, supplanting and reducing draft cattle use. This forced a shift in the reason for raising these cattle to beef production.

The Japanese Black is now found in all regions of Japan. This breed has increased in number in the Kyushu and Hokkaido regions. However, in the Chugoku region, which was once the main production region for this breed, the number of this breed has decreased.

The characteristics of the breed include dull black coat and skin, small to medium body size with withers height and body weight being 124 cm, 420 kg and 137 cm, 700 kg in mature cow and bull, respectively. This breed has horns, but no humps. The milk yield over 180 days is about 1000 kg. Compared to the other Japanese indigenous breeds, the Japanese Black are noted for their capacity to produce high degree of fat marbling beef with a thin fat layer beneath the skin and surrounding the internal organs.

II-4. Japanese Brown

The Japanese Brown breed has two distinct strains and reared mainly in Kumamoto and Kochi prefectures, respectively. The developmental processes of these strains are quite different and usually described separately:

II-4-a. Kumamoto strain (Fig. 6)

The Kumamoto cattle is a red colored strain in Kumamoto prefecture originally developed from imported Korean cattle. After the late 1900’s, this breed was crossbred with many imported foreign breeds such as the Simmental and Devon breeds. A large body size crossbred cattle was produced when Simmental cattle was used. The features of this breed are high weight gain rate and large rib eye area. The body weight of mature females and males are 600 kg and 950 kg, respectively.

II-4-b. Kochi strain

The Kochi strain was developed from crossing the Simmental with Korean cattle introduced from Kyushu Island. This crossbreeding period was substantially shorter than that for the Kumamoto strain. This reduced the dilution of the original breed's characteristics, retaining important differences. These cattle have a yellow-brown coat, which is much lighter than the Kumamoto strain. The cattle with black skin at horns, hoofs, eyelids, muzzle, tongue, switch and anus are more valuable due to its similarity to typical of the original Korean breed. The beef production performance of this strain is similar to that of the Kumamoto strain. The body weight of mature females and males are 600 kg and 950 kg, respectively.

II-5. Japanese Poll (Fig. 7)

This breed has been developed since 1916 from a cross between the indigenous cattle with Aberdeen Angus bulls imported from England. Furthermore, Japanese Poll cows were crossed with Japanese Black bulls to improve meat quality in 1975. Therefore, it can be expected that not many pure bred Japanese Poll cattle remained currently. However, neither performance nor progeny tests have been practiced since 1986. The phenotypic characteristics include hornless and black coat color with withers height and body weight being 122 cm, 450 kg and 137 cm, 800 kg in mature cows and bulls, respectively.

II-6. Japanese Shorthorn (Fig. 8)

This breed is the result of crossbreeding begun in 1871 between the imported dairy Shorthorn cattle and indigenous cattle in the northern parts of Honshu Island (Tohoku region). It is claimed that this breed can utilize the rough summer grazing available in the mountainous parts of this region better than other breeds. They are distributed mainly in the Tohoku and Hokkaido regions. The coat color of this breed is a deep red-brown that is darker than the Japanese Brown. The Japanese shorthorn seems superior to the Japanese Black for milk production, forage intake and growth rate. The withers height and body weight of mature females and males are 128 cm, 500 kg and 140 cm, 800 kg, respectively.

III. Genetic analysis of Japanese native cattle breeds and populations

III-1. Genetic variability of Japanese Cattle

The genetic variability of three breeds, Japanese Black, Japanese Brown and Japanese Shorthorn, is almost the same as that of Holsteins from several indices estimated using the blood type, blood protein, milk protein and microsatellite DNA polymorphisms as genetic markers. Mishima cattle revealed low genetic variability, which accounted nearly half of the other breeds (Abe *et al.*, 1977; Kato, 2002). Kuchinoshima Feral Cattle also showed the same level of genetic variability as Mishima cattle using the same set of microsatellite DNA loci (Kato, 2002).

In the mtDNA, inherited through the maternal line, 24 haplotypes were observed based on 18 mutations in the Japanese Black (Mannen *et al.*, 2000). Only two haplotypes were found in the 6 maternal lines known for Mishima cattle (Shi *et al.*, 2002).

Abe *et al.* (1977) reported that the Japanese Poll possessed slightly lower genetic variability than the other Wagyu breeds. However, the population size of this breed has recently been drastically reduced. The level of variability also seems to have been decreased to a critical level.

P.poly, the average heterozygosity and average number of effective alleles in each breed and population are shown in Table 2. The values for these indices in the Japanese native cattle populations are clearly lower than that in the other three Wagyu breeds. The average number of effective alleles of the Holstein, Kuchinoshima Feral and Mishima were 2.51, 1.48 and 1.40, respectively. The average heterozygosity was 0.521, 0.242 and 0.209, respectively. It is clear that the genetic variability of Japanese pure native cattle is quite low (Table 2).

III-2. Genetic relationship among Japanese native breeds and populations estimated from genetic distance

One hundred forty two alleles from 23 microsatellite loci were found in the three Wagyu breeds, two pure Japanese native populations and the Holstein breed. Only 58 alleles were observed in the Mishima and Kuchinoshima population. Forty-five of 58 alleles are shared with other groups, the three Wagyu breeds and Holstein. Twelve alleles are shared with only the Wagyu breeds. Only one allele was specific to the Mishima population. Therefore, it is suggested that many genes inherited from the past native Japanese cattle population still remain in the present Japanese beef cattle breeds.

The genetic distance estimated from the blood type, protein and DNA polymorphism shows that the Wagyu and Holstein have a close relationship. The Japanese native cattle, Mishima and Kuchinoshima reveal a relatively large distance from the Wagyu and Holstein groups. The genetic distance between the Mishima and Kuchinoshima is greater than that to the Japanese Black and Japanese Brown (Table 3).

Although many alleles shared with the pure Japanese native are still left in the Wagyu breeds, Japanese beef cattle breeds are rather close to the Holstein breed presumed from the genetic distance. While the Wagyu originated from native Japanese cattle, they differ greatly genetically from their origin because of crossbreeding with exotic breeds in the early breed development stage.

The large genetic distance between the two Japanese native populations is believed partially due to a genetic drift in different directions after introduction to both islands. This also suggests the existence of geographical differentiation in the past Japanese cattle population. Other phenotypical differences were reported in these two populations too. The coat colors of the two populations are different, as described above. The meat quality of Mishima cattle is similar to the Japanese Black, which is famous for marbled meat. The Kuchinoshima produce lean meat. The muscular marbling in the Japanese Black is deemed to have crossed with indigenous cattle in the Chugoku district where the Japanese Black developed and Mishima cattle originated.

IV. Perspective on Japanese native cattle

Four beef cattle breeds, the Japanese Black, Japanese Brown, Japanese Poll and Japanese Shorthorn were established in Japan and considered as indigenous to Japan, although they were initially extensively crossbred with foreign breeds in the early 1900's. The breeds used for crossing and the selection criteria varied significantly from prefecture to prefecture. Consequently, a number of distinct strains were established. At present, however, the genetic diversity is decreasing due to the concentration around a limited number of Japanese Black strains noted for their superior meat quality. After the liberalization on beef importation in 1991, other breeds, with meat quality thought difficult to discriminate from foreign beef breeds, are decreasing steeply.

Japanese native cattle could therefore be categorized into three groups: (i) not at risk, Japanese Black; (ii) presently not at risk but potentially endangered, Japanese Brown and Japanese Shorthorn; (iii) at risk, Japanese Poll, Mishima and Kuchinoshima feral cattle. From the genetic conservation point of view, the systematic conservation of minor Japanese breeds and minor strains of Japanese Black is recommended using frozen semen and embryos for future genetic resource demands such as emergency measures or as supplemental measures for *in situ* and live animal conservation.

From the sustainable cattle breed viewpoint and for making full use of Japanese natural resources without environmental damage, it is necessary to develop appropriate rearing systems for these cattle breeds and the two indigenous populations. The Japanese Brown in Kumamoto and Japanese Shorthorn in the Tohoku region have superior grazing traits compared to the Japanese Black. The Japanese Brown was bred and grazed in grasslands located in mountainous-hilly areas. In 2000, direct payment systems to the mountainous-hilly areas started in accordance with the Basic Law on Food, Agriculture and Rural Areas. In Aso, this grant is used to promote animal production focusing on the maintenance and management of grasslands and the Japanese Brown cattle.

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Table 1. Foreign breeds crossed with native cattle in each Prefecture

Name of modern breed	Prefecture	Foreign breed
Japanese Black	Kyoto	Brown Swiss
	Hyogo	Shorthorn, Devon, Brown Swiss
	Okayama	Shorthorn, Devon
	Hiroshima	Simmental, Brown Swiss, Shorthorn, Ayrshire
	Tottori	Brown Swiss, Shorthorn
	Shimane	Devon, Brown Swiss, Simmental, Ayrshire
	Yamaguchi	Devon, Ayrshire, Brown Swiss
	Ehime	Shorthorn
	Ohita	Brown Swiss, Simmental
	Kagoshima	Brown Swiss, Devon, Holstein
Japanese Brown	Kochi	Simmental, Korean Cattle
	Kumamoto	Simmental, Korean Cattle, Devon
Japanese Poll	Yamaguchi	Aberdeen-Angus
Japanese Shorthorn	Aomori	Shorthorn
	Iwate	Shorthorn
	Akita	Shorthorn, Devon, Ayrshire

Table 2. Genetic variability of five Japanese native cattle breeds and populations

Breed	P.poly	Mean±SE		
		Nnumber of alleles	Number of effective alleles	Observed heterozygosity
Kuchinoshima	56.5%	1.78±0.85	1.48±0.59	0.242±0.248
Mishima	52.2%	1.78±0.90	1.40±0.48	0.209±0.236
Japanese Black	87.0%	4.09±2.21	2.28±1.09	0.446±0.281
Japanese Shorthorn	95.7%	4.13±1.74	2.51±1.17	0.516±0.234
Japanese Brown	95.7%	4.48±2.11	2.90±1.35	0.560±0.267
Holstein	87.0%	3.78±2.07	2.51±1.23	0.521±0.260

Table 3. Genetic distance (DA) among Japanese native cattle breeds and populations

Breed	Kuchinoshima	Mishima	Japanese Black	Japanese Shrothorn	Japanese Brown	Holstein
Kuchinoshima	*					
Mishima	0.349	*				
Japanese Black	0.249	0.225	*			
Japanese Shorthorn	0.382	0.383	0.196	*		
Japanese Brown	0.251	0.254	0.104	0.183	*	
Holstein	0.411	0.323	0.184	0.181	0.178	*

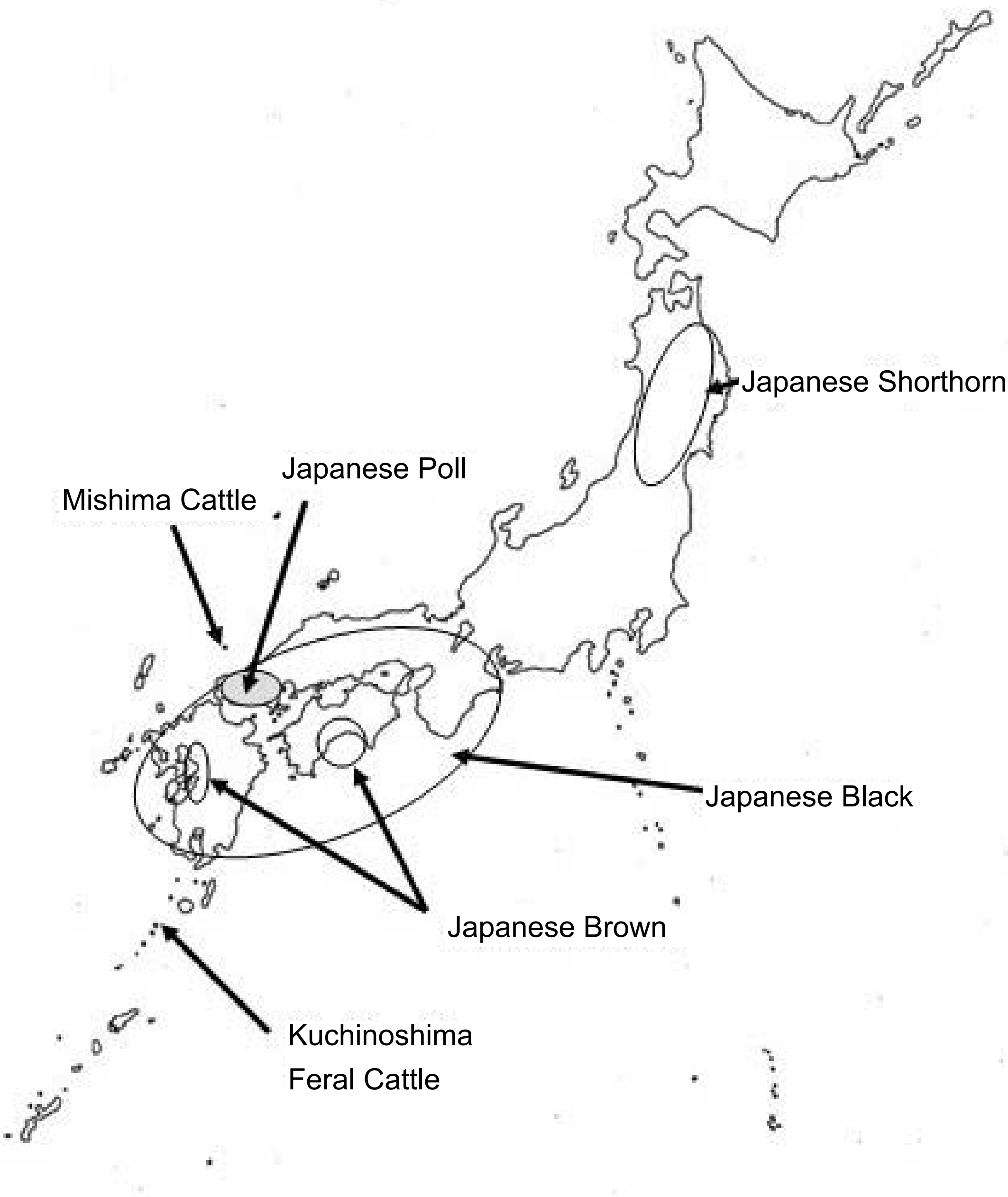

Fig. 1. Original Japanese native cattle breed and population locations

Fig. 2. Cattle in Japanese old fashion style festival

Fig. 3. Mishima Cattle (Bull)

Fig. 4. Kuchinoshima Feral Cattle

Fig. 5. Japanese Black (Bull)

Fig. 6. Japanese Brown, Kumamoto strain (Bull)

Fig. 7. Japanese Poll (Bull)

Fig. 8. Japanese Shorthorn (Cow)

Chicken

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ASIA-PACIFIC ECONOMIC COOPERATION

AGRICULTURAL TECHNICAL COOPERATION WORKING GROUP

Japanese Native Chickens

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Introduction

There are approximately 50 breeds of native chickens in Japan (Table 1). Japanese native chickens are classified into 2 groups. The first group is those for hobbyists. The second group is for egg and/or meat production. The former group will be called "Japanese fancy fowl" and the latter "Japanese utility fowl" in this article. Japanese fancy fowl are further classified into 2 subgroups. The first subgroup includes chickens introduced to Japan more than 2,000 years ago. The second subgroup includes chickens introduced to Japan later. The former is called "Jidori (Japanese Old Type)". Among the latter, the Shoukoku (Japanese Elegancy) breed was introduced to Japan during the Heian Era (794 – 1192). The Oh-Shamo (Japanese Large Game), Chabo (Japanese Bantam), and Ukokkei (Japanese Silkie) breeds were introduced during the early Edo Era (1603 – 1867). Other Japanese fancy breeds were established by the end of the Edo Era via mating these foreign derived chickens with Jidori and followed by selective propagation.

The Japanese Government has designated many Japanese fancy fowl as "Natural Monuments of Japan". They are Jidori (Japanese Old Type), Shoukoku (Japanese Elegancy), Shamo (Japanese Game), Chabo (Japanese Bantam), Ukokkei (Japanese Silkie), Uzurao (Japanese Small Rumplessness), Tosa-Onagadori (Japanese Long Tail), Ohiki (Japanese Tail Dragger), Toutenkou (Japanese Red Crower), Koeyoshi (Japanese Good Crower), Toumaru (Japanese Black Crower), Kuro-Kashiwa (Japanese Black), Satsuma-Dori (Kagoshima Game), Hinai-Dori (Japanese Dainty), Minohiki (Japanese Saddle Hackle Dragger), Jitokko (Japanese Creeper), and Kawachi-Yakko (Japanese Brave). Among them, the Tosa-Onagadori was designated as "Special Natural Monument of Japan".

The Jidori classification includes three or more breeds. The three major Jidori breeds are the Tosa-Kojidori (Japanese Old Type-Tosa), Gifu-Jidori (Japanese Old Type-Gifu), and Mie-Jidori (Japanese Old Type-Mie). The Shamo classification actually involves seven breeds: Oh-Shamo (Japanese Large Game), Ko-Shamo (Japanese Small Game), Yamato-Gunkei (Yamato Game), Yakido (Mie Game), Kinpa (Japanese Henny Feathered Game), Nankin-Shamo (Japanese Slender Game), and Echigo-Nankin-Shamo (Niigata Slender Game).

The majority of the Japanese utility breeds were established during the Meiji Era (1868 – 1912). Although these breeds were originally used for egg production and/or meat production, from the Meiji Era to the early Shouwa Era (1926 – 1989), the number of utility chickens is actually very small in present Japan. People mostly rear them to enjoy their beautiful figure.

The following is the brief description of the features of the main Japanese native chicken breeds.

Japanese fancy fowl

Tosa-Kojidori [Japanese Old Type-Tosa (Fig. 1), Natural Monument designated in 1941]

This breed is one of the oldest breeds in Japan and is the smallest breed among the Japanese native chickens. The ancestor of this breed is thought introduced to Japan more than 2,000 years ago. The body shape and plumage color of this breed are similar to the Red Jungle Fowl (RJF). However, the brown neck and saddle hackles of the male are heavier in color than those in the RJF.

The prefecture of origin: Kochi Prefecture
Standard body weight (BW) in adults: 675 g in male, 600 g in female
Plumage color varieties: black-breasted red, white
Comb: single
Earlobe color：red
Shank color：yellow

Gifu-Jidori [Japanese Old Type-Gifu (Fig. 2), Natural Monument designated in 1941]

This is also one of the oldest breeds in Japan. The ancestor of this breed is thought introduced into Japan more than 2,000 years ago. The body size of this breed is larger than that of the Tosa-Kojidori. The body shape shows the RJF type. The plumage color is similar to the RJF, that is, the brown neck and saddle hackles in the males are more yellow than those in the Tosa-Kojidori.

The prefecture of origin: Gifu Prefecture
Standard BW in adults: 1,800 g in male, 1,350 g in female
Plumage color varieties: black-breasted red (e^+/e^+ or e^y/e^y)
Comb: single
Earlobe color：red
Shank color：yellow

Mie-Jidori [Japanese Old Type-Mie (Fig. 3), Natural Monument designated in 1941]

This is also one of the oldest breeds in Japan. The ancestor of this breed is thought introduced into Japan more than 2,000 years ago. The body shape shows the RJF type like the Tosa-Kojidori and Gifu-Jidori, but its plumage color is different.

The prefecture of origin: Mie Prefecture
Standard BW in adults: 1,800 g in male, 1,350 g in female
Plumage color varieties: buff columbian
Comb: single
Earlobe color：red
Shank color：yellow

Shoukoku [Japanese Elegancy (Fig. 4), Natural Monument designated in 1941]

The ancestor of this breed was introduced to Japan during the Heian Era (794 – 1192) from China. The Shoukoku is a graceful breed with long (more than 1 m) tail feathers and long saddle hackles. The body shape shows the RJF type, but the arrangement and amount of tail feathers are different from the RJF type. During the Heian Era, this breed was used for cock fighting. Today it is used only for enjoying its beautiful color and figure.

Main habitat: Kyoto Prefecture, Mie Prefecture, Shiga Prefecture
Standard BW in adults: 2,000 g in male, 1,600 g in female
Plumage color varieties: black-breasted white (silver duckwing), black-breasted white with brown wing coverts, white

Comb: single
Earlobe color：red
Shank color：yellow

Oh-Shamo [Japanese Large Game (Fig. 5), Natural Monument designated in 1941]

The ancestor of this breed was introduced into Japan during the early Edo Era (1603 – 1867) from Thailand. There is also another view that the ancestor of this breed was introduced to Japan during the Heian Era (794 – 1192). The Oh-Shamo is a large chicken with a Malay-type body shape; that is, the body (the line from the shank, breast to throat) is erect. The feathers are tightly attached to the body and the tail feathers are short. There are no feathers around the keel and thus red skin is easily visible in this region. The Oh-Shamo was originally a breed for cock fighting. This breed has a large amount of good quality meat. The Oh-Shamo is often used as a sire to improve meat-type chickens in Japan.

Main habitat: Tokyo, Ibaraki Prefecture, Chiba Prefecture, Aomori prefecture, Akita Prefecture, Kochi Prefecture
Standard BW in adults: 5,620 g in male, 4,875 g in female
Plumage color varieties: black-breasted red, black, white, mottled, blue, silver duckwing, buff columbian
Comb: pea
Earlobe color：red
Shank color：yellow

Chabo [Japanese Bantam (Fig. 6), Natural Monument designated in 1941]

This is a small breed, next to the Tosa-Kojidori in size. The body shape does not correspond to any of the RJF, Malay, or Cochin types. The tail feathers do not curve and are erect. The ancestor of this breed was introduced to Japan in the early Edo Era(1603 - 1867). This breed has short shanks. It is thought that the short shank is not controlled by the *Cp* gene. The genetic details for the short shank are unknown at present.

Main habitat: Tokyo, Chiba Prefecture, Kanagawa Prefecture, Saitama Prefecture, Gunma Prefecture, Shizuoka Prefecture, Osaka Prefecture, Kumamoto Prefecture

Standard BW in adults: 730 g in male, 610 g in female
Plumage color varieties: white columbian, white, black, buff, buff columbian, black-breasted red, silver duckwing, silver gray, barred, blue, pile, and many others
Comb: single
Earlobe color：red
Shank color：yellow

Ukokkei [Japanese Silkie (Fig. 7), Natural Monument designated in 1941]

This breed is a strange breed having numerous mutant characteristics. The Ukokkei has no normal feathers on its' body. The feathers of this breed do not have a flat web. The feathers have abnormal barbules and no barbicels, resulting in a silky appearance. The skin is blackish and the earlobes are blue. The surface of the bones and viscera are blackish. It has a comb and crest on the head. Some birds show a bone rising at the top of the skull. In addition to the crest, some birds have a muff and beard. The Ukokkei has feathered shanks and five digits per leg. The ancestor of this breed was introduced to Japan in the early Edo Era (1603 – 1867) from China or India.

Main habitat: Tokyo, Mie Prefecture, Osaka Prefecture, Hiroshima Prefecture, Yamaguchi Prefecture, Kagawa Prefecture
Standard BW in adults: 1,125 g in male, 900 g in female
Plumage color varieties: white, black
Comb: both walnut and crest
Earlobe color：blue
Shank color：lead-gray

Uzurao [Japanese Small Rumplessness (Fig. 8), Natural Monument designated in 1937]

This is a small breed similar to the Tosa-Kojidori, except for its tail morphology and earlobe color. This breed has white earlobes and lacks tail feathers. This breed is thought established in the late stages of the Edo Era (1603 – 1867).

The prefecture of origin: Kochi Prefecture
Standard BW in adults: 675 g in male, 600 g in female
Plumage color varieties: black-breasted red, white, mottled, and many others

Comb: single
Earlobe color：white
Shank color：yellow

Tosa-Onagadori [Japanese Long Tail (Fig. 9), Natural Monument designated in 1923, Special Natural Monument designated in 1952]

This is a peculiar breed. The basic body shape of this breed is the RJF type. However, the males have very long tail feathers more than 10 m in the longest case. Some tail feathers and all of the saddle hackles in the males show no molting throughout their lives. The tail feathers successively extend at the pace of 70 to 100 cm per year, with the saddle hackles about 30 cm per year. This breed is thought established in the late Edo Era (1603 – 1867).

The prefecture of origin: Kochi Prefecture
Standard BW in adults: 1,800 g in male, 1,350 g in female
Plumage color varieties: black-breasted white (Silver duckwing), black-breasted red, white, buff columbian
Comb: single
Earlobe color：white
Shank color：grayish green

Ohiki [Japanese Tail Dragger (Fig. 10), Natural Monument designated in 1937]

This breed has a small body size somewhat larger than the Chabo. In spite of the small body size, the males have considerably long (70 – 80 cm) tail feathers. The saddle hackles are also long. These feathers molt, unlike the case of the Tosa-Onagadori. This breed is thought established in the late stages of the Edo Era (1603 – 1867).

The prefecture of origin: Kochi Prefecture
Standard BW in adults: 937 g in male, 750 g in female
Plumage color varieties: black-breasted red, black-breasted white, white
Comb: single
Earlobe color：white
Shank color：grayish green

Toutenkou [Japanese Red Crower (Fig. 11), Natural Monument designated in

1936]

This breed is characterized by long (around 15 seconds) crowing in a high-pitched tone. The body shape of this breed resembles that of the Shoukoku breed. The tail feathers and saddle hackles are also rich and long like the Shoukoku. However, the plumage, earlobes, and shank colors are different. The Toutenkou is thought established in the late Edo Era (1603 – 1867).

The prefecture of origin: Kochi Prefecture
Standard BW in adults: 2,250 g in male, 1,800 g in female
Plumage color varieties: black-breasted red
Comb: single
Earlobe color：white
Shank color：grayish green

Koeyoshi [Japanese Good Crower (Fig. 12), Natural Monument designated in 1937]

This breed is similar to the Oh-Shamo in body shape with richer body feathers and longer tail feathers. This breed is characterized by long (around 15 seconds) crowing as with the Toutenkou. However, this breed crows in a low key. This breed is thought established in the late stages of the Edo Era (1603 – 1867). Judging from the external appearance, this breed seems to have been affected by genes from the Oh-Shamo.

Main habitat: Akita Prefecture, Aomori Prefecture, Iwate Prefecture
Standard BW in adults: 4,500 g in male, 3,750 g in female
Plumage color varieties: black-breasted white with brown wing coverts
Comb: pea
Earlobe color：red
Shank color：yellow

Toumaru [Japanese Black Crower (Fig. 13), Natural Monument designated in 1939]

The Toumaru is a black fowl with an RJF-type body shape and rich tail feathers. The saddle hackles are not long. The comb, face, and wattle are blackish red in the females. Cock crows around 15 seconds in average and thus classified as a long duration crow as the Toutenkou and Koeyoshi. The Toumaru males crow in an intermediate-pitched tone between the Toutenkou and Koeyoshi. The Toutenkou, Koeyoshi, and Toumaru are “the three major Japanese long crowing breeds”. The Toumaru is thought established in the early Meiji Era (1868 – 1912).

The prefecture of origin: Niigata Prefecture
Standard BW in adults: 3,750 g in male, 2,800 g in female
Plumage color varieties: black, white
Comb: single
Earlobe color：red or blackish red in male, blackish red in female
Shank color：black

Kuro-Kashiwa [Japanese Black (Fig. 14), Natural Monument designated in 1940]

This breed looks similar to the Toumaru at first glance because the Kuro-Kashiwa is also a black chicken with rich tail feathers. Both sexes have a blackish red comb, face and wattles. However, the body size of the Kuro-Kashiwa is smaller than the Toumaru. The body shape is similar to that of the Shoukoku, but the saddle hackles are not long. This breed is thought established in the late Edo Era (1603 – 1867). Although the appearance of the Kuro-Kashiwa is similar to that of Toumaru, the Kuro-Kashiwa has no direct genetic relation to the Toumaru.

Main habitat: Shimane Prefecture, Yamaguchi Prefecture
Standard BW in adults: 2,800 g in male, 1,800 g in female
Plumage color varieties: black
Comb: single
Earlobe color：blackish red
Shank color：black

Satsuma-Dori [Kagoshima Game (Fig. 15), Natural Monument designated in 1943]

This breed has a somewhat erect body shape like the Oh-Shamo. However, it has more abundant feathers than the Oh-Shamo. The tail feathers in the males are rich and fan out when the male is excited. This chicken was originally bred for cock fighting. A small sword was attached to the leg around the spur. Cock fighting of this kind is prohibited in present Japan. People now rear this breed to enjoy its beautiful figure. The Satsuma-Dori is thought established in the late Edo Era (1603 – 1867). One of its ancestors seems to be the Oh-Shamo, since the head morphology and erect body shape of this breed are similar to the Oh-Shamo.

The prefecture of origin: Kagoshima Prefecture
Standard BW in adults: 3,375 g in male, 2,625 g in female
Plumage color varieties: black-breasted red, black-breasted white, black, white
Comb: pea
Earlobe color：red
Shank color：yellow

Hinai-dori [Japanese Dainty (Fig. 16), Natural Monument designated in 1942]

This breed has an intermediate body shape between the RJF and Cochin types. The Hinai-Dori was originally bred for meat and egg production. People now rear this breed to enjoy its beautiful figure. This breed is believed established in the late stages of the Edo Era (1603 – 1867) and derived from crossing the Oh-Shamo with some other Japanese breed.

The prefecture of origin: Akita Prefecture
Standard BW in adults: 3,000 g in male, 2,300 g in female
Plumage color varieties: black-breasted red
Comb: pea
Earlobe color：red
Shank color：yellow

Minohiki [Japanese Saddle Hackle Dragger (Fig. 17), Natural Monument designated in 1940]

This breed has an erect body shape somewhat similar to the Oh-Shamo. However, the tail feathers and saddle hackles in the males are rich and long as in the Shoukoku. This breed is thought established in the late stages of the Edo Era (1603 – 1867) from crossing the Oh-Shamo with the Shoukoku.

Main habitat: Aichi Prefecture, Shizuoka Prefecture
Standard BW in adults: 2,500 g in male, 1,800 g in female
Plumage color varieties: black-breasted red, black-breasted white, black breasted white with brown wing coverts, buff columbian, white
Comb: pea or walnut

Earlobe color：red
Shank color：yellow

Jitokko [Japanese Creeper (Fig. 18), Natural Monument designated in 1943]

This breed has an intermediate body shape between the RJE and Cochin types and is characterized by short legs controlled by the *Cp* gene. Some birds have a beard, muff and crest. This breed is thought established in the late stages of the Edo Era (1603 – 1867).

The prefecture of origin: Kagoshima Prefecture, Miyazaki Prefecture
Standard BW in adults: 3,000 g in male, 2,500 g in female
Plumage color varieties: black-breasted red, black, white, buff columbian
Comb: pea or single (with or without crest)
Earlobe color：red
Shank color：yellow

Kawachi-Yakko [Japanese Brave (Fig. 19), Natural Monument designated in 1943]

This breed has a strange body shape among the Japanese fancy chickens. The body is somewhat erect with somewhat short tail feathers. Although this breed does not belong to the Shamo classification, these characteristics appear to be similar to those of the Shamo-classification chickens. Originally, this breed is thought established in the late stages of the Edo Era (1603 – 1867). The present stocks of this breed were restored in the early stages of the Shouwa Era (1926 – 1989).

The prefecture of origin: Mie Prefecture
Standard BW in adults: 930 g in male, 750 g in female
Plumage color varieties: black-breasted white with brown wing coverts
Comb: large sized pea
Earlobe color：red
Shank color：yellow

Japanese utility fowl

Nagoya (Fig. 20)

This breed was established in Aichi Prefecture during the Taishou Era (1912 – 1926) by removing the leg feathers from the Nagoya Cochin. The Nagoya Cochin was established during the Meiji Era (1868 – 1912) by crossing the Cochin, whose origin is in China, and some Japanese native breed. Today, the Nagoya Cochin is extinct. The Nagoya breed has a Cochin-type body shape with buff columbian colored plumage. The buff color of this breed has an orange tinge. Until White Leghorn and broiler chickens were introduced to Japan on a large scale from the U.S.A., this breed was used to produce eggs and meat. However, after the introduction of American utility breeds, people have reared the Nagoya only to enjoy its beautiful figure. This breed was again used for egg and meat production in Japan on a small scale, because the Japanese recognized that this breed produces more delicious meat and eggs than the American utility breeds. The other features of Nagoya are a single comb, red earlobes and lead-gray shanks.

Tosa-Kukin (Fig. 21)

The Japanese word "Kukin" means Cochin. This breed was established in Kochi Prefecture during the Meiji Era (1868 – 1912) by crossing the Cochin and some Japanese native breed. The body size and shape are very similar to the Nagoya mentioned above. The plumage color is buff columbian like the Nagoya breed. The buff color of this breed is true buff and the tail feathers are brownish, differing from the Nagoya, which is an Orange buff color with black tail feathers. The Tosa-Kukin was originally used for egg and meat production. However, the number of Tosa-Kukin is very small. People now rear this breed to enjoy its figure. The other features included a single comb, red earlobes and yellow shanks.

Mikawa (Fig. 22)

This breed was established in Aichi Prefecture during the Meiji Era (1868 – 1912) for egg production. Although the breed was established in Japan, no Japanese native breeds contributed to its establishment. Some foreign breeds were crossed in Japan to make this breed. This breed has an RJF-type body shape with buff colored plumage. Similar to the Tosa-Kukin, the number of this bird is very small currently in Japan. This bird has a single comb, white earlobes and yellow shanks.

Conclusion

In the past, Japanese fancy chicken breeds were not used for egg and meat production. However, they have good quality eggs and meat. The author thinks that Japanese fancy chicken breeds are valuable genetic resources for improving commercial chickens. In Japan, new meat-type chickens have been produced in every Prefectural Livestock Research Institute by mating Japanese fancy fowl (e.g., Oh-Shamo, Satsuma-Dori, and Hinai-Dori) to American breeds (e.g., White Plymouth Rock, Barred Plymouth Rock, and Rhode Island Red) to produce more delicious meat than commercial broilers (F_1 hybrid between White Cornish and White Plymouth Rock) meat.

The author is now performing quantitative trait loci (QTL) analyses to reveal useful genes controlling meat and egg quality. When this analysis is completed, we will be able to efficiently produce new useful chicken lines or breeds based on Marker Assisted Selection.

In addition to the QTL analyses, the author is performing a phylogenetic study on Japanese native chickens using microsattelite DNA polymorphisms. When this study is completed, the genetic relationship between Japanese native breeds will be precisely revealed.

Table 1. The breeds of Japanese native chickens

Japanese name	English name	The prefecture of origin or main habitat
	Fancy fowl	
Aizu-Jidori*	Japanese Old Type —Aizu	Fukushima Pref.
Chabo	Japanese Bantam	Tokyo, Chiba Pref., Kanagawa Pref., Saitama Pref., Gunma Pref., Shizuoka Pref., Osaka Pref.
Daigiri-Shamo	Single Combed Large Game	Yamaguchi Pref.
Echigo-Nankin-Shamo	Niigata Slender Game	Niigata Pref.
Ehime-Jidori*	Japanese Old Type-Ehime	Ehime Pref.
Gan-Dori	Aomori Creeper	Aomori Pref.
Gifu-Jidori	Japanese Old Type — Gifu	Gifu Pref.
Hinai-Dori	Japanese Dainty	Akita Pref.
Hiroshima-Tsuuji	Hiroshima Game	Hiroshima Pref.
Ingie	Kagoshima Large Rumplessness	Kagoshima Pref.
Iwate-Jidori*	Japanese Old Type-Iwate	Iwate Pref.
Jisuri	Short Legged Large Game	Kumamoto Pref.
Jitokko	Japanese Creeper	Kagoshima Pref., Miyazaki Pref.
Kawachi-Yakko	Japanese Brave	Mie Pref.
Kinpa	Japanese Henny Feathered Game	Akita Pref., Aomori Pref.
Koeyoshi	Japanese Good Crower	Akita Pref., Aomori Pref., Iwate Pref.

Japanese name	English name	The prefecture of origin or main habitat
Ko-Shamo	Japanese Small Game	Tokyo, Kanagawa Pref., Niigata Pref., Shizuoka Pref., Kochi Pref.
Kureko-Dori	Kumamoto Long Tail	Kumamoto Pref.
Kuro-Kashiwa	Japanese Black	Yamaguchi Pref., Shimane Pref.
Mie-Jidori	Japanese Old Type —Mie	Mie Pref.
Minohiki	Japanese Saddle Hackle Dragger	Aichi Pref., Shizuoka Pref.
Miyaji-Dori	Kochi Creeper	Kochi Pref.
Nankin-Shamo	Japanese Slender Game	Ibaraki Pref., Chiba Pref.
Ohiki	Japanese Tail Dragger	Kochi Pref.
Oh-Shamo	Japanese Large Game	Tokyo, Ibaraki Pref., Chiba Pref., Aomori Pref., Akita Pref., Kochi Pref.
Okinawa-Hige-Jidori*	Okinawa Old Type —bearded	Okinawa Pref.
Sado-Hige-Jidori*	Japanese Old Type —Niigata bearded	Niigata Pref.
Satsuma-Dori	Kagoshima Game	Kagoshima Pref.
Shibattori	Japanese Old Type —Niigata	Niigata Pref.
Shoukoku	Japanese Elegancy	Kyoto Pref., Mie Pref., Shiga Pref.
Tokara-Jidori*	Japanese Old Type — Tokara	Kagoshima Pref.
Tokuji-Jidori*	Japanese Old Type — Tokuji	Yamaguchi Pref.
Tosa-Kojidori	Japanese Old Type —Tosa	Kochi Pref.

Japanese name	English name	The prefecture of origin or main habitat
Tosa-Onagadori	Japanese Long Tail	Kochi Pref.
Toumaru	Japanese Black Crower	Niigata Pref.
Toutenkou	Japanese Red Crower	Kochi Pref.
Tsushima-Jidori*	Tsushima Old Type	Nagasaki Pref.
Ukokkei	Japanese Silkie	Tokyo, Mie Pref., Osaka Pref., Hiroshima Pref., Yamaguchi Pref., Kagawa Pref.
Utaicharn	Okinawa Crower	Okinawa Pref.
Uzurao	Japanese Small Rumplessness	Kochi Pref.
Yakido	Mie Game	Mie Pref.
Yamato-Shamo	Yamato Game	Tokyo, Saitama Pref., Fukuoka Pref.
	Utility fowl	
Izumo	—	Shimane Pref.
Kumamoto	—	Kumamoto Pref.
Mikawa	—	Aichi Pref.
Nagoya	—	Aichi Pref.
Tosa-Kukin	—	Kochi Pref.

*There is no evidence that these breeds are real "Jidori (Old Type)", but they are generally called "Jidori". Further studies are necessary in the future to elucidate whether these are real "Jidori".

Fig. 1. Tosa-Kojidori (Japanese Old Type-Tosa), black-breasted red
Left: male, Right: female

Fig. 2. Gifu-Jidori (Japanese Old Type-Gifu), black-breasted red
Left: male, Right: female

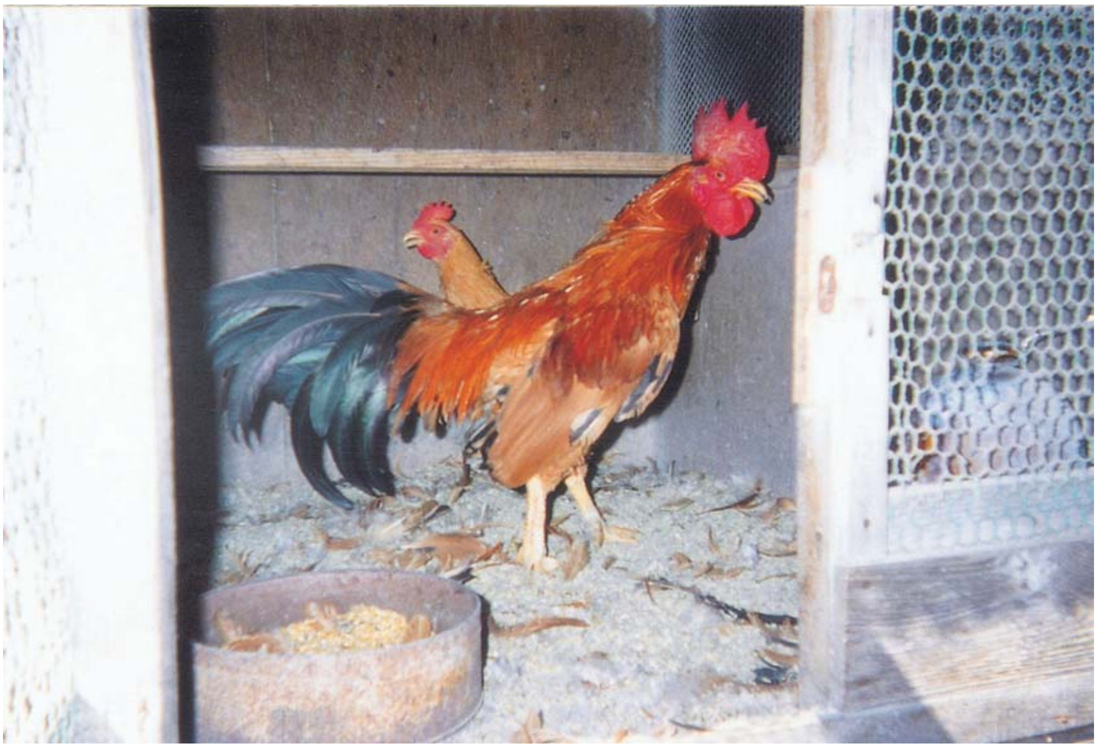

Fig. 3. Mie-Jidori (Japanese Old Type-Mie) cock, buff columbian

Fig. 4. Shoukoku (Japanese Elegancy) cock, black-breasted white with brown wing coverts

Fig. 5. Oh-Shamo (Japanese Large Game) cock, black-breasted red

Fig. 6. Chabo (Japanese Bantam) cock, white columbian (black-tailed white)
The tail feathers are shorter than in the normal condition due to molting.

Fig. 7. Ukokkei (Japanese Silkie), white
Left: male, Right: female

Fig. 8. Uzurao (Japanese Small Rumplessness), black-breasted red
Left: male, Right: female

Fig. 9. Tosa-Onagadori (Japanese Long Tail) cocks, white (left) and black-breasted white (silver duckwing)

Fig. 10. Ohiki (Japanese Tail Dragger), black-breasted red
Front: male, Back: female

Fig. 11. Toutenkou (Japanese Red Crower) cock, black-breasted red

Fig. 12. Koeyoshi (Japanese Good Crower) cock, black-breasted white with brown wing coverts. He is molting. The tail feathers are shorter and poorer than in their normal condition.

Fig. 13. Toumaru (Japanese Black Crower) cock, black

Fig. 14. Kuro-Kashiwa (Japanese Black), black Left: female, Right: male

Fig. 15. Satsuma-Dori (Kagoshima Game) cock, black-breasted red

Fig. 16. Hinai-Dori (Japanese Dainty), black-breasted red
Left: male, Right: female

Fig. 17. Minohiki (Japanese Saddle Hackle Dragger) cock, buff columbian
(Photo by K. Kimata)

Fig. 18. Jitokko (Japanese Creeper), black-breasted red Front: male, Back: female

Fig. 19. Kawachi-Yakko (Japanese Brave) cock, black-breasted white with brown wing coverts

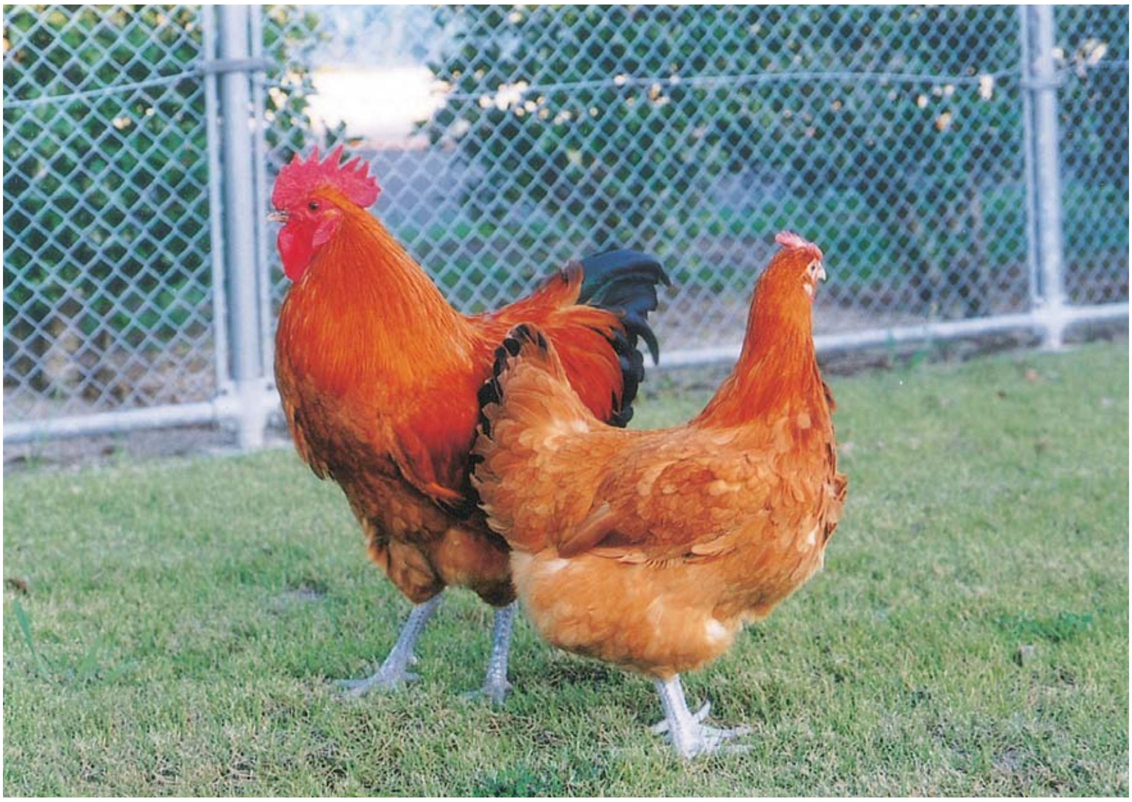

Fig. 20. Nagoya, buff columbian   Front: female, Back: male

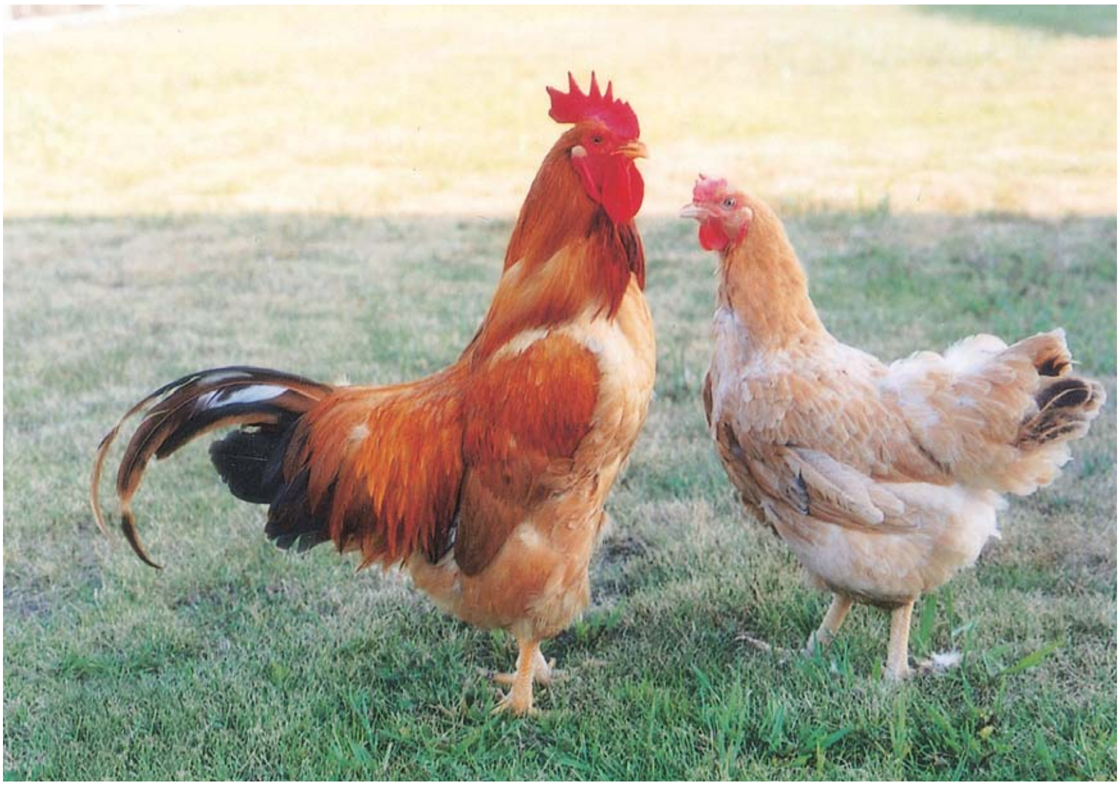

Fig. 21. Tosa-Kukin, buff columbian with brownish black tail feathers
Left: male, Right: female

Fig. 22. Mikawa cock with a dubbed comb and buff colored plumage

Pig

豬

ASIA-PACIFIC ECONOMIC COOPERATION

AGRICULTURAL TECHNICAL COOPERATION WORKING GROUP

The Role of Pigs as a Meat Source in the Environment and Human Culture

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Portuguese sailors on their way to Japan came across an island not identified on their maps in 1542. Amazed at the forest-cloaked land, they shouted, "Ilha Formosa," meaning "Beautiful Island." The island had thus come to be known as Formosa, which was to become what we know today as Taiwan with a total land area of 36,179 km^2. The main island of Taiwan is mountainous and afforested, with fertile, cultivated, well-watered and heavily populated lowlands to the west of the central mountain range. The climate is subtropical, with hot humid summers, mild winters and heavy rainfall. There is a continuous growing season for crops and agriculture prospers, in spite of typhoons, violent summer thunderstorms, and flooding as well as prolonged winter droughts. About a quarter of the land is arable. Five percent of the land is meadow and pasture. The human population is 23.1 million and there were more than 6.8 million hogs raised by 13,054 farms in 2002.

Wild pig hunting

The pig has been a tremendously important meat source along with deer in the life of the prehistoric Taiwan inhabitants. This is based on a vast archaeological bone fossil find in Formosa (B.C. 5000 – 6000). The prehistoric inhabitants of Formosa might have had the ability to raise dogs for wild animal hunting to obtain meat sources such as pigs, deer and other mammalian animals. Several tribes inhabited Formosa before discovered by Portuguese. Presently they continue to maintain several traditional hunting skills for wild pigs hunting and pig bones collection. Such skills are used to encourage young boys into maturity. The scientific name of the Formosa wild pig is "Porcula talvana Swinhoe" which was introduced in 1862 to European people by British Robert Swinhoe and written in his report "On the mammals of the island of Formosa". This report was published in the proceedings of the Zoology Society at London. Robert Swinhoe, an explorer of the natural resources in Formosa, conducted observations of wild animals and plants in northern Hsinchu County in 1856 and in southern Tainan County in 1858. In 2000, Taiwanese zooarchaeologist Ming-yung Chiu theorized from the differing dental criteria for domestic and wild pigs that prehistoric inhabitants raised pigs at the Shisan Hsing and Chih-shan-yen prehistoric sites.

Archaeologically, Taiwan was home to both Paleolithic and Neolithic cultures. The latter appeared at least six to seven thousand years ago. Inhabited by indigenous peoples from the Austronesian linguistic group, Taiwan was primarily a primitive society at the turn of the 17th century. Some scholars believe that Austronesian-speaking peoples first emerged in southeastern coastal China roughly five or six thousand years ago, and that Taiwan was one of their original homes. Australian archaeologist Peter Bellwood theorized that the forefathers of the Austronesian peoples crossed the sea in waves from rice-growing areas along the southeast China coast to Taiwan approximately six thousand years ago. From Taiwan these people dispersed to the Philippines and Indonesia roughly five thousand years ago. They colonized Micronesia more than two millennia ago, and arrived in Hawaii, Easter Island, New Zealand, and other Polynesian islands about a thousand years ago. Conversely, some scholars have interpreted chromosomal analysis results to imply that Southeast Asia may have been the original homeland of two groups of Austronesian immigrants. One group went to Taiwan, and the other to Polynesia. Richard Jr. Shulter and Jeffrey C. Marck relied on linguistic and archaeological data and the theories of Isidore Dyen concerning language distribution and human migration, to propose that Taiwan was the cradle of Austronesian speaking peoples.

In recent years researchers have obtained specific data concerning the genetic and blood relationship between Taiwan's Austronesian inhabitants and groups living in other regions. Taiwan's Mackay Memorial Hospital performed DNA research involving red blood cells and blood types, discovering that Taiwan's aborigines may be the world's most homogenous ethnic group – a so-called "purebred group." Haplotypes (specific gene configurations) commonly seen in Taiwan aborigines also appear in New Zealand's Maori, New Guinean highlanders, Australian aborigines, the Inuit, Mongolians, Japanese, Manchurians, and Tlingit Indians living in Northern Canada. This suggests that the Taiwan aborigines are genetically linked to these groups. There seems to be a particularly strong relationship between Taiwan's Amis, the New Guinea highlanders and the Australian aborigines. There is also a close genetic link between the Yami of Orchid Island in Taiwan and the Ivatan of Batam Island in the Philippines. The languages of these two groups are still mutually intelligible. Several years ago the Yami initiated a series of visits between Orchid and Batam islands.

Historical records indicated that the Taiwan aborigines were classified as either “raw” or “cooked” during the early years of the Qing Dynasty, depending on whether they obeyed the government and accepted **Han**-Chinese customs. When Taiwan was a colony of Japan, the aborigines were generally termed "*takasago*". An official survey taken during the Japanese period recorded at least 19 different aboriginal groups in Taiwan. The government continued to follow the Japanese classification scheme in 1949, but substituted the term "shan-bao (mountain compatriot)" for "*takasago*". The government also classified the aboriginal population as "mountain shan-bao" and "plains shan-bao " to facilitate administration. By the year 2000, the name of each aboriginal group was recognized again. The recognized groups were the Amis, Atayal, Bunun, Paiwan, Puyuma, Rukai, Saisiyat, Thao, Tsou, and the Yami of Orchid Island. Except for the Yami, with the skill to raise pigs, the other tribes maintain a wild mountain pig hunting culture. The various aboriginal groups in Taiwan are highly diverse in terms of social organization, culture, language, religion and even body type. In pre-modern times, the lifestyle of most groups was constrained by their environment. Those living near the coast specialized in fishing and those living in the mountains specialized in hunting. The aborigines once subsisted through hunting, gathering and slash and burn mountainside land cultivation. Apart from the Amis of Eastern Taiwan and the Yami of Orchid Island, the majority of Taiwan's aboriginal groups have no seafaring traditions. The rapid socioeconomic changes that have occurred in recent decades have caused aboriginal residents to give up hunting, fishing and shifting agriculture. Instead, most make their living by fixed agriculture and other commercial activities. Despite periods of control by other colonial powers, including the Dutch and Japanese, many Taiwan aboriginal groups have assimilated into Han-Chinese culture. Some traditional cultures have disappeared completely. A few groups still preserve their cultural heritage – a heritage deriving from several millennia of history – relatively intact. Presently, the Yami of Orchid Island in Taiwan still maintain their traditional family values, i.e., adult males should raise their own pigs. The meat from these pigs should be shared equally with all friends on special occasions.

Raising domestic pigs

Pig domestication occurred some 5000 years ago to provide a source of food protein in several civilizations. In China, pork is the meat of choice. Pork fat is used as shortening in the majority of dishes. Chinese cuisine has actually evolved around pork. Valerie Porter mentioned that domesticated pigs are marvelously diverse in shape, size, features and colors. The sway-backed, pot-bellied, wrinkle-skinned lard pigs of South East Asia are in sharp contrast to the long, lean white breeds of Western Europe. The thick, curly coat of Eastern Europe's Managalitsa defies its relationship with the hairless miniature cuino of Central America. Because of the large human population in China, pigs were confined to small households or farms much earlier than in Europe. This type of confinement led pigs to evolve into more docile, lethargic animals that were more dependent upon man for their food supply. In recent years, Chinese archaeologists have claimed that pigs have been domesticated there for 7,000 years. This is from carbon-14 evidence dating pig bones at sites spread widely over the country. It is not only by their bones that prehistoric domesticants can be recognized but also artistic representations give clues. It was only after domestication that pigs gained curly tails or lop ears. In 3486 B.C., emperor Fo-Hi of China decreed that swine should be bred and raised.

Development of the pig industry

With a monsoon climate similar to that of Southern China, and with a history of immigration, it is hardly surprising that most of the local pigs are the Southern Chinese type. The Taiwan native pigs include the Taoyuan and Taiwan Small Black. The Taoyuan is a large pig with a black or dark gray coat color; lop ears, wrinkled skin and a straight tail. The Taiwan Small Black was believed to have descended from a mixture of domestic pigs brought over from Southern China by immigrants and the local wild *Sus scrofa taivanus* that was domesticated by Taiwan's aboriginal people. The Taiwan Small Black with characteristics of long, straight snout and very small ears is also called a miniature pig since the 1970s.

Since the 1990s, it has been called the Lanyu. Both are probably the last to survive and exist only in tiny numbers. The Taoyuan is an indigenous Taiwan breed whose ancestors were brought from Ming-Ching dynasty China in the seven-teenth century. In 1897, Taiwan brought in 7 head of the exotic Berkshire boar breed to cross with local breed Taoyuan sows to produce hybrid vigor hogs. This promoted tremendous meat production in Taiwan. Modern exotics introduced from 1959 onwards, including the Duroc, Hampshire, Yorkshire and Landrace breeds. Later from 1975, it was found that a Duroc boar with Yorkshire/Landrace crossbred sows produced much better progeny for meat production. The three-way cross then became more popular in Taiwan.

Pigs are often fed in confinement on small land holdings with small exercise yards, next to the owner’s household. After World War II, Taiwan’s successful small-scale farm development played various critical roles and laid the foundation for an economic miracle. Feed mills began producing formulated livestock feeds using mostly imported ingredients on a large scale at the end of the 1960s. The large swine farms, with thousands of sows used modern feed, formulated on farms with modern management and housing systems. During 1986 and 1996, Taiwan became a major exporter of pork to Japan. There were five significant stages in this development:

1. **Meeting the food demand in the rehabilitation stage (1945 to 1953)**
   The government was struggling to restore agricultural irrigation facilities, increase fertilizer supplies, provide better variety and improve farming techniques to increase food production as quickly as possible. The "Rice-fertilizer Barter System", "Fertilizer Distribution Regulation", "Food Management Act", "37.5%-Rent-Reduction", "Sale-of-Public-Lands", and "Land-to-the-Tiller" were in effect. Agricultural production was restored to the pre-war period level.

2. **Fostering the industry sector through agriculture (1954 to 1967)**
   After laying foundation for basic agricultural development, the first four-year national economic development plan was carried out. The "Fostering Industry through Agriculture and Developing Agriculture by Industry" plans were announced. The government reinforced production incentive measures using the "Integrated Pig Farm Programs", "Integrated Crop and Livestock Program", "Farm Financing Project", and "Regulation for Agricultural Extension" programs. To accelerate transferring capital funds from the agricultural sector to the non-farm sector, "The Farm Land Tax in Kind" and

"Compulsory Paddy Rice Purchase" programs were promulgated in 1954 under the food price cap policy.

3. **Developing industry as well as agriculture (1968 to 1983)**

The development of Taiwan's economy was further advanced. Although the industrial and commercial services led the driving forces for national development, the role of agriculture in providing staple food and its contribution to the entire economy were still recognized. Agricultural production focused on the development of labor-intensive cash crops for exportation. Products such as mushrooms, asparagus and processed tomatoes were used in the early stage. In the later stage, capital-intensive production involved coastal and inshore fishing and hog and chicken commercial farming. Agricultural policy programs such as the "Accelerated Mechanical Program (1970)", "Agricultural Development Act (1973)", "Guaranteed Price for Paddy Rice Procurement (1974)", "Increasing Farmer Income and Enhancing Rural Reconstruction (1979)”, and "Enhancing Basic Construction and Boosting Farmer Income (1982)” were launched.

4. **Adjustment and renovation (1984 to 1990)**

After thirty-years development, agriculture, then a traditional and closed-door sector, reached its development climax under limited and scarce natural resources. At the same time, upon request from trading partners, the foreign importation of agricultural products surged into the domestic market. It was unavoidable that the gap between the production and marketing structure widened due to the influx of foreign products. The "Strengthening the Agricultural Structure and Boosting Farm Income" and "The Paddy Rice Diversion” Programs were implemented. Although agricultural production increased at a 2% annual growth rate, agricultural contribution to GNP declined from 6.3% in 1984 to 4.2% in 1990. The agriculturally employed population was reduced from 17.6% to 12.9% during the same period.

5. **Multi-functionality (after 1991)**

To meet the challenge of trade liberalization, nature conservation and environmental protection, Taiwan launched the "Integrated Adjustment Program" in 1991, which emphasized the importance of multi-functionality through human resources, land, markets, techniques, organization, fishery, welfare and conservation. The "White Paper on Agricultural Policy" was announced in 1995. It declared a long-term policy toward commitment to integrating production, living and conservation. In 1997, the "Cross-Century

Agricultural Development" program was enacted. The percentage of agricultural contribution to GNP continues to decline in spite of its growing magnitude. Agriculture's contribution further dropped to 2.1% in 2000. The role of agriculture has been transformed from "production-oriented" in the early stage to non-economic contributions such as "open space, greening, scenery and nature conservation".

In 2000, two native breeds were classified: the Taoyuan and Lanyu. The Taoyuan was found only in tiny numbers at research institutes. A few Lanyu remained on the outer islands. The exotic Duroc, Landrace and Yorkshire are the most popular breeds for three-way cross hog production. Young Duroc, Yorkshire and Landrace boars with registered parent(s) were performance tested at the Taiwan Livestock Research Institute, COA started from the first test group of September 1989. There were 40 contemporary groups finishing the growth performance tests at the station by August 1999. There were 3,796 boars in attendance, with 82.8% completing the tests. The starting weight was set around 30 kg during 1989 to 1995. It was then increased to 40 kg in accordance with the national hog cholera free project requirements. The end weight was set at 110 kg during all test periods. The average daily gain, feed efficiency and backfat thickness were recorded and evaluated as a contemporary group deviation form for selection index calculation purposes. All original data and evaluated results were stored in an internet-based database. The performance tested data and related information can be easily accessed from anywhere on the World Wide Web *http://www.angrin.tlri.gov.tw*. The economically important traits such as PSS genotype, lineage information such as registration information, and tested parental performance can be accessed recursively through the web. The minimum ages of the tested boars at 110 kg body weight were 128, 134 and 131 days of age in Landrace (199905 tested group), Yorkshire (199609 tested group) and Duroc (199905 tested group), respectively.

Pig for science studies

Pigs have been closely associated with humans and contributed to human well being for many centuries. They provide humans with food, leather, brushes, fertilizer and serve as companions and garbage cleaners for farm families. In 1950, scientists in a group led by Professor Winters at Minnesota University initiated biomedical research on pigs known as the Hormel and Pitman-More research in the United States. In 1962, Gottingen University in Germany developed the Gottingen miniature pig, which was considered a new and universal miniature pig. Recently indigenous pigs have declined in Taiwan in the last century. Indigenous pigs were culled and replaced with exotic breed pigs. The miniature pigs reigned as the preferred experimental animal for medicine and/or biomedical research. These miniature pigs were crossed with the Small-eared pig, it has been called the Lanyu, that was one of the indigenous pigs in Taiwan. Today, the Small-eared pig is developed for its small size and conserved as one of the native breeds by the Livestock Research Institute (LRI), Council of Agriculture (COA) and National Taiwan University.

Contribution to biomedical science

The miniature pig was in use for medical research as experimental animals. The Hormel, Pitman-Moore from Minnesota and Gootinggen minipig from Germany were put to good use in biomedical laboratory research. Several special minipigs are used in research. The “Sinclair” is used in cancer research; the “Yucatan” for diabetes and the “von Willebrand” is used for hemoglobin types. These miniature pigs have found tremendous use in biomedical research in Taiwan. Miniature pigs are used as experimental animals because the physical constitution is more similar to that of human beings than any other experimental animals. Therefore, it is a good animal model for pre-clinical operation trial usage. In testing the toxicity of a drug on the kidneys, a metabolic cage can be used to isolate the pig’s urine and excrement. Minipigs are also used for preoperative cardiac catheter testing. The surgeon professor of National Taiwan University Hospital used a piglet with 3 kg body weight and 3 weeks of age for a fresh liver transfer into a yearling pig with 60 – 70 kg of body weight. This experiment simulated the transfer of a healthy liver from a new-born deformed baby into an old man to replace the malfunctioning liver. Several years ago, more than half the current number of minipigs was used to develop embryo transfer or/and transgenic techniques. Some pigs were used in parasitology, ophthalmology and food science. At present, embryo transfer, transgenic animals, parasitology, ophthalmology and food sciences are applied less than dentistry, arthropathy, immunology, otolaryngology and orthopedics uses. This might reflect the current biomedical research trend in Taiwan.

Miniature pigs moved to the experimental animal stage because of the development of organic transplant technology. The mouse, rat, and rabbit were the historical experimental or laboratory animals due to less cost in propagation and management. Although the reproductive cycle, growth, and life span of the traditional laboratory animals were favorable, the body weight and organ sizes were more far from the corresponding organs in human when compared with those of pig. Primates, monkeys or macaques, were not used because they exhibited poorer reproductive performance and had higher management costs. Pigs are omnivorous animals, like dogs, and can play an important role as experimental animals. Although the reproductive performance of pigs is less efficiency than that of mice or rats, its 114 days gestation (3 months, 3 weeks and 3 days; 3x30+3x7+3 days=114 days) are easy to manage. With 4 weeks nursing after parturition one can expect to have two parturitions within a year with 7－8 piglets per litter. Furthermore, the shape and size of heart and kidneys of pigs are similar to the corresponding human organs, which conduce to organ transplant technique development, and thus make pig being the choice of experimental animal. Finally, what remains is to make the pig easy handle on the operating table and improve feeding management. Therefore, the first consideration is reducing the pig's size to the miniature level for experimental purposes.

Small-eared pig is a miniature pig source

The Small-eared pig has served as the animal model in the Society of Research on Native Livestock reports in Japan. The Taiwan Small-eared pig has small ears and small body size. It has a black coat color, straight erect face and small ears. Because they are not production economically efficient, the small pigs disappeared from the main Taiwan Island before World War II. However, they do exist on Orchid Island, also called Lanyu in Chinese. Lanyu is a separate island off Taitung county in southeast Taiwan in the Pacific Ocean. Primordial Lanyu, called the Nude Island in former centuries, is belongs to one of the Taiwan aborigine Yami races. The Yami tribe on Lanyu raised Taiwan indigenous Small-eared pigs, it has been called the Lanyu since the 1990s, before the official conservation policy made. They kept Small-eared pigs in bunkers. With not enough for food, the pigs were fed taro skins, garbage and human excrement. Century after century natural selection has given Small-eared pig a small body size. Also, the Yami traditionally choose a nursling piglet for food after parturition, which can reduce the litter size and ensure reproduction success under poor environmental conditions. Thus, both natural and artificial selections strategies helped the development of miniature pig.

The Guam small-eared wild pig, Vietnamese indigenous small-eared pig and Gottingen Miniature Pig of Germany were all developed under similar conditions. Taiwan Small-eared pigs are now developed as experimental animals. With economic growth and development in Taiwan, living standard of the Yami has been greatly promoted. Therefore, it can be expected that the Lanyu bunker Small-eared pigs will be replaced by exotic breeds due to efficient production performance.

Many indigenous pigs in Taiwan are not fed complete mixed feed, such as "Western feed". When indigenous pigs are fed western feed, both growth and reproduction performances are incompatible to that of exotic western breeds raised on western feed (complete mixed feed). These low efficiency indigenous pigs will eventually be culled and extinct. The indigenous Taoyuan pigs were crossed with the exotic Berkshire to produce two highly efficient hybrid breeds for meat production at the beginning of the 1900s. The Taoyuan pigs are currently conserved in the Livestock Research Institute, COA. The Small-eared pig has less economic efficiency and was lost to the main Taiwan Island and kept only by the Yami tribe on Lanyu, a solitary island. It is believed that only changing from food source to experimental animal usage will the Small-eared miniature pig be conserved.

Development of the Lee-Sung minipig

Professor T. Y. Lee and Dr. Y. Y. Sung, from Department of Animal Science, National Taiwan University in 1975, initiated the development of Small-eared pig as a laboratory animal and named as Lee-Sung minipig. In Lanyu, the usual mass selection method was carried out at three weeks of age in one male and five female bases with 3 kg weight each. The selected male is considered as precious piglet that the Yami will not sell to another village. The Yami believe that if you sell your boar, all of your hogs will run away from the village. The litter size of Small-eared pigs ranges from 5-6 head. The Yami tribe will choose slaughter male piglets day by day for food to decrease the litter stress, and thus increases the suckling opportunity for remaining piglets. Therefore, nearly all piglets are females because quite limited male piglets are allowed to survive. This is why it is difficult to acquire a Small-eared boar and has contributed to the disappearance of Small-eared pigs on the main Taiwan Island. Six piglets chosen were then sent to the department pigsty for performance observations, including body weight measurement, and fed western feed instead. At early maturity, about four months of age with 10 kg body weight in average, the pigs show the mounting behavior and a 21-day estrous cycle, as ordinary pigs. However, boar reaches sexual maturity a little earlier than that of gilt. Although pregnancy is possible from 4 months of age due to early mature characteristics, pig is usually bred at about seven months of age. The pregnancy lasts about 114 days as ordinary pigs and gives 5 – 7 piglets per litter.

Hand feeding for miniature pigs

Small-eared pigs can be hand or trough fed. During the growth period the pigs always have a good appetite and are easy to fatten. Obesity will occur if the pigs are overfed. However, obese pigs with stubby legs are not suitable experimental animals. The cost difference in hand feeding (limited feeding) and trough feeding is substantial. Hand feeding Small-eared pig is limited to 10 minutes consumption time and accounted for 70% of trough feed quantity. The pigs were hand fed from 8 weeks of age to 52 weeks old. The difference between boar and gilt weights was significant at 52 weeks. The adult boar of exotic breeds is, in general, heavier than that of gilt and it was not the case in the Small-eared pigs. Reasons for this are as follows: (1) The artificial selection method used by the Yami tribe resulted to larger male pigs slaughtered for meat and the smallest male pig reserved as the special male piglet for replacement. (2) Early sexual behavior, such as mounting each other starting from 4 months of age, occurred in boar. Early puberty in male piglet also results appetite loss and standing at attention for females, and thus loss weight.

Agricultural by-products were used to study the digestion physiology of pigs and corresponding roughage tolerance measurements were collected. Both Lanyu miniature and TLRI Black No. 1 pigs were used to conduct pig-pasturing experiments in summer. In the Lanyu miniature pig experiment, 14 gilts (5 months old) and 14 30-day pregnant sows (3 years old) were allocated into a 30 x 80 m grazing pasture. The grazing pasture area was equipped only with a water supply and 120 cm height of grasses. After 7 weeks of pasturing, the weights of gilt and sow decreased from 22.5 ± 4.8 to 15.2 ± 3.4 kg and 65.7 ± 14.3 to 49.0 ± 11.5 kg, respectively. By giving half the amount of normal feeding for another two weeks, weights of gilt and sow gained to 18.2 ± 3.9 and 57.0 ± 14.6 kg, respectively. Although 16 kg weight loss occurred after 7 weeks of pasture grazing, forty-three percent (6/14) of the sows maintained pregnancy to term and produced viable fetuses with 5.1 born alive litter size on average. These results confirmed that the Lanyu pig had high tolerance to forage. Similar experiment was also conducted for TLRI Black No. 1 pigs, which was comprised of 75% Duroc and 25% Taoyuan breeds. Six 5-month-old gilts and six 3-year-old weaned sows were allocated to the grazing pasture for 7 weeks too. Weights of gilt and sow decreased from 63.4 ± 9.2 to 52.5 ± 8.7 kg and 183.6 ± 31.9 to 151.1 ± 29.8 kg. After two weeks on diet feeding after pasturing, the corresponding weights gained to 55.3 ± 11.9 and 155.1 ± 31.9 kg, respectively. There were 32.4 and 17.2% of weight loss in Lanyu miniature and TLRI Black No. 1 gilts. Similar trend was also found in sows of corresponding breeds, which accounted for 25.4 and 17.7% weight loss. The 7-week grazing model in summer pasture for forage tolerance determination could serve as a fiber utilization efficiency evaluation among pig breeds.

Inbred line – Spotty Lanyu

The small pig size has a benefit for laboratory animals. It is always best to have some small variations in genetics. This will reduce the intra-variation error and increases the differences in inter effect treatments in the animals experiment. Therefore, Small-eared pigs served as laboratory animals need decreased genetic variation and thus inbreeding via full-sib mating can be used to accelerate the genetic homology. Selection for small size via full-sib mating was conducted in research institute. The litter size, birth weight, 8-week weaning weight and survival rate, 22-week body weight and yearling weight were investigated and recorded. The inbreeding coefficient in the first inbred generation was 37.5%, which was much higher than that of ordinary selection program. In general, the inbreeding coefficient of farm animals breeding herd is maintained less than 3% for economic purposes. The body size of the third generation offspring from full-sib mating was decreased and corresponding offspring revealed slightly weak body condition. However, the litter size did not decrease although the inbreeding coefficient reached 59.4%. Inbreeding usually has a depressive effect on progeny vitality. Thereby, it was not surprised a recessive lethal gene defect was observed in Small-eared pigs, such as no hind-legs white spotty offspring found in the first generation of full-sib mating. Because these pigs were incapable of movement, they soon succumbed. To improve the vitality of the inbred pigs, line inbreeding within closed herd was conducted to characterize the uniform small body size with good vigor. The inbreeding coefficient was maintained low and increased slowly in the following generations.

The Lanyu pigs is a native breed with solid black coat color. The founder population of Lanyu pigs was formed and conserved as a closed herd at the Taitung Animal Propagation Station, LRI, COA, Chinese Taipei. There were 4 males and 16 females introduced originally from Orchid Island in 1980 and propagated via random mating since then. In 1993, thirty-seven piglets with white spots on solid black coat were observed and isolated, which may be due to unavoidable inbreeding occurred in the closed conserved population. Following up the isolation in white spots, six boars and eighteen sows were selected to form the base population (G0) of "Spotty Lanyu–inbred line". There were, in total, 37 male and 53 female piglets from 18 litters obtained in the first generation (G1) with average birth weight (mean ± standard deviation) being 0.80 ± 0.20 and 0.74 ± 0.18 kg, respectively. Based on coat color and one-generation per year selection scheme, 6 boars and 18 sows were selected as replacement breeding stocks for each following generation.

The body conformations of G1 and G2 pigs at five months of age were recorded for evaluation, which included body weight, body height, body length, ear length, ear width, chest depth, chest girth, length and girth of fore limb, girth of hind limb, rump width and length of tail. There was no significant difference observed between generations or gender ($P>0.05$). G2 boars and gilts at five months of age weighed 20.30 ± 2.67 and 17.90 ± 4.14 kg, respectively, with a body height of 38.71 ± 1.20 and 36.04 ± 3.51 cm, and body length of 63.90 ± 3.53 and 54.75 ± 12.31 cm, which indicated the potential of Spotty Lanyu being an ornamental pig for recreation. In G4 generation, 63 piglets from14 litters with 4.5 mean litter size farrowed by G3 gilts were obtained with body weights of 0.88 ± 0.21 (N=31) and 0.86 ± 0.13 kg (N=32) at birth for males and females, respectively. The corresponding average weaning weights at eight weeks of age were 6.30 ± 0.67 and 6.18 ± 0.39 kg, respectively. The preweaning survival rate of the G4 piglets was 88.9%.

Inbreeding depression was found in litter size born alive of sows in the Spotty Lanyu inbreeding selection scheme. The G0 to G4 sows had 5.18 ± 2.30, 5.00 ± 2.13, 4.68 ± 2.40, 4.50 ± 1.64 and 4.38 ± 2.09 born alive piglets per litter at first parity, respectively. There was no significant difference among the age at first parity for the G0 to G4 sows. The range of farrowing age at the first litter was 300 – 315 days of age. The survival rates at 8 weeks of weaning age were 90.5, 84.2, 87.4, 88.9 and 86.0%, respectively. Finally, the Spotty Lanyu pigs could also serve as a animal model for biomedical research due to highly inbreeding background.

Coat color

Although the Small-eared pig is a minipig suitable as an animal model, biomedical research prefers white animals. The "Gottingen" pig in Germany has white and black strains with greater demand in white pigs. Some white spotted pigs were produced in Small-eared inbred herd. However, if the white spots become evenly expanded, the pig develops poor in health. This has thus far prevented white Small-eared pig development. The white spots are the result of inbreeding and F1, of which the white spot X white spot are evidence that the white spot gene is recessive. This recessive gene might be a modified recessive lethal gene. Fortunately, there is evidence that white coat color in pigs is dominant and mating black Small-eared pigs with white Landrace pigs produce white Small-eared pigs. Furthermore, the F1 hybrid appears white or with some small black spots and thus the black coat color in F2 is expected from the segregation of F1 with recessive black coat color of the Small-eared pig and dominant white in the Landrace breed. The white miniature pig is preferable although the body size is larger. Body size is an intermediate inheritance; therefore, the smaller Small-eared pig was used to produce a white colored miniature pig for decreased body size. A back crosses to the recessive black Small-eared pig is a backcross strategy to maintain the dominant white color in the white miniature pig. The Lee-Sung pig body size is between that of the inbred miniature pig and Landrace. Result from hybrid of the former two breeds showed much less weight at six months of age compared to that of exotic breeds, 36.9 kg on average *vs.* 90 – 100 kg. In addition, four Lee-Sung males at 10 months of age with 25 kg body weight were used to evaluate both semen quantity and quality. The semen quantity was less compared to that of exotic breed boars but the higher sperm concentration made the same of the total sperm number for each collection. The chromosomal karyotype was shown as 2n=38 and similar to all domestic pigs. Also, the Bgl II and Stu I endonuclease cleavage patterns on mitochondria DNA confirmed the maternal lineage between the Lee-Sung strain and the Small-eared pig strain I.

Mitsai – A miniature pig selected for ornamental and recreation purposes

A new miniature pig for ornamental purposes was developed. In 1989, two Lanyu boars were mated with six Duroc sows. Semen was collected from three Duroc boars and used to inseminate five Lanyu sows. Then the hybrid piglets were examined for coat color at eight weeks of age. All piglets exhibited longitudinal stripes from head to tail. Several brown stripes and black stripes appeared side by side on piglets from either Lanyu x Duroc crossing or Duroc x Lanyu crossing. Piglets with brown-black stripes were then selected as breeding stocks and bred using half-sibling relations to produce brown-white striped offspring. However, the brown-white stripping faded at puberty. These brown-white striped piglets were named the Mitsai pig and selection program for brown-white stripping was launched in 1992 with six male and 18 female breeding stocks each generation. The generation interval was preplanned on one year for each generation. Experimental results were as follows: The third generation (F3) of Mitsai sows produced 6.00 ± 2.10 live piglets per litter and 72.8% of the F4 piglets exhibited brown-white stripes, compared to 25.3% in F3. This was an increase of nearly three times. In F6 generation, all piglets showed brown-white stripes, which remained until the pigs reached maturity. The gene for brown-white stripping was postulated to relate to a recessive gene. For economic usage, the Mitsai line with miniature characteristics and brown-white stripping coat color could be served both as an ornamental pig for recreation and a laboratory animal for biomedical research.

The brown-white stripes of Mitsai piglets are expressed as several longitudinal stripes from head to tail with the brown stripe next to the white one. Twelve boars and 24 gilts born in 1998 were mated via full-sibling mating. Ages at first litter of gilts were 280 – 456 days of old with the average age 335 ± 48 days. The litter size at birth and born alive at first parity were 5.0 ± 1.6 and 4.7 ± 1.8 piglets, ranging from 3 to 9 and 1 to 9 piglets, respectively. Litter size at weaned and survival rate at 3 weeks of age were 3.9 ± 1.9 piglets and 83.0%, respectively, with weaned sow weight at first parity being 80.3 ± 15.7 kg. The farrowing interval between the first and second parities was 155 ± 12 days. The litter size at birth in the second parity was 5.3 ± 1.8 piglets with birth weights being 1.04 ± 0.22 kg (N=53) and 1.05 ± 0.25 kg (N=54) for males and females, respectively. The body weights at weaned and at 5 months of age were 3.63 ± 0.94 kg (N=44) and 27.8 ±

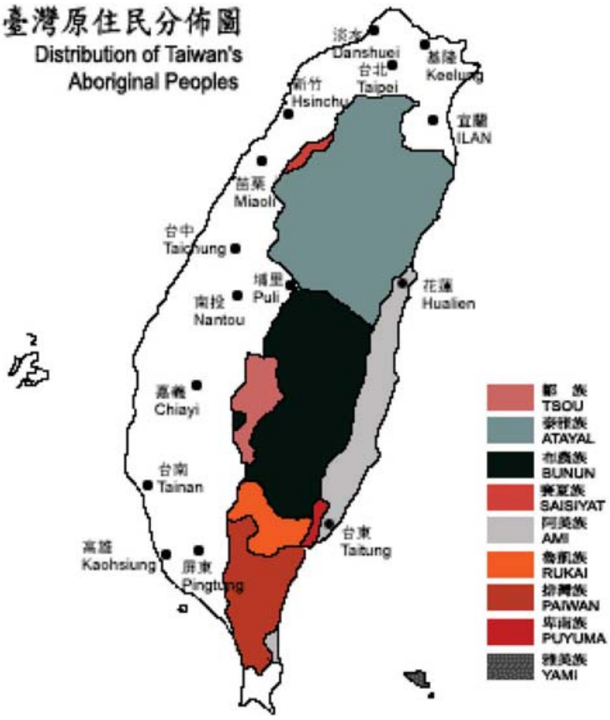
6.1 kg (N=19) for males, and 3.36 ± 0.91 kg (N=45) and 24.1 ± 6.1 kg (N=22) for females, respectively. Results showed that Mitsai sows produced more than 5 piglets per litter at birth and all piglets grew normally when full-sib mating was applied. Inbreeding depression due to full-sib mating was not observed.

Wild pig hunting

Pig skulls collection

Raising domestic pigs

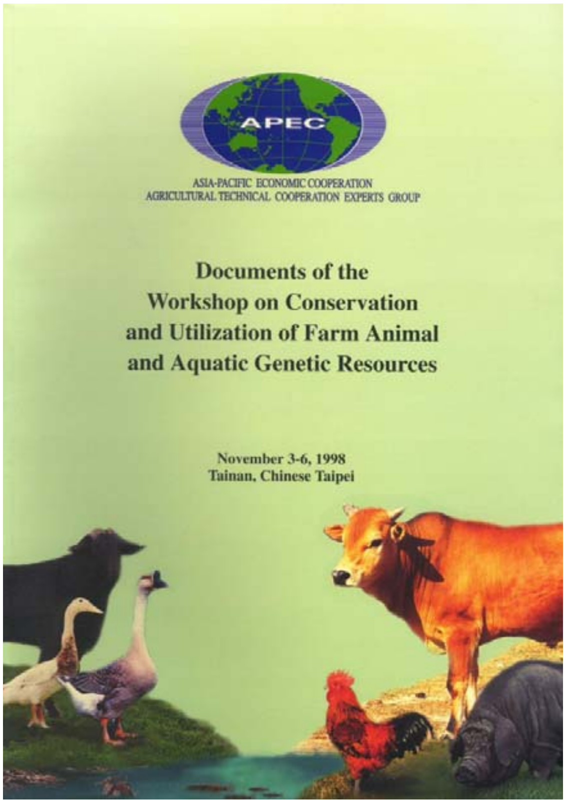
Conservation sites for domestic animals in Chinese Taipei



Distribution of Taiwan aboriginal peoples

Pig breeds in Taiwan in 2000

Pig meat



Documents from the Workshop on Conservation and Utilization of Farm Animals – 1998

New breed – Mitsai pig

郁 和 Swinhoe, Robert
1836～1877

台灣早期最偉大的博物學家

Robert Swinhoe, explorer of nature resources in Formosa

Prehistoric inhabitants in Formosa might have had the ability to raise hunting dogs for wild animal hunting to obtain meat from pigs, deer, and other mammals

後壁鄉泰安宮保有多隻不會腐壞的豬腳，最久的已將近四十年，據悉可以消災解厄，廟方放在媽祖神像前妥善保存。（記者王涵平攝）

破避官隨身糧食…遶境獲加持

紅線豬腳得神蹟…信徒保安康

茄苳媽 好神

豬腳不臭不腐數十載

Pig toe with red paper used for people’s wish in temple

Quail

鵪鶉

ASIA-PACIFIC ECONOMIC COOPERATION

AGRICULTURAL TECHNICAL COOPERATION WORKING GROUP

The Japanese Quail

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The Japanese quail belongs to the order *Galiformes*, genus *Coturnix*, and species *japonica*. The scientific designation for Japanese quail is *Coturnix japonica*, different from the common quail (*Coturnix coturnix*). The Japanese quail is found in Japan, Korea, Eastern China, Mongolia and Sakhalin as migrating birds.

The plumage color of the wild type is predominantly dark cinnamon brown. However, adult females have pale breast feathers that are speckled with dark colored spots. Adult males have uniform dark rust-red feathers on the breast and cheek (Fig. 1). Sex differences in plumage color appear about 3 weeks of age but not at 0 – 2 weeks of age.

The eggshell color of the wild quail is white, flesh-tint, light brown or speckled blue and/or brown. The size, shape and color pattern on the eggs vary considerably among females. These differences in egg color have been proposed as a means of identifying hens.

The Japanese quail is only one of many animals domesticated by the Japanese. The first record of wild Japanese quail appeared in the eighth century in Japan. Thereafter, several records of wild Japanese quail were found in several eras in Japan. The Japanese quail was semi-domesticated during the sixteenth century as a singing bird. Within the period from 1907 to 1941, the Japanese quail was selected for increased egg production. In 1941, about 2 million Japanese quail were kept. However, the majority of these domesticated quail were lost during the Second World War. After the war, the Japanese quail egg industry was rebuilt from the few remaining domesticated birds, possibly with the addition of domesticated lines from Korea, China, Taiwan and quails captured in the wild. Japanese quail are now farmed mainly for egg production in Japan. In Europe, they are selected for increased body weight for meat production. The body weight of meat quail is 2 – 3 times heavier than that of the egg production type.

Currently, about seven million Japanese quail are kept in Japan. About 4 million birds are kept in Toyohashi City in Aich prefecture. About 70 percent of the eggs are produced in this area. Recently, sex-linked brown plumage color has been used for auto-sexing in the quail industry in Toyohashi.

As mentioned above, the Japanese quail was used first as a singing bird and then as an egg producer. It later became popular as a laboratory animal, because of its small body size, little consumption and rapid maturation. Some standard biological data are shown in Table 1.

Table 1. Normal data on Japanese quail

Trait	Range
Body weight at one-day-old	6 ~ 8 g
Adult male	100 ~ 130 g
Adult female	120 ~ 160 g
Egg weight	9 ~ 10 g
Egg number/100 days	80 ~ 90
Age at sexual maturity	38 ~ 42 days of age
Life span	Max: 7 years in male
	Mean: 3 ~ 4 years

In Japan many Japanese quail strains were established and derived from commercial birds. Some of them are also registered in the International Registry of Poultry Stocks (Somes, 1988). These strains are classified into the following five groups with characteristics described as follows:

I. Random bred closed colonies in which as many varieties are maintained as possible.

I-1. WE strain: A random-bred white eggshell strain with wild plumage color was established in 1972 and maintained at the Nippon Institute for Biological Science (NIBS).

I-2. WT strain: A random-bred colored eggshell strain with wild type plumage color maintained at Hiroshima University.

I-3. Commercial strain: A random-bred colored eggshell strain with wild type plumage color maintained at the National Institute of Livestock and Grassland Science.

I-4. Wild strain: A random-bred colored eggshell strain with wild type plumage color derived from wild Japanese quail captured at Mt. Fuji. This strain is maintained at the National Institute of Livestock and Grassland Science.

I-5. Normal strain: A random bred colored eggshell strain with wild type plumage color maintained at Okayama University.

II. Closed colonies in which some specific marker genes (plumage color, eggshell color, blood typing *et al.*) are fixed.

II-1. PS strain: A random bred autosomal recessive pansy plumage strain maintained at Hiroshima University (Tsudzuki and Wakasugi, 1987). The pansy chicks show light yellow down with three narrow black stripes on the back. The adult plumage is basically composed of three colors, i.e. rust, black and white. Black is predominant on the head. The male has a brown or heavy rust face. The female shows a wheat-straw colored face with black stripes. In the back feathers, color bands are arranged from the base to the tip as follows: a gray base, mixed area of rust and black, large black area, a rust area and white tip. The rachis color is white at the base and becomes dark toward the tip.

II-2. YWE strain: Established in 1974. A random bred white eggshell strain maintained at NIBS. Segregated for autosomal homolethal yellow plumage color gene.

II-3. AMRP strain: Established in 1974 and maintained at NIBS by random breeding in a closed colony. Selected using natural agglutinin for mouse red blood cells. This strain is homozygous for blood group system with following loci by lectins: *Sn/Sn* (*Glycine soja*) (Mizutani *et al.*, 1977a, b), *Ns/Ns* (fruits bodies of *Naematoloma sublaitum*) (Mizutani *et al.*, 1981). The genes of $Es\text{-}D^a$ isozyme in red blood cells and autosomal recessive plumage color panda(s) of this strain are homozygous too. The Panda is a spotted plumage color mutant shown in Fig. 2 (Mizutani *et al.*, 1974). The chicks are primarily white, however, wild type down or feathers are sprinkled around the eyes and ears and on the head, back, tail, secondary flight and covert feathers.

II-4. SBPN strain: Established in 1973 by pedigree breeding at NIBS and maintained to date by random breeding in a closed colony. This strain is homozygous for blood group systems with the following loci by lectins: *sn/sn* (*Glycine soja*), *ns/ns* (fruits bodies of *Naematoloma sublatium*), and for the autosomal recessive plumage color panda gene(*s*).

II-5. PNN strain: Established in 1972 and maintained at NIBS as a random-bred closed colony with colored eggshells and wild type plumage. The strain is homozygous for blood group systems with *Ly2/Ly2* locus by isoimmune serum (Katoh and Wakasugi, 1981) and the following loci by lectins: *pn/pn* (Peanut) (Mizutani *et al.*, 1977), *Sn/Sn*, and *ns/ns*.

II-6. TKP strain: Obtained from the Takeda Co. in 1983 and maintained at NIBS as a random-bred closed colony with colored eggshells and wild type plumage. This strain is homozygous for blood group system with *Ly3/Ly3* locus by isoimmune sera, following loci by lectins: *Sn/Sn* and *Ns/Ns*, and for Es-D^b isozyme of red blood cells.

II-7. GUC strain: Obtained from Gifu University in 1994 and maintained at NIBS. The strain is homozygous for autosomal recessive eggshell color celadon (*ce*) (Ito *et al.*, 1993). The eggshell color resembles Sung era porcelain. A spectrophotometric analysis revealed that celadon eggshell pigments are protoporphyrin and biliverdin as in the wild type eggshell, but the protoporphyrin content is much lower than that in the wild type. The biliverdin content was 44% of the wild type. A quail with both genes of eggshell color celadon and white homozygously lays a pure white egg (Fig. 3).

III. Closed colonies used as animal models for human hereditary diseases, malformations and abnormalities controlled by one or few genes.

III-1. S strain

Mutant genes: silver plumage, *B*, and the Amy-2A, are kept in the strain. Silver is controlled by an autosomal incomplete dominant gene. Homozygous quail show white plumage and a retinal defect (ring retina). A central part of the retina lacks pigment (Homma *et al.*, 1969). Grossly, a circular area of hypopigmentation in the posterior retina with thinning in the subjacent sclera is observed in all *B/B* homozygous quails. As the birds mature, the thinned sclera progresses to scleral ectasia. Posterior scleral ectasia may have developed secondarily to a congenital structural defect in the posterior portion of the sclera associated with general ocular defects. Heterozygous quail show grayish plumage except for several white feathers on the wing tip. Recently, silver homozygous quail were reported to have mutations in the Mitf gene. The Mitf gene in *B/B* homozygous quail impair osteoclastic bone resorption (Kawaguchi *et al.*, 2001). The same mutant is kept at NIBS as a GUB strain (Fig. 4).

III-2. DFND (dark feather nervous disorder) strain

The mutant is controlled by an autosomal recessive gene. The plumage of chicks and adults is dark brown and the primary and secondary feathers are frayed. The mutant is characterized by cerebellar functional disorders involving fine tremors in the extremities and trunk, gait disturbance and tumbling when the quail is active or excited. The mutant quail shows smaller cerebellum profiles than the normal. In the mutant's cerebellum, the Purkinje cell soma is small and fusiform in shape, independent of its location. In the normal quail, the Purkinje soma is flask-shaped. Purkinje cells in the mutant are more intensely stained in the Bodian and Nissl preparations. The mean cell number per unit area of Purkinje cells and granular cells is not different from the normal quail. This mutant is similar to the Reeler mouse in histopathology and clinical features. However, this mutant lacks Golgi II neurons in the white matter of the cerebellum as observed in the Reeler mouse (Ueda *et al.*, 1979).

III-3. RWN strain

Established in 1976 and maintained at NIBS. Glycogen storage disease type II (acid maltase deficiency, AMD) appears in all quails in this strain. The AMD is controlled by an autosomal recessive gene. The AMD quail symptoms involve wing dysfunction (Fig. 5). Histopathologically, the cells in the liver, heart and skeletal muscles show cytoplasm with decreased staining by hematoxylin and eosin. PAS-positive material deposition is observed in the liver, heart, skeletal muscles and to a lesser extent in the brain, intestine and gizzard. This material is digested by diastase in all affected tissues and considered glycogen. The superficial pectralis muscle is most severely affected in the skeletal muscle. With 4-MUG as the substrate, the acid maltase activity is decreased in the femoral muscle, superficial pectral muscle, heart muscle and liver of affected quail. However, there is no difference in the neutral maltase activity in those tissues (Murakami *et al.*, 1982).

We attempted to establish an early onset strain by mating quails that showed wing dysfunction at 3 weeks of age. However, we occasionally found some birds with normal behavior at 10 weeks of age in every generation. From original early onset AMD quails (RWNE strain), we isolated late onset AMD quails (RWNL strain) with a normal wing functions in spite of the presence of pathological changes in the pectral and wing muscle. So far, late onset AMD quails have not exhibited the severe wing dysfunction found in early onset AMD quails even after 35 weeks of age. The segregation ratio for the early onset type and late onset type in the RWNE strain is 2:1. The RWNL strain produces only the late onset type AMD quail. The hatchability of the RWNE strain is always lower than that of the RWNL strain. These results indicate that a dominant modifier gene influences the severity of AMD in Japanese quail. Namely, quail that have a dominant modifier gene homozygously die before hatching. The heterozygous quail show early onset type AMD. The recessively homozygous quail show late onset type AMD. Histopathological analysis could not detect the cause of death in quail embryos that had a homozygous dominant modifier gene. These three types of AMD quail resemble the human infantile form, child form and adult form, respectively.

Enzyme replacement therapy for AMD quail using human recombinant GAA showed a decrease in glycogen in the heart and liver (Kikuchi *et al.*, 1998). In 1997, the full-length acid maltase cDNA of Japanese quail was isolated from cDNA library derived from Japanese quail liver (Kunita *et al.*, 1997).

III-4. LWC strain

Myotonic dystrophy quail appear in two third of the quail in this strain. The mutant is controlled by an autosomal dominant homo lethal gene. The disorder is clinically apparent as early as 28 days of age. It is characterized by generalized myotonia, muscle stiffness and muscle weakness. Affected birds are identified by their inability to lift their wings vertically upward and by their inability to right themselves when placed on their dorsum. This symptom is very similar to that in AMD quail (Braga *et al.*, 1995).

Electromyographic studies in mutant quail show high-frequency repetitive discharges comparable to those in myotonic runs. These discharges persist after nerve resection. The distinctive histopathlogic changes in the various muscles examined are ring fibers, sarcoplasmic masses and internal migration in the sarcolemmal nuclei. A slight decrease in the size of type IIB muscle fibers and a slight increase in the size of the type IIA fibers are observed in the *M. pectralis thoracicus* of affected quails (Fig. 6). The typical muscle lesions and multi-system involvement, manifested by testicular degeneration and atrophy in affected male quail specimens and bilateral lenticular cataracts in 6 of 13 affected quail, suggest the resemblance of this inherited muscular disorder to myotonic dystrophy in humans. The relationship between the development of muscle lesions and age, as well as immunohistochemical and ultrastructural features in this mutant quail are described in reference (Tanaka *et al.*, 1996).

III-5. Quv strain

Neurofilament deficiency appears in all quail in this strain. The mutants show head or body quivering, or both. This trait is characterized by neurofilament deficiency in the axons of the cervical spinal cord and the optic and sciatic nerves, and named “hypotrophic axonopathy”. This characteristics is controlled by an autosomal recessive gene (Mizutani *et al.*, 1992). This is the first mutant suggesting compatibility without neurofilaments (NFs) in a vertebrate. The existence of this mutant showed that NFs are not necessary to the maintenance of life.

The mutant strain (Quv) was successfully established. Electron microscopically and immunohistochemically, neurofilaments are not detected in the axons or neuronal cell bodies in Quv. Axons in Quv are composed mainly of microtubules, which are increased in number in relation to the axonal size (Fig. 7). Gel electrophoresis and Western blot analysis indicate that the low, middle and high molecular mass neurofilament subunits are markedly deficient in the brain, cervical spinal cord and sciatic nerve of Quv. Immunohistochemically, the Quv spinal cord has no immunoreactive products corresponding to low molecular mass NF. However, the middle and high molecular mass NF antisera stained axons (Yamasaki *et al.*, 1992).

We hypothesize that the NF deficiency in Quv results from an alteration in the filament assembly caused by defective expression of low molecular mass NF (NF-L). When the NF-L gene sequences of normal and mutant quail were compared, the NF-L gene in the mutant was found to have a nonsense mutation at the deduced amino acid residue

114. This indicates that the mutant is incapable of producing even a trace amount of NF-L protein in any situation. The morphological features of the myelinated fibers in Quv were also studied in detail (Zaho *et al.*, 1995). Furthermore, the neurotoxic effects of acrylamide (Takahashi *et al.*, 1995), β - β '-iminodipropionitrile (Mitsuishi *et al.*, 1993) and 2,5-Hexanedione (Hirai *et al.*, 1999) were also investigated using the Quv strain.

III-6. ET strain

This strain was found in the B strain maintained at Nagoya University, and is now maintained at Hiroshima University. Ear tufts and irregular shaped ear openings appear in all quail in this strain. The mutant ear opening is oval shaped with a fissure on its ventral margin. Ear tufts project from the ventral end of this fissure or the posterior margin of the ear opening. The ear tufts are composed of a feathered peduncle. The size of the ear tufts and the ear-opening abnormality are variable. In 5-day old ET strain embryos, the incidence of an incomplete closure of the hyomandibular furrow is 91%. This hyomandibular furrow abnormality seems to be the primary defect leading to the ear opening and ear-tuft traits. This characteristics is controlled by an autosomal recessive gene (Tsudzuki and Wakasugi, 1988).

III-7. TT strain

In 1985, two chicks exhibiting throat-tufts (TT) were found in the Japan-Taiwan mixture (JTM) strain maintained at Nagoya University. The TT strain is now maintained at Hiroshima University.

The throat-tuft phenotype in Japanese quail is characterized by a throat tuft consisting of an epidermal peduncle and covering feathers. Sometimes it is accompanied by abnormal ear openings showing a wide cleft at the ventral margin and, in some instances, an extra bony projection on the peduncle or in its vicinity (Fig. 8). The incidence of throat tufts and ear opening abnormalities in 15-day embryos in the TT strain are 50% and 17%, respectively. The 5-day TT embryos exhibited peduncle formation and hyomandibular furrow defects that are thought to cause throat tuft and ear opening abnormalities, respectively. Mating experiments suggest that the throat tuft characteristic is controlled by an autosomal recessive gene that is allelic and dominant to the ear tuft gene (Tsudzuki and Wakasugi, 1989, 1990).

III-8. HMM strain

Hereditary multiple malformation (HMM), a new mutation in Japanese quail (Fig. 9), was discovered among the progeny from a pair from the WT strain kept at Osaka Prefecture University, now maintained at Hiroshima University.

This characteristics is controlled by an autosomal recessive gene. The majority of the homozygotes die on the sixth day of incubation and the remaining die at various stages until 15 days of incubation. The homozygotes surviving to the late embryonic stages have greatly shortened lower and upper beaks that are set apart and show an early embryo-like body shape, with feather buds but no plumules. Furthermore, they show syndactylous polydactyly in both the fore and hind limbs. In the abdomen of the homozygotes, a portion of the ventriculus, liver and small intestine protrudes out of the umbilicus region. In the skeleton of the late HMM embryos, ossification is generally delayed and morphogenetic abnormalities are observed all over the body. This mutant has become a useful animal model in the morphogenesis research field (Tsudzuki *et al.*, 1998).

III-9. SLB strain

Abnormal embryos with a short lower beak (SLB) were discovered among the progeny from a pair from the DDL strain maintained at Osaka Prefecture University, now maintained at Hiroshima University.

The SLB individuals are characterized by a shortened lower beak, opened mouth and small body size. These mutants die in the late embryonic stages. Skeletal analyses revealed that the Meckel's cartilage of the mandible is abnormally bent downward in its proximal portion. The mandibular bones are formed around the abnormal Meckel's cartilage, which seems to be responsible for the shortened lower beak and the opened mouth. The appendicular bones in the mutant embryos are also shortened. Skeletal abnormalities are also observed in the hyoid apparatus, ribs and cervical vertebrae. Genetic analyses revealed that the SLB mutation is controlled by two linked autosomal recessive genes with a recombination rate of 33%. This mutant might be a useful animal model in the study of morphogenesis of the mandible, hyoid apparatus, cervical vertebrae, ribs and appendicular bones (Nakane and Tsudzuki, 1998a; Nakane, 1998).

III-10. ZN strain

Abnormal embryos (Zazen) showing crossed legs and opened eyes were discovered among the progeny from a pair from the SBK strain maintained at Osaka Prefecture University, now maintained at Hiroshima University. The name of the mutant, Zazen, is based on a leg condition similar to the religious mediation figure (=za-zen) in the Zen sect. Zazen birds are characterized by crossed legs, opened eyes and abnormal beaks. In this skeletal system, all mutant embryos have a full-length fibula in both legs from the knee to the hock joint. The femur is articulated with the fibula, but not the tibia. Other skeletal abnormalities are observed in the premaxilla, parietal, and ribs. All Zazen mutants die in the late embryonic stages. Genetic analyses reveal that the mutation is controlled by two genes, autosomal dominant gene and sex-linked recessive gene. The latter is epistatic to the former. This mutant might be a useful animal model in the study of developmental leg skeleton aspects in relation to the genes controlling morphogenesis (Nakane and Tsudzuki, 1998b; Nakane, 1998).

IV. Closed colonies that were established by successive selections of specific characteristics controlled by many genes.

IV-1. LAP strain

Hyperlipidemia atherosclerosis-prone (LAP) strain susceptible to experimental atherosclerosis was established by repeated breeding of highly susceptible quails induced by a diet containing 1% cholesterol. The LAP strain was derived from the HAP strain established by Ohtsuka Pharmaceutical Co. Ltd. The following findings are described.

(1) The retarded rate of cholesterol biosynthesis or catabolism is not responsible for hypercholesterolemia (Nagata *et al.*, 1996).

(2) Cholesterol feeding had no effect on the level of cholesterol, chemical composition or fatty-acid composition of the high-density lipoprotein fractions in LAP and normal strain. Although the lipoprotein and apoprotein profiles in LAP quail show resemblance to those of normal quail, expression of the 470 kDa protein in the lipoprotein appears to be pronounced in the LAP quail (Nagata *et al.*, 1997).

(3) The tissue distribution for apolipoprotein A-I (apo A-I) is similar in both LAP and normal strains, but LAP quail expresses more apo A-I-mRNA than normal quail in all tissues examined (Iwasaki *et al.*, 1999).

(4) The DNA sequence of LAP apo A-I cDNA is similar to that in the normal quail (Iwasaki *et al.*, 1999).
(5) The structure and expression of the major low molecular weight apoprotein has no relevance to higher LAP susceptibility to experimental atherosclerosis (Iwasaki *et al.*, 2000).

IV-2. H2 and L2 strains

The High responder strain (H2) and low responder strain (L2) were established by selective breeding experiments through 50 generations for high and low responders to inactivated Newcastle disease virus (NDV) antigen at National Institute for Environmental Science (NIES) (Takahashi *et al.*, 1984). Hemagglutination inhibition titers of the H2 strain and L2 strain in F18 are 8.54log2 and 1.85log2, respectively. The mortality of the H2 strain after NDV challenge was lower than that for the L2 strain. The H2 strain is a high responder when they are immunized with influenza virus, sheep red blood cells and *S. pullorum*. There is no correlation between antibody production and reproduction. The mitogenic response of lymphocytes to PHA is higher in the H2 strain than the L2 strain. The rate of spontaneous rosette cells in blood lymphocytes with either rabbit or fowl erythrocytes in the H2 strain were higher than that in the L2 strain (Inooka *et al.*, 1984).

IV-3. LL, SS, RR and SL strains

Three strains for either large (LL) or small (SS) body size at 6 weeks of age and random-bred control strain (RR) were developed by successive selection of 80 generations at Saga University. At 12 weeks of age, the body weights of LL, SS and RR strain are 212.0 g, 66.5 g and 104.8 g, respectively. Researches using above strains are as follows:

(1) Comparative studies on body weight, tibia length and abdominal weight (Ardiningsasi *et al.*, 1992).
(2) Investigation of the feed conversion to body weight gain and egg production (Okamoto *et al.*, 1989).
(3) Genetic studies on muscle protein turnover rate, acid protease activity and calcium-activated neutral protease activity (Maeda *et al.*, 1986; Maeda *et al.*, 1989; Maeda *et al.*, 1991).
(4) Research on the heterosis effects existing in the productive traits (weekly body weight, egg laying traits, fertility, hatchability, rate of raising and viability) (Piao *et al.*, 2002).

The SL strain was derived from the SS strain by selecting large body size. The SS and SL strains would be useful for research on body size miniaturization from molecular biologic and metabolic aspects to provide an insight into the evolutionary mechanism (Suda *et al.*, 2002).

V. Closed colonies that are used in auto-sexing of newly hatched chicks.

V-1. AWE strain

This strain was established in 1975 at NIBS, and is a random-bred white eggshell strain with a homozygous sex-linked albino gene. As the AWE strain was previously crossed with the WE strain; the genetic background of these two strains is similar. These strains are used to investigate the screening and testing of endocrine disruptors on the gonads of Japanese quail. It is possible to check the sex of chicks and embryos using their plumage color when a male AWE quail is mated with female WE quail (Fig. 10).

V-2. YBC strain

The strain was established at NIBS and is a random-bred white eggshell strain segregated for sex-linked brown, sex-linked cinnamon and autosomal yellow plumage color genes.

V-3. SBC strain

The strain was established at Hiroshima University. The sex-linked brown and the sex-linked cinnamon genes are segregated.

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Fig. 1. Japanese quail (Left: female, Right: male)

Fig. 2. Japanese quail with panda plumage

Fig. 3. Egg shell color (we: white, ce: celadon, pw: pure white)

Fig. 4. GUB strain (Silver plumage)

Fig. 5. AMD quail

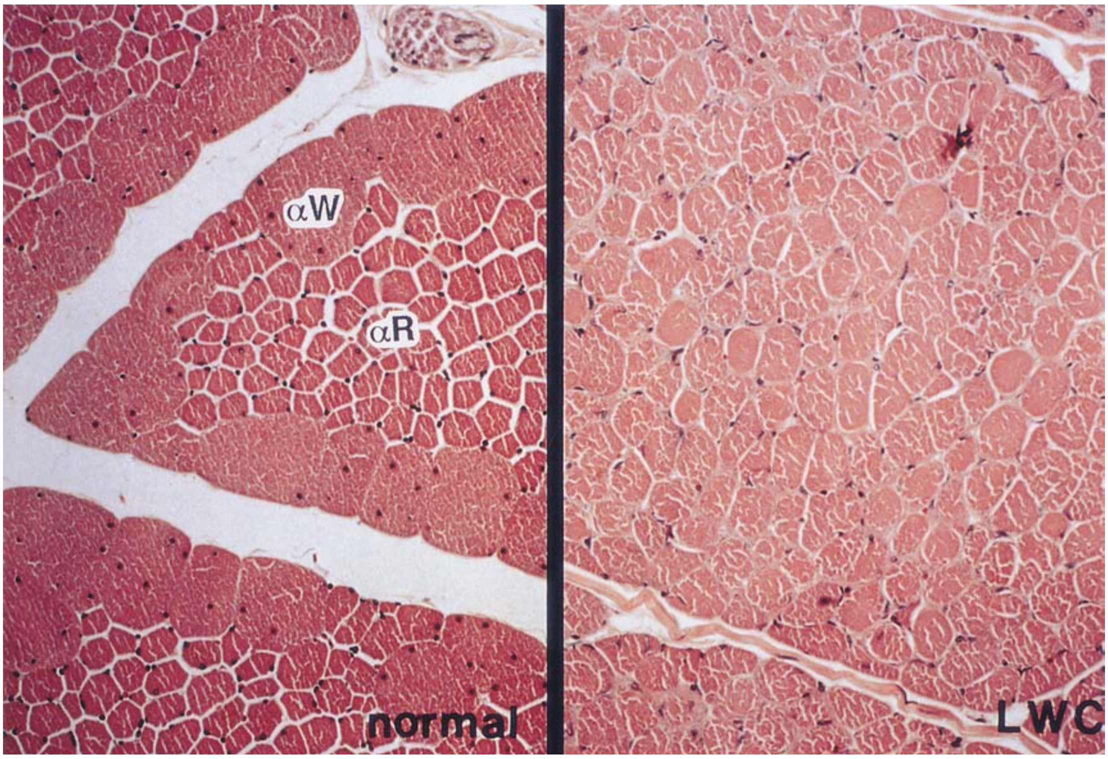

Fig. 6. *M. pectoralis thoracicus* of normal (left) and LWC (right) quail
Left: Type αW (IIB) and αR (IIA) fibers are well differentiated
Right: Note a slight decrease in the size of the type αW fibers with a relative increase in the size of type αR fibers compared to the normal quail

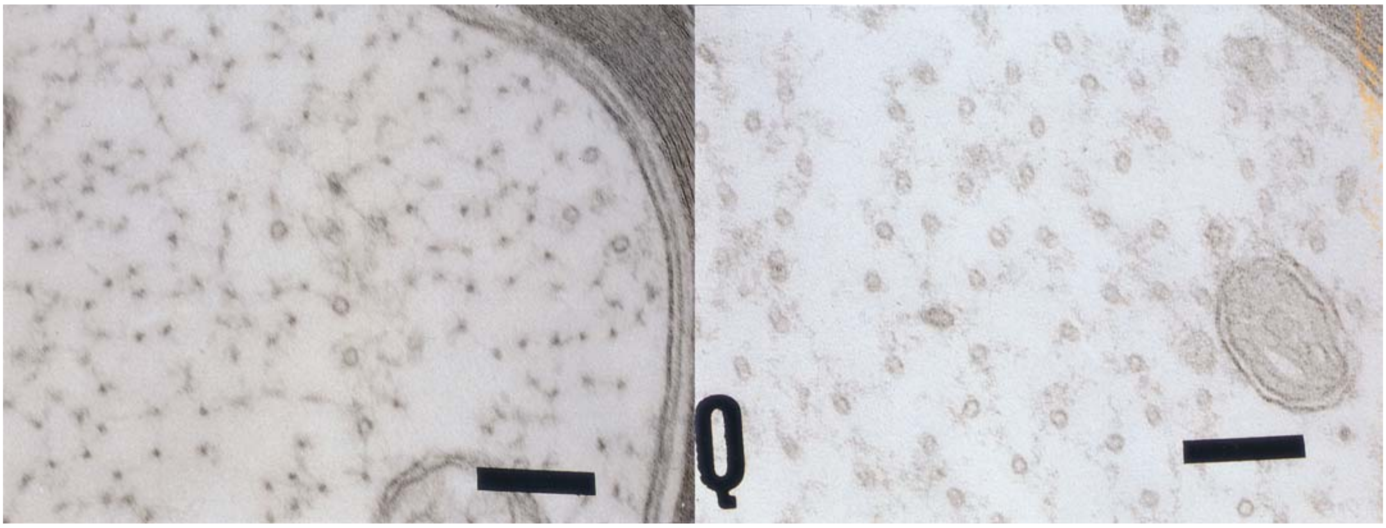

Fig. 7. Electron microscopy of nerve fiber of normal (left) and Quv (right) quail
Left: axonal cytoskeleton of normal quail comprise a number of NFs with less microtubules
Right: NF central cores were not observed but microtubules were increased in number

Fig. 8. Dotted white quail with a large throat tuft on the left side only (Photo by M. Tsudzuki)

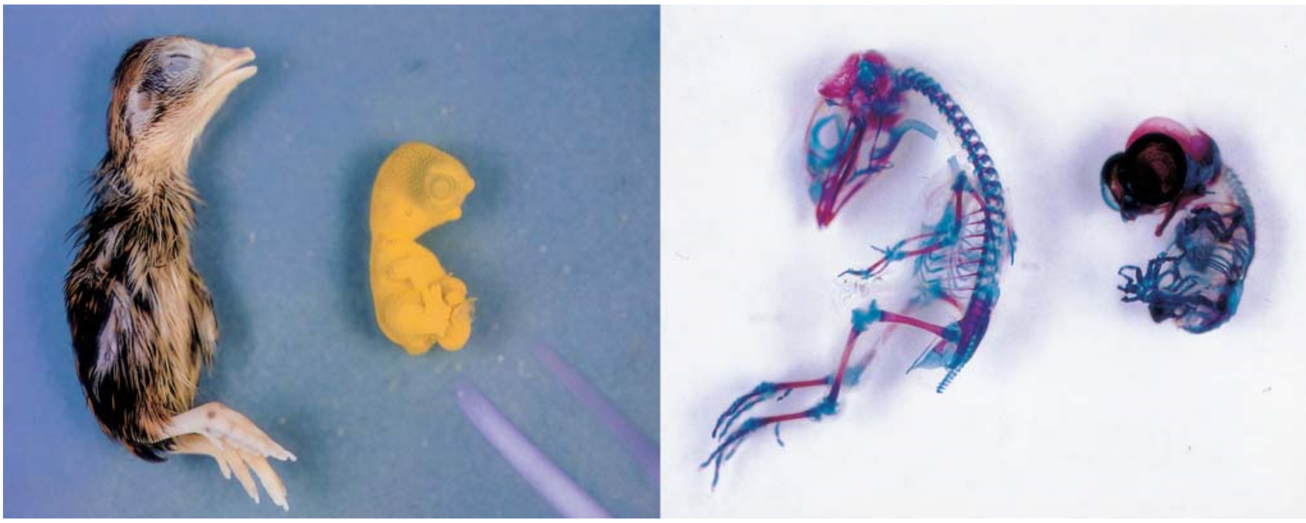

Fig. 9. Comparison of an external appearance and skeleton of 13-days embryo of normal (left) and HMM mutant quail (right) (Photo by M. Tsudzuki)

Fig. 10. Left: Male of AWE strain, Right: Female of WE strain

Appendix 1. Agricultural production indexes of major countries

Year	Country	Agriculture	Crops	Cereals	Livestock	Standard
1985	World	114.21	115.04	116.94	111.76	1979-81=100.0
1985	Developed Countries	108.08	108.51	113.02	106.71	1979-81=100.0
1985	Developing Countries	120.23	119.91	120.1	122.56	1979-81=100.0
1985	Chinese Taipei	111.97	96.92	96.12	138.84	1979-81=100.0
1985	Australia	109.44	124.18	118.11	98.36	1979-81=100.0
1985	Belgium	101.00	113.49	108.48	103.91	1979-81=100.0
1985	Canada	113.41	116.92	114.09	108.12	1979-81=100.0
1985	France	106.97	110.22	121.44	103.57	1979-81=100.0
1985	Germany, Fed. Rep.	108.29	112.90	114.24	103.82	1979-81=100.0
1985	India	123.57	120.79	123.28	133.99	1979-81=100.0
1985	Indonesia	126.25	124.77	129.79	148.90	1979-81=100.0
1985	Italy	101.98	99.4	99.72	105.05	1979-81=100.0
1985	Japan	107.06	104.53	110.34	113.69	1979-81=100.0
1985	Thailand	123.60	122.67	125.57	127.78	1979-81=100.0
1985	Malaysia	135.91	123.15	90.47	181.01	1979-81=100.0
1985	Netherlands	108.21	111.42	88.74	113.87	1979-81=100.0
1985	Philippines	99.44	104.08	116.71	89.32	1979-81=100.0
1985	Singapore	105.92	57.73	0	92.54	1979-81=100.0
1985	South Africa	95.78	89.46	77.68	111.26	1979-81=100.0
1985	Korea, Rep. of	110.33	106.16	109.45	154.69	1979-81=100.0
1985	United Kingdom	110.32	118.02	120.78	103.63	1979-81=100.0
1985	United States	106.67	107.24	113.87	106.79	1979-81=100.0
1990	World	125.89	124.90	126.70	126.05	1979-81=100.0
1990	Argentina	110.93	117.83	88.87	96.68	1979-81=100.0
1990	Canada	128.09	136.11	138.80	113.79	1979-81=100.0
1990	United States	105.53	105.11	104.57	109.95	1979-81=100.0
1990	Australia	116.28	123.76	110.38	112.40	1979-81=100.0
1990	New Zealand	101.88	127.04	110.87	100.34	1979-81=100.0
1990	Belgium	109.89	119.09	102.63	108.69	1979-81=100.0
1990	France	106.03	112.80	120.60	102.34	1979-81=100.0
1990	Germany	116.62	115.53	118.69	104.54	1979-81=100.0
1990	Italy	97.55	91.43	96.41	109.84	1979-81=100.0
1990	Netherlands	113.09	130.70	106.01	113.38	1979-81=100.0
1990	United Kingdom	110.68	123.08	122.38	102.78	1979-81=100.0
1990	Chinese Taipei	98.98	97.69	99.48	100.65	1979-81=100.0
1990	China	159.27	145.03	138.56	219.32	1979-81=100.0
1990	India	147.54	142.96	143.61	168.15	1979-81=100.0
1990	Indonesia	157.74	153.08	154.32	210.68	1979-81=100.0
1990	Japan	98.13	96.06	100.33	116.66	1979-81=100.0
1990	Korea, Rep. of	113.40	109.46	106.13	200.22	1979-81=100.0
1990	Malaysia	184.14	154.06	96.10	283.03	1979-81=100.0
1990	Philippines	118.61	117.77	135.32	135.17	1979-81=100.0
1990	Thailand	124.08	125.52	103.82	143.86	1979-81=100.0
1990	Viet Nam	152.09	143.88	164.92	187.37	1979-81=100.0

Year	Country	Agriculture	Crops	Cereals	Livestock	Standard
1990	South Africa	103.44	97.98	79.49	113.92	1979-81=100.0
1992	World	126.92	126.53	126.58	125.66	1979-81=100.0
1992	Developed Countries	107.41	108.47	112.80	106.86	1979-81=100.0
1992	Developing Countries	146.08	140.04	137.71	165.87	1979-81=100.0
1992	Chinese Taipei	124.24	90.41	79.23	198.57	1979-81=100.0
1992	Australia	121.44	140.86	118.91	114.04	1979-81=100.0
1992	Belgium	126.62	128.33	109.64	118.96	1979-81=100.0
1992	Canada	117.20	123.88	121.14	109.06	1979-81=100.0
1992	France	108.23	117.72	130.99	102.44	1979-81=100.0
1992	India	156.28	150.87	146.97	184	1979-81=100.0
1992	Indonesia	169.61	169.53	165.25	204.37	1979-81=100.0
1992	Italy	102.04	103.31	108.9	105.1	1979-81=100.0
1992	Japan	96.30	94.04	100.61	115.79	1979-81=100.0
1992	Thailand	139.35	136.11	109.83	183.75	1979-81=100.0
1992	Malaysia	187.82	153.63	91.25	307.62	1979-81=100.0
1992	Netherlands	122.3	131.98	100.02	118.28	1979-81=100.0
1992	Philippines	118.34	112.48	126.14	145.83	1979-81=100.0
1992	Singapore	74.77	8.59	0	51.47	1979-81=100.0
1992	South Africa	83.58	69.41	35.02	114.56	1979-81=100.0
1992	Korea, Rep. of	119.75	107	100.04	219.52	1979-81=100.0
1992	United Kingdom	113.67	126.93	120.61	102.87	1979-81=100.0
1992	United States	113.24	114.42	116.62	115.16	1979-81=100.0
1993	World	128.49	126.1	124.15	128.76	1979-81=100.0
1993	Chinese Taipei	106.86	102.12	98.02	113.04	1979-81=100.0
1993	Australia	124.52	152.12	136.48	113.78	1979-81=100.0
1993	Belgium	141.04	138.11	112.8	123.92	1979-81=100.0
1993	Canada	123.02	136.28	125.12	110.57	1979-81=100.0
1993	France	105.21	105.97	121.2	107.85	1979-81=100.0
1993	Germany	105.73	114.9	112.24	88.35	1979-81=100.0
1993	India	158.53	151.18	148.91	192.69	1979-81=100.0
1993	Indonesia	181.59	177.44	162.11	234.47	1979-81=100.0
1993	Italy	102.96	100.15	108.12	109.3	1979-81=100.0
1993	Japan	82.45	79.89	74.49	118.36	1979-81=100.0
1993	Thailand	133.53	133.68	110.46	158.64	1979-81=100.0
1993	Malaysia	225.19	170.36	103.05	408.44	1979-81=100.0
1993	Netherlands	122.45	134.41	104.08	120.54	1979-81=100.0
1993	Philippines	119.4	116.39	131.1	144.26	1979-81=100.0
1993	South Africa	100.48	94.59	87.24	117.94	1979-81=100.0
1993	Korea, Rep. of	108.11	102.31	89.91	267.44	1979-81=100.0
1993	United Kingdom	103.44	116.98	105.26	99.61	1979-81=100.0
1993	United States	101.33	96.87	87.49	112.81	1979-81=100.0
1994	Argentina	108.5	116.4	127.6	102.9	1989-91=100.0
1994	Canada	107.6	112.3	87.5	105.6	1989-91=100.0
1994	United States	116.4	121.8	122.4	110.1	1989-91=100.0
1994	Australia	102.4	87.3	70	108.3	1989-91=100.0
1994	New Zealand	114.4	112.8	107.7	114.1	1989-91=100.0

Year	Country	Agriculture	Crops	Cereals	Livestock	Standard
1994	Belgium	113.8	120.9	102.9	110.2	1989-91=100.0
1994	France	97.8	97.6	93.1	101.2	1989-91=100.0
1994	Germany	87.7	95.1	97.3	83.5	1989-91=100.0
1994	Italy	100.5	100.1	105.3	101.9	1989-91=100.0
1994	Netherlands	104	107.6	101.8	102.8	1989-91=100.0
1998	World	117.5	117.0	109.9	116.3	1989-91=100.0
1994	United Kingdom	99.2	95.4	89.1	101.2	1989-91=100.0
1994	Chinese Taipei	107	98.6	91.3	119.5	1989-91=100.0
1994	China	124.3	109.6	100.2	159.5	1989-91=100.0
1994	India	112.5	111.9	108.9	114.3	1989-91=100.0
1994	Indonesia	108	107.1	104.2	120.6	1989-91=100.0
1994	Japan	99.2	98.7	114.6	99.4	1989-91=100.0
1994	Korea, Rep. of	112.5	98.7	87.8	134.5	1989-91=100.0
1994	Malaysia	113.4	104.4	109.1	138.5	1989-91=100.0
1994	Philippines	112.3	105.3	106.1	135.9	1989-91=100.0
1994	Thailand	107.3	106.8	108	110.8	1989-91=100.0
1994	Viet Nam	120.6	120.4	122.4	121.6	1989-91=100.0
1994	South Africa	99.1	108.1	129.9	91	1989-91=100.0
1995	World	110.1	108.3	100.8	110.7	1989-91=100.0
1995	Argentina	114.9	122.5	121.6	107	1989-91=100.0
1995	Canada	110.6	113	92.1	110.6	1989-91=100.0
1995	United States	109.2	103.2	95.1	113.6	1989-91=100.0
1995	Australia	114.8	129.9	132.6	109.1	1989-91=100.0
1995	New Zealand	112.2	126	99.8	110.8	1989-91=100.0
1995	Belgium	113.7	122	107.8	110.9	1989-91=100.0
1995	France	101.1	99.2	93.3	104.8	1989-91=100.0
1995	Germany	89.7	102.7	107.8	84	1989-91=100.0
1995	Italy	99.9	98.4	109.4	103.1	1989-91=100.0
1995	Netherlands	102.4	109.3	114.5	100.2	1989-91=100.0
1995	United Kingdom	100.5	98.9	97.6	101.2	1989-91=100.0
1995	Chinese Taipei	110.8	100.5	100.6	125.4	1989-91=100.0
1995	China	142.3	124.7	106.3	183.7	1989-91=100.0
1995	India	114.9	114.3	109.1	117	1989-91=100.0
1995	Indonesia	115.7	113.9	112.4	135.2	1989-91=100.0
1995	Japan	97.9	95.5	102.5	97.8	1989-91=100.0
1995	Korea, Rep. of	113	99.1	81.1	144.8	1989-91=100.0
1995	Malaysia	114.7	106.5	107.7	142	1989-91=100.0
1995	Philippines	118.2	111.2	105	141.5	1989-91=100.0
1995	Thailand	108.9	111.1	108.7	104.4	1989-91=100.0
1995	Viet Nam	126.8	126.9	130.3	126.4	1989-91=100.0
1995	South Africa	85.4	82.6	61.2	92.1	1989-91=100.0
1996	World	115.2	115.4	109.3	114.1	1989-91=100.0
1996	Argentina	119.4	134.7	157.8	102	1989-91=100.0
1996	Canada	115.8	119	109.8	117.4	1989-91=100.0
1996	United States	114.7	115.9	115.5	113.3	1989-91=100.0
1996	Australia	118.5	154.2	170.2	103	1989-91=100.0

Year	Country	Agriculture	Crops	Cereals	Livestock	Standard
1996	New Zealand	114	132.4	118.9	112.7	1989-91=100.0
1996	Belgium	115.8	125.3	124.8	116.6	1989-91=100.0
1996	France	105.4	107.8	108.8	105.8	1989-91=100.0
1996	Germany	91.1	105.5	113.8	85	1989-91=100.0
1996	Italy	100.9	101.3	116.5	103.7	1989-91=100.0
1996	Netherlands	107.9	112.2	126.4	104.1	1989-91=100.0
1996	United Kingdom	68.3	107.3	109.7	97.3	1989-91=100.0
1996	Chinese Taipei	112.9	100.3	100.3	133.6	1989-91=100.0
1996	China	154	136	114.7	206.1	1989-91=100.0
1996	India	119.7	118.5	111	124.4	1989-91=100.0
1996	Indonesia	124.1	122.3	116.7	135.5	1989-91=100.0
1996	Japan	95.5	92.6	99.1	96.2	1989-91=100.0
1996	Korea, Rep. of	118	105.7	91.3	147.6	1989-91=100.0
1996	Malaysia	118.8	107.9	101.6	149.8	1989-91=100.0
1996	Philippines	120.3	113.1	111.7	147.9	1989-91=100.0
1996	Thailand	114.5	114.4	113.8	120.5	1989-91=100.0
1996	Viet Nam	136.3	136.7	138.8	134.5	1989-91=100.0
1996	South Africa	102.4	112.3	112.3	90.4	1989-91=100.0
1997	World	116.5	116.6	110.8	116	1989-91=100.0
1997	Argentina	124.5	141.3	176.4	109.8	1989-91=100.0
1997	Canada	114.2	113.5	92.2	118.9	1989-91=100.0
1997	United States	117.3	121.6	117.6	113.3	1989-91=100.0
1997	Australia	116.9	142.3	136.2	104.9	1989-91=100.0
1997	New Zealand	117.1	130.7	115.4	116.1	1989-91=100.0
1997	Belgium	112.8	123.3	115	114.7	1989-91=100.0
1997	France	104.5	107.6	109.9	104.9	1989-91=100.0
1997	Germany	90.7	105.6	122.7	84.9	1989-91=100.0
1997	Italy	96.8	96.2	109.3	101	1989-91=100.0
1997	Netherlands	107.7	111.5	118.2	104.1	1989-91=100.0
1997	United Kingdom	67.5	105.7	105	96.6	1989-91=100.0
1997	Chinese Taipei	110.3	101.9	102.6	123.7	1989-91=100.0
1997	China	159.5	137.7	113.2	216.4	1989-91=100.0
1997	India	121.8	119.6	113.6	128.3	1989-91=100.0
1997	Indonesia	123	120.5	115.7	139	1989-91=100.0
1997	Japan	96	94.4	96.5	95.5	1989-91=100.0
1997	Korea, Rep. of	121.7	109.6	91.1	152.9	1989-91=100.0
1997	Malaysia	121.6	111.8	100	149.8	1989-91=100.0
1997	Philippines	120.9	111.3	110.9	156.8	1989-91=100.0
1997	Thailand	114.6	113	110.7	126.4	1989-91=100.0
1997	Viet Nam	137.1	136	138.8	140.3	1989-91=100.0
1997	South Africa	97.6	102.9	94.8	91.3	1989-91=100.0
1998	Argentina	132.5	159.8	181.8	105.2	1989-91=100.0
1998	Canada	121.7	123.3	92.5	127.5	1989-91=100.0
1998	United States	119.4	120.3	120.2	117.2	1989-91=100.0
1998	Australia	122.5	154.8	151.8	110.0	1989-91=100.0
1998	New Zealand	118.6	134.7	109.7	117.3	1989-91=100.0

Year	Country	Agriculture	Crops	Cereals	Livestock	Standard
1998	Belgium	112.9	131.7	119.7	114.5	1989-91=100.0
1998	France	106.3	111.3	119.4	105.5	1989-91=100.0
1998	Germany	94.4	112.6	120.7	86.0	1989-91=100.0
1998	Italy	101.2	101.4	115.8	102.9	1989-91=100.0
1998	Netherlands	98.4	97.7	106.1	100.8	1989-91=100.0
1998	United Kingdom	99.4	101.2	102.0	99.1	1989-91=100.0
1998	Chinese Taipei	102.1	93.8	90.9	114.5	1989-91=100.0
1998	China	157.6	140.5	115.9	201.6	1989-91=100.0
1998	India	120.9	118.2	115.8	131.6	1989-91=100.0
1998	Indonesia	117.1	115.3	114.1	124.9	1989-91=100.0
1998	Japan	92.4	88.5	86.4	95.0	1989-91=100.0
1998	Korea, Rep. of	124.0	103.9	86.0	161.9	1989-91=100.0
1998	Malaysia	117.3	102.7	98.2	153.6	1989-91=100.0
1998	Philippines	122.9	109.7	100.2	168.9	1989-91=100.0
1998	Thailand	113.2	110.3	118.6	130.9	1989-91=100.0
1998	Viet Nam	150.2	150.6	152.9	155.6	1989-91=100.0
1998	South Africa	95.2	98.0	79.6	93.9	1989-91=100.0
1999	World	119.4	118.8	109.9	117.4	1989-91=100.0
1999	Argentina	132.5	155.8	176.4	105.9	1989-91=100.0
1999	Canada	130.7	132.6	92.2	133.4	1989-91=100.0
1999	United States	120.4	118.4	117.6	120.8	1989-91=100.0
1999	Australia	123.1	160.7	136.2	110.6	1989-91=100.0
1999	New Zealand	113.5	140.5	115.4	111.3	1989-91=100.0
1999	Belgium	96.8	135.0	115	93.3	1989-91=100.0
1999	France	107.7	113.5	109.9	104.6	1989-91=100.0
1999	Germany	95.0	115.3	122.7	85.9	1989-91=100.0
1999	Italy	105.3	108.2	109.3	102.5	1989-91=100.0
1999	Netherlands	101.0	111.4	118.2	99.8	1989-91=100.0
1999	United Kingdom	99.2	103.4	105	97.7	1989-91=100.0
1999	Chinese Taipei	104.5	100.3	102.6	110.3	1989-91=100.0
1999	China	160.0	141.6	113.2	205.1	1989-91=100.0
1999	India	126.1	123.1	113.6	135.7	1989-91=100.0
1999	Indonesia	117.2	115.4	115.7	125.6	1989-91=100.0
1999	Japan	92.5	90.1	96.5	93.8	1989-91=100.0
1999	Korea, Rep. of	100.6	107.7	91.1	132.4	1989-91=100.0
1999	Malaysia	128.3	117.3	100	153.6	1989-91=100.0
1999	Philippines	128.8	114.8	110.9	176.3	1989-91=100.0
1999	Thailand	115.9	113.7	110.7	128.7	1989-91=100.0
1999	Viet Nam	161.6	160.9	138.8	171.9	1989-91=100.0
1999	South Africa	100.4	105.6	94.8	95.8	1989-91=100.0
2000	World	123.4	122.5	110.3	121.0	1989-91=100.0
2000	Argentina	135.5	160.1	194.3	112.1	1989-91=100.0
2000	Canada	129.4	128.7	96.4	128.7	1989-91=100.0
2000	United States	1231	121.6	117.6	123.0	1989-91=100.0
2000	Australia	130.1	175.2	177.7	114.0	1989-91=100.0
2000	New Zealand	120.9	148.1	115.0	118.8	1989-91=100.0

Year	Country	Agriculture	Crops	Cereals	Livestock	Standard
2000	Belgium	114.7	151.2	116.5	109.1	1989-91=100.0
2000	France	105.4	109.2	114.7	104.5	1989-91=100.0
2000	Germany	98.0	120.8	123.9	87.0	1989-91=100.0
2000	Italy	103.2	103.6	114.1	105.5	1989-91=100.0
2000	Netherlands	104.0	115.9	129.4	101.2	1989-91=100.0
2000	United Kingdom	97.6	102.0	108.5	96.4	1989-91=100.0
2000	Chinese Taipei	104.3	95.5	95.2	116.7	1989-91=100.0
2000	China	169.7	145.8	104.3	218.2	1989-91=100.0
2000	India	130.2	126.3	121.0	144.3	1989-91=100.0
2000	Indonesia	120.3	121.8	118.8	114.8	1989-91=100.0
2000	Japan	92.1	87.8	92.4	94.2	1989-91=100.0
2000	Korea, Rep. of	130.6	113.9	89.9	161.3	1989-91=100.0
2000	Malaysia	127.3	118.9	119.6	155.6	1989-91=100.0
2000	Philippines	128.9	120.0	120.8	162.6	1989-91=100.0
2000	Thailand	121.3	120.7	129.6	127.6	1989-91=100.0
2000	Viet Nam	165.2	170.2	171.4	155.5	1989-91=100.0
2000	South Africa	108.0	112.7	108.4	103.4	1989-91=100.0
2001	World	124.0	122.6	110.4	122.6	1989-91=100.0
2001	Argentina	140.4	169.8	193.5	109.7	1989-91=100.0
2001	Canada	118.0	129.0	82.0	107.0	1989-91=100.0
2001	United States	121.7	119.0	111.5	122.4	1989-91=100.0
2001	Australia	131.3	163.6	148.3	116.5	1989-91=100.0
2001	New Zealand	123.8	139.6	119.4	122.6	1989-91=100.0
2001	Belgium	112.5	136.7	108.9	110.6	1989-91=100.0
2001	France	102.4	101.9	104.5	103.5	1989-91=100.0
2001	Germany	98.7	120.6	136.2	88.6	1989-91=100.0
2001	Italy	102.6	102.2	110.5	106.5	1989-91=100.0
2001	Netherlands	100.7	113.2	128.8	99.0	1989-91=100.0
2001	United Kingdom	89.1	88.2	83.4	92.1	1989-91=100.0
2001	Chinese Taipei	101.9	91.4	85.8	117.0	1989-91=100.0
2001	China	173.0	147.8	102.5	224.9	1989-91=100.0
2001	India	127.8	121.3	119.2	147.9	1989-91=100.0
2001	Indonesia	116.9	116.7	109.0	122.3	1989-91=100.0
2001	Japan	91.5	87.9	88.5	93.3	1989-91=100.0
2001	Korea, Rep. of	128.6	115.2	93.5	154.5	1989-91=100.0
2001	Malaysia	131.7	124.1	120.7	157.3	1989-91=100.0
2001	Philippines	133.7	124.1	125.4	169.7	1989-91=100.0
2001	Thailand	122.5	119.8	128.7	137.7	1989-91=100.0
2001	Viet Nam	164.9	169.3	168.8	155.9	1989-91=100.0
2001	South Africa	101.8	100.9	76.2	103.4	1989-91=100.0

Sources: 1. Chinese Taipei – "Agricultural Production Statistics Abstract", Council of Agriculture
2. Other countries – Food and Agriculture Organization of the United Nations

Appendix 2. Distribution of employed population by industry

Year	Country	Employed Population (1000 persons)					Percentage (%)			
		Total	Agriculture	Industry	Service	Others	Agriculture	Industry	Service	Others
1981	India	244605	153123	31065	38403	22014	62.6	12.7	15.7	9.0
1986	Belgium	4212	101	1057	2536	518	2.4	26.1	60.2	12.3
1986	New Zealand	1609	163	439	883	124	10.1	27.3	54.9	7.7
1989	Indonesia	75508	41284	9738	22348	2138	54.7	12.9	29.6	2.8
1990	Thailand	31748	19725	4321	6774	928	62.1	13.6	21.3	2.9
1991	Italy	24244	1823	6915	12854	2652	7.5	28.5	53.0	10.9
1991	France	24609	1257	6422	14393	2537	5.1	26.1	58.5	10.3
1991	Netherlands	7011	293	1645	4536	537	4.2	23.5	64.7	7.7
1992	United Kingdom	28141	548	6679	17946	2968	1.9	23.7	63.8	10.5
1992	Germany	30949	903	10006	20040	—	2.9	32.3	64.8	—
1992	United States	128541	3653	32123	91747	1018	2.8	25.0	71.4	0.8
1992	Indonesia	79451	42048	11230	24236	1937	52.9	14.1	30.5	2.4
1992	Sri Lanka	5948	2380	959	1619	990	40.0	16.1	27.2	16.6
1992	Singapore	1620	5	546	1025	44	0.3	33.7	63.3	2.7
1992	Philippines	26179	10869	3816	9210	2284	41.5	14.6	35.2	8.7
1992	Korea,Rep. of	19385	3025	6546	9350	464	15.6	33.8	48.2	2.4
1992	Japan	65780	4110	22270	37680	1720	6.2	33.9	57.3	2.6
1992	Germany	30923	914	10987	19022	—	3.0	35.5	61.5	—
1992	Canada	13795	466	3233	9990	106	3.4	23.4	72.4	0.8
1992	Australia	8586	430	2025	5714	418	5.0	23.6	66.6	4.9
1992	Pakistan	33829	15043	6289	10351	2146	44.5	18.6	30.6	6.3
1993	United Kingdom	28271	522	7454	17406	2889	1.8	26.4	61.6	10.2
1993	France	25155	1102	6080	15062	2911	4.4	24.2	59.9	11.6
1993	Canada	13946	481	3194	10149	122	3.4	22.9	72.8	0.9
1993	Australia	8537	433	1962	5993	149	5.1	23.0	70.2	1.7
1993	Japan	66150	3830	22110	38280	1930	5.8	33.4	57.9	2.9
1993	Singapore	1636	4	539	1049	44	0.2	32.9	64.1	2.7
1993	Korea, Rep. of	19754	2845	6382	9976	551	14.4	32.3	50.5	2.8
1993	Netherlands	6406	232	1506	4187	481	3.6	23.5	65.4	7.5
1993	Philippines	26822	11194	3793	9443	2392	41.7	14.1	35.2	8.9
1993	Canada	12383	550	2752	9082	—	4.4	22.2	73.4	—
1993	China,Rep. of	8874	1005	3418	4323	128	12.1	39.2	47.3	1.5
1993	United States	129525	3509	31571	93442	1003	2.7	24.4	72.1	0.8
1993	Germany	28665	854	10452	17359	—	3.0	36.5	60.5	—
1993	Sri Lanka	6066	2011	1092	2124	839	33.2	18.0	35.0	13.8
1994	Thailand	31049	12401	7074	10300	1274	39.9	22.8	33.2	4.1
1994	Australia	7920	404	1852	5664	—	5.1	23.4	71.5	—
1994	France	22110	1048	5875	15187	—	4.7	26.6	68.7	—
1994	Italy	20004	1573	6478	11953	—	7.9	32.4	59.7	—
1994	Sri Lanka	5299	1834	1086	2080	299	34.6	20.5	39.3	5.6
1994	Philippines	25166	11249	3970	9939	8	44.7	15.8	39.5	0.0
1994	Korea, Rep. of	19837	2699	6583	10556	—	13.6	33.2	53.2	—
1994	Netherlands	6692	264	1525	4720	183	4.0	22.8	70.5	2.7
1994	Chinese Taipei	9081	976	3506	4456	143	10.7	38.6	49.2	1.6
1994	Australia	8254	423	1994	5837	—	5.1	24.2	70.7	—
1994	United States	130452	3862	31925	94617	48	3.0	24.5	72.5	0.0
1995	Chinese Taipei	9045	954	3504	4587	—	10.6	38.7	50.7	—

Year	Country	Employed Population (1000 persons)					Percentage (%)			
		Total	Agriculture	Industry	Service	Others	Agriculture	Industry	Service	Others
1995	Japan	64570	3670	21670	38970	260	5.7	33.6	60.3	0.4
1995	Italy	20002	1572	6478	11952	—	7.9	32.4	59.8	—
1996	Sri Lanka	5587	1963	1252	2166	206	35.1	22.4	38.8	3.7
1996	United Kingdom	26219	511	5346	20242	120	1.9	20.4	77.2	0.5
1996	Netherlands	6971	259	1557	4986	169	3.7	22.3	71.5	2.4
1996	Germany	35892	1076	12583	21963	—	3.0	35.3	61.7	—
1996	Canada	13676	565	3116	9995	—	4.1	22.8	73.1	—
1996	Korea, Rep. of	20764	2424	6882	11055	16	11.9	33.8	54.3	0.1
1996	Japan	64840	3560	21580	39410	290	5.5	33.3	60.8	0.4
1996	United States	126708	3570	30519	92619	—	2.8	24.1	73.1	—
1996	Singapore	1748	3	529	1213	3	0.2	30.3	69.4	0.2
1996	Philippines	27442	11451	4567	11419	5	41.7	16.6	41.6	0.0
1996	Indonesia	85702	37720	15508	32464	10	44.0	18.1	37.9	0.0
1997	Indonesia	87050	35849	16545	34653	3	41.2	19.0	39.8	0.0
1997	Brazil	68040	16771	13864	37405	—	24.6	20.4	55.0	—
1997	Thailand	33162	16691	6538	9924	9	50.3	19.7	29.9	0.0
1997	Singapore	1831	5	553	1270	3	0.3	30.2	69.4	0.2
1997	Japan	65570	3500	21700	40030	340	9.8	33.1	61.0	0.5
1997	United Kingdom	129558	3538	31264	94756	—	2.7	24.1	73.1	—
1997	Netherlands	7194	259	1606	5171	158	3.6	22.3	71.9	2.2
1997	Germany	35805	1049	12287	22469	—	3.0	35.3	61.7	—
1997	Australia	8394	436	1858	6100	—	5.2	22.1	72.7	—
1997	United States	129558	3538	31264	94756	—	2.7	24.1	73.1	—
1997	Canada	13941	537	3231	10173	—	3.9	23.2	73.0	—
1997	Chinese Taipei	9176	878	3502	4795	—	9.6	38.2	52.3	—
1997	Korea, Rep. of	21048	2324	6581	12143	—	11.0	31.3	57.7	—
1997	Philippines	27888	11260	4659	11964	5	40.4	16.7	42.9	0.0
1998	Indonesia	87672	39415	14278	33979	—	45.0	16.3	38.8	—
1998	Malaysia	5946	2472	1338	1987	150	41.6	22.5	33.4	2.5
1998	Netherlands	7398	236	1613	5388	161	3.2	21.8	72.8	2.2
1998	Sri Lanka	5946	2472	1338	1987	150	41.6	22.5	33.4	2.5
1998	Denmark	2692	97	717	1873	5	3.6	26.6	69.6	0.2
1998	Japan	65140	3430	20870	40480	360	5.3	32.0	62.1	0.6
1998	Brazil	69963	16388	14072	39503	—	23.4	20.1	56.5	—
1998	Canada	14326	534	3203	10590	—	3.7	22.4	73.9	—
1998	United States	131463	3509	31367	96587	—	2.7	23.9	73.5	—
1998	Australia	8394	421	1862	6111	—	5.0	22.2	72.8	—
1998	United Kingdom	26947	465	7161	19248	73	1.7	26.6	71.4	0.3
1998	Thailand	32138	16472	5688	9971	8	51.3	17.7	31.0	0.0
1998	Korea, Rep. of	19926	2424	5542	11960	—	12.2	27.8	60.0	—
1998	Singapore	1870	4	545	1318	3	0.2	29.1	70.5	0.2
1998	Philippines	26262	11272	4442	12540	8	39.9	15.7	44.4	0.0
1998	Chinese Taipei	9289	822	3523	4944	—	8.8	37.9	53.2	—
1998	Germany	35860	1024	12131	22705	—	2.9	33.8	63.3	—
1999	Japan	64620	3350	20460	40400	410	5.2	31.7	62.5	0.6
1999	Philippines	29003	11342	4518	13133	10	39.1	15.6	45.3	0.0
1999	Indonesia	88817	38878	15845	34094	—	43.8	17.8	38.4	—

Year	Country	Employed Population (1000 persons)					Percentage (%)			
		Total	Agriculture	Industry	Service	Others	Agriculture	Industry	Service	Others
1999	Brazil	71676	17372	13805	40499	—	24.2	19.3	56.5	—
1999	Canada	14531	522	3258	10751	—	3.6	22.4	74.0	—
1999	United States	133488	3416	31090	98982	—	2.6	23.3	74.2	—
1999	Australia	8747	433	1872	6442	—	5.0	21.4	73.6	—
1999	Germany	36402	1026	12150	23226	—	2.8	33.4	63.8	—
1999	Chinese Taipei	9385	776	3492	5117	—	8.3	37.2	54.5	—
1999	Singapore	1886	6	537	1341	2	0.3	28.5	71.1	0.1
1999	Thailand	32807	15564	5890	11338	15	47.4	18.0	34.6	0.0
1999	United Kingdom	27442	425	7104	19834	79	1.5	25.9	72.3	0.3
1999	Korea, Rep. of	20281	2349	5563	12369	—	11.6	27.4	61.0	—
2000	Australia	9010	439	1975	6596	—	4.9	21.9	73.2	—
2000	Italy	21225	1020	6767	13438	—	4.8	31.9	63.3	—
2000	Netherlands	7731	248	1634	5652	197	3.2	21.1	73.1	2.5
2000	Malaysia	9322	1712	3000	4610	—	18.4	32.2	49.5	—
2000	Japan	64460	3260	20130	40680	390	5.1	31.2	63.1	0.6
2000	United States	135208	3457	31341	100410	—	2.6	23.2	74.3	—
2000	Chinese Taipei	9491	740	3534	5218	—	7.8	37.2	55.0	—
2000	Germany	36604	988	12102	23514	—	2.7	33.1	64.2	—
2000	Thailand	33001	16096	6276	10619	10	48.8	19.0	32.2	0.0
2000	Korea, Rep. of	21061	2288	5905	12868	—	10.9	28.0	61.1	0.6
2000	Singapore	2095	5	717	1371	2	0.2	34.2	65.4	0.1
2000	Philippines	27775	10401	4444	12926	4	37.4	16.0	46.5	0.0
2000	Canada	14910	492	3369	11049	—	3.3	22.6	74.1	—
2001	Chinese Taipei	9383	708	3377	5298	—	7.5	36	56.5	—

Note: "Others" activates not adequately defined

Sources: 1. Chinese Taipei—"Yearbook of Manpower Survey Statistics", DGBAS, Chinese Taipei

2. Other countries—"Yearbook of Labor Statistics", ILO

Appendix 3. Economic growth and per capita income, and industrial origin of gross domestic product in Chinese Taipei

Year	GDP			Per Capita GNP		
	Amount		Economic Growth Rate (%)	Amount		Growth Rate (%)
	(Million NT$)	(Million US$)		NT$	US$	
1952	17251	1675	11.98	2019	196	8.25
1953	22955	1476	9.33	2602	167	5.86
1954	25204	1621	9.54	2759	177	5.80
1955	29981	1928	8.11	3162	203	4.16
1956	34410	1389	5.50	3502	141	1.82
1957	40173	1621	7.36	3959	160	3.98
1958	44966	1815	6.71	4282	173	3.23
1959	51833	1425	7.65	4782	131	4.30
1960	62507	1718	6.31	5601	154	3.11
1961	70043	1751	6.88	6078	152	3.54
1962	77159	1929	7.90	6498	162	4.73
1963	87252	2181	9.35	7137	178	6.20
1964	101966	2549	12.20	8113	203	9.08
1965	112627	2816	11.13	8697	217	7.93
1966	126022	3151	8.91	9480	237	6.06
1967	145817	3645	10.71	10685	267	7.89
1968	169904	4248	9.17	12151	304	6.56
1969	196845	4921	8.95	13783	345	6.62
1970	226805	5670	11.37	15544	389	9.02
1971	263676	6592	12.90	17730	443	10.73
1972	316172	7904	13.32	20885	522	11.31
1973	410405	10730	12.83	26596	695	10.7
1974	549577	14463	1.16	34974	920	-0.66
1975	589651	15517	4.93	36642	964	2.50
1976	707710	18624	13.86	43033	1132	11.41
1977	828995	21816	10.19	49449	1301	8.06
1978	991602	26836	13.59	58282	1577	11.91
1979	1195838	33218	8.17	69115	1920	6.38
1980	1491059	41418	7.30	84398	2344	5.08
1981	1773931	48218	6.16	98179	2669	3.80
1982	1899971	48568	3.55	103803	2653	2.22
1983	2100005	52421	8.45	113103	2823	6.91
1984	2343078	59139	10.6	125496	3167	10.01
1985	2473786	62062	4.95	131430	3297	4.14
1986	2855180	75434	11.64	151148	3993	11.34
1987	3237051	101570	12.74	168832	5298	11.06
1988	3523193	123146	7.84	182511	6379	7.13
1989	3938826	149141	8.23	201402	7626	6.79
1990	4307043	160173	5.39	218092	8111	4.38
1991	4810705	179370	7.55	240909	8982	6.37
1992	5338952	212200	7.49	264338	10506	6.23
1993	5918376	224266	7.01	289337	10964	5.67
1994	6463600	244278	7.11	312386	11806	5.84
1995	7017933	264928	6.42	336042	12686	5.41
1996	7678126	279611	6.10	364115	13260	5.08
1997	8328780	290201	6.68	390103	13592	5.37
1998	8938967	267154	4.57	413582	12360	3.30

Year	GDP			Per Capita GNP		
	Amount		Economic Growth Rate (%)	Amount		Growth Rate (%)
	(Million NT$)	(Million US$)		NT$	US$	
1999	9289929	287881	5.42	427097	13235	4.74
2000	9663388	309426	5.86	443087	14188	5.53
2001	9506624	281178	-2.18	435321	12876	-2.32

Source : "Statistical Abstract of National Income in Taiwan Area", Directorate-General of Budget, Accounting and Statistics (DGBAS), Chinese Taipei

Appendix 4. Industrial Origin of Gross Domestic Product in Chinese Taipei

Year	Amount (Million NT$)				Rate (%)		
	Total	Agriculture	Industry	Service	Agriculture	Industry	Service
1952	17251	5558	3396	8297	32.22	19.69	48.09
1953	22955	7909	4452	10594	34.46	19.39	46.15
1954	25204	7064	6030	12110	28.03	23.92	48.05
1955	29981	8720	6966	14295	29.09	23.23	47.68
1956	34410	9446	8401	16563	27.45	24.41	48.14
1957	40173	10977	10147	19049	27.32	25.26	47.42
1958	44966	12035	11163	21768	26.76	24.83	48.41
1959	51833	13657	14045	24131	26.35	27.10	46.55
1960	62507	17838	16796	27873	28.54	26.87	44.59
1961	70043	19225	18616	32202	27.45	26.57	45.97
1962	77159	19269	21772	36118	24.97	28.22	46.81
1963	87252	20286	26128	40838	23.25	29.95	46.80
1964	101966	24989	30968	46009	24.51	30.37	45.12
1965	112627	24611	34025	51991	23.63	30.21	46.16
1966	126022	28379	38494	59149	22.52	30.55	46.93
1967	145817	30057	48053	67707	20.61	32.96	46.43
1968	169904	32308	58524	79072	19.02	34.44	46.54
1969	196845	31276	72565	93004	15.89	36.86	47.25
1970	226805	35076	83530	108199	15.47	36.83	47.40
1971	263676	34455	102680	126541	13.07	38.94	47.99
1972	316172	38619	131670	145883	12.21	41.64	46.15
1973	410405	49678	179893	180834	12.11	43.83	44.06
1974	549577	68279	223609	257689	12.42	40.69	46.89
1975	589651	74875	235419	279357	12.70	39.92	47.38
1976	707710	80504	305443	321763	11.37	43.17	45.46
1977	828995	87875	364393	376727	10.60	43.96	45.44
1978	991602	93033	448007	450562	9.38	45.18	45.44
1979	1195838	102248	542210	551380	8.55	45.34	46.11
1980	1491059	114556	682114	694389	7.68	45.75	46.57
1981	1773931	129496	806657	837778	7.30	45.47	47.23
1982	1899971	147041	842505	910425	7.74	44.34	47.92
1983	2100005	153331	944178	1002496	7.30	44.96	47.74
1984	2343078	148414	1081510	1113154	6.33	46.16	47.51

Year	Amount (Million NT$)				Rate (%)		
	Total	Agriculture	Industry	Service	Agriculture	Industry	Service
1985	2473786	143083	1144712	1185991	5.78	46.28	47.94
1986	2855180	158326	1345071	1351783	5.55	47.11	47.34
1987	3237051	171728	1510912	1554411	5.30	46.68	48.02
1988	3523193	177416	1579639	1766138	5.04	44.83	50.13
1989	3938826	192872	1666633	2079321	4.90	42.30	52.80
1990	4307043	180110	1775583	2351350	4.18	41.22	54.60
1991	4810705	182356	1975634	2652715	3.79	41.07	55.14
1992	5338952	191974	2139747	3007231	3.60	40.08	56.32
1993	5918376	215333	2328822	3374221	3.64	39.35	57.01
1994	6463600	227172	2437727	3798701	3.51	37.71	58.78
1995	7017933	244265	2552997	4220671	3.48	36.37	60.15
1996	7678126	245184	2742061	4690881	3.19	35.72	61.09
1997	8328780	212100	2941615	5175065	2.55	35.31	62.14
1998	8938967	220605	3090002	5628360	2.47	34.45	62.97
1999	9289929	237531	3082452	5969946	2.56	33.19	64.25
2000	9663388	201810	3128699	6332879	2.09	32.38	65.53
2001	9506624	185182	2955721	6365721	1.95	31.09	66.96

Source: "Statistical Abstract of National Income in Taiwan Area", DGBAS, Chinese Taipei

Appendix 5. Per capita annual food availability in Chinese Taipei

Year	Cereals			Starchy Roots	Sugar & Honey	Pulses, Nuts and oilseeds	Vegetables	Fruits	Meat	Eggs	Fish & Sea food	Milk	Oil and Fats
	Total	Polished Rice	Wheat Flour										
1952	138.13	126.06	11.33	62.41	9.41	9.86	61.73	16.81	16.82	1.59	15.07	1.17	3.46
1953	157.07	141.19	15.15	65.34	9.41	9.47	60.23	17.94	17.81	1.45	16.05	1.59	3.43
1954	145.05	124.85	15.88	71.00	9.41	9.64	59.05	16.49	17.26	1.69	17.25	2.00	3.38
1955	149.20	134.18	14.29	65.68	9.41	10.35	57.55	14.45	16.31	1.65	18.68	5.75	4.08
1956	150.16	132.59	16.55	66.65	9.41	10.87	58.38	14.52	17.04	1.63	18.81	6.03	3.72
1957	157.44	133.91	21.92	67.92	9.41	11.52	59.60	19.10	18.87	1.60	19.49	4.18	3.81
1958	153.14	131.74	20.16	72.10	9.41	11.92	60.59	20.94	18.64	1.66	20.74	5.34	4.28
1959	156.29	135.31	19.09	68.20	9.41	10.81	59.10	19.40	16.67	1.68	21.29	8.66	3.83
1960	159.68	137.74	20.02	68.37	9.41	11.42	61.05	22.07	16.24	1.62	21.67	3.19	4.72
1961	165.03	136.78	24.57	58.08	9.41	12.28	57.18	19.86	15.60	1.63	25.33	9.38	4.84
1962	156.81	132.10	22.04	54.50	9.41	10.64	56.16	21.62	16.04	1.63	26.14	8.42	4.32
1963	156.77	134.36	18.47	46.46	9.22	11.29	60.28	20.74	17.90	1.91	27.27	4.92	4.79
1964	150.84	129.87	17.17	59.59	9.58	13.18	56.58	17.81	18.45	2.06	28.20	5.65	6.41
1965	157.34	132.85	22.33	51.32	10.03	13.56	56.81	21.01	19.21	2.35	27.74	5.30	5.39
1966	156.33	137.42	16.58	47.17	11.70	13.50	52.67	26.18	22.91	2.63	28.84	4.77	5.02
1967	157.80	141.47	13.43	48.74	11.13	16.25	52.49	34.11	26.26	2.63	28.69	4.67	6.50
1968	162.59	139.93	20.37	23.98	13.17	13.15	67.56	52.65	27.08	3.47	29.69	6.70	6.56
1969	166.67	138.74	24.88	38.98	13.96	15.62	74.97	38.45	23.32	3.86	30.32	8.31	6.19
1970	164.11	134.45	25.42	21.28	15.01	18.29	84.83	45.83	25.25	4.11	34.18	10.43	7.72
1971	164.63	134.28	25.51	21.44	15.35	17.43	91.27	44.96	26.43	4.12	34.34	10.38	7.78
1972	165.78	133.52	27.10	18.10	15.97	19.01	91.17	41.75	27.34	4.61	35.28	11.42	9.10
1973	161.58	129.84	26.96	16.98	18.26	16.96	92.98	50.23	28.71	4.75	36.96	13.65	9.63
1974	167.81	134.15	28.72	15.52	18.60	17.28	98.93	62.93	27.45	4.49	34.25	15.89	8.24
1975	162.11	130.39	24.21	14.47	18.11	19.01	109.79	55.03	26.98	5.22	35.56	14.98	9.09
1976	156.25	128.12	20.78	11.18	20.33	19.19	118.39	62.14	31.64	5.86	35.27	16.95	10.02
1977	156.63	125.06	22.58	10.26	21.81	17.22	122.37	57.41	35.26	6.27	35.05	20.83	9.71
1978	146.46	113.99	23.92	10.66	24.34	19.45	114.93	54.32	36.12	7.55	36.48	24.32	10.67
1979	142.39	105.27	23.81	8.90	24.57	18.41	127.50	66.62	40.26	7.83	38.09	23.79	10.07

Year	Cereals			Starchy Roots	Sugar & Honey	Pulses, Nuts and oilseeds	Vegetables	Fruits	Meat	Eggs	Fish & Sea food	Milk	Oil and Fats
	Total	Polished Rice	Wheat Flour										
1980	134.08	100.82	23.62	8.18	23.95	18.78	129.58	70.16	42.62	8.02	38.74	24.55	10.98
1981	128.76	96.54	23.38	6.97	22.82	19.44	115.60	80.51	42.99	8.56	35.79	24.77	11.33
1982	127.56	93.07	23.29	7.05	22.42	19.28	118.21	71.54	46.36	8.00	35.16	26.08	12.75
1983	121.95	89.33	24.21	5.37	23.82	19.73	116.61	68.42	50.02	10.76	33.09	27.76	13.50
1984	114.00	84.40	23.25	13.18	25.61	20.24	109.62	105.83	52.76	10.94	35.56	30.16	15.25
1985	110.47	80.18	24.94	14.40	25.40	21.87	103.42	111.50	55.75	10.94	35.13	32.37	15.30
1986	111.32	76.46	27.48	16.69	27.22	25.97	93.14	105.13	56.46	10.71	35.64	35.51	17.69
1987	110.55	73.33	29.03	18.72	27.16	27.06	102.93	126.30	58.89	11.25	42.27	34.69	18.70
1988	109.55	70.14	31.49	18.36	27.63	26.43	98.54	135.48	59.16	10.71	41.34	37.32	19.39
1989	105.53	68.26	29.68	17.40	27.49	26.10	98.29	135.71	61.35	11.71	45.49	40.95	21.94
1990	102.23	65.94	28.62	20.19	27.15	28.98	93.32	131.50	62.89	12.13	47.47	43.00	22.45
1991	99.51	62.50	28.46	21.17	26.28	29.36	94.74	138.69	64.50	13.36	39.71	49.98	23.70
1992	100.38	62.23	28.97	21.99	26.05	29.05	97.46	129.81	67.18	13.72	43.96	51.39	23.56
1993	99.30	60.69	28.91	21.69	25.34	29.23	98.09	144.58	70.33	14.21	47.46	54.68	24.92
1994	101.72	59.89	31.54	21.18	25.12	30.25	93.31	136.54	72.38	14.89	38.36	58.33	25.91
1995	100.36	59.10	31.85	18.06	24.51	31.70	101.85	137.47	72.75	16.23	38.34	58.79	26.02
1996	97.14	58.84	29.55	19.73	24.94	31.86	108.83	138.87	75.35	17.57	38.42	56.93	26.05
1997	96.20	58.40	30.27	23.40	24.45	31.57	108.76	150.06	77.30	19.43	42.30	59.01	26.75
1998	95.84	56.74	31.90	22.19	24.54	25.26	104.94	135.53	78.77	19.35	39.41	56.82	24.22
1999	94.12	54.90	31.66	23.35	25.11	25.74	124.48	148.34	78.09	19.41	43.72	56.75	26.49
2000	92.48	52.69	32.60	23.63	28.65	26.40	115.52	136.30	79.00	19.22	40.22	56.04	25.06
2001	89.44	50.10	33.18	21.60	25.68	24.69	109.88	134.38	76.57	19.19	35.45	54.37	23.27

Note : Food conversion ratios : powdered milk : fresh milk = 1:8.

Source : "Taiwan Food Balance Sheet", 1956-1983；" Food Supply & Utilization Yearbook ", 1984-2001, COA, Chinese Taipei

Appendix 6. Per capita daily nutrient availability in Chinese Taipei

Year	Energy (kcal)	Protein (gm)			Fat (gm)
		Total	Animal Protein	Vegetable Protein	
1952	2078	49.04	11.73	37.31	35.47
1953	2283	53.42	12.49	40.93	36.70
1954	2176	51.88	12.74	39.14	36.30
1955	2247	53.15	13.30	39.85	37.17
1956	2262	53.93	13.50	40.43	37.32
1957	2369	56.80	14.09	42.71	40.24
1958	2359	56.89	14.60	42.29	41.58
1959	2340	56.57	14.59	41.98	38.29
1960	2339	57.13	13.91	43.22	40.85
1961	2430	60.34	15.79	44.55	41.17
1962	2317	57.83	16.18	41.65	38.92
1963	2325	58.76	16.81	41.94	42.07
1964	2364	59.51	17.47	42.04	48.49
1965	2411	61.20	17.58	43.62	46.66
1966	2433	62.26	19.28	42.98	47.40
1967	2504	64.47	19.30	45.17	55.52
1968	2545	64.85	20.52	44.33	54.37
1969	2639	69.06	21.20	47.86	55.80
1970	2662	72.17	23.32	48.85	63.52
1971	2674	72.42	23.87	48.55	64.13
1972	2737	74.61	24.79	49.82	68.79
1973	2754	73.68	25.67	48.01	72.01
1974	2780	74.24	24.73	49.51	66.70
1975	2772	74.70	24.56	50.14	67.51
1976	2771	75.90	26.70	49.20	73.39
1977	2805	76.59	28.68	47.91	77.50
1978	2822	76.95	29.75	47.20	81.27
1979	2845	78.72	31.85	46.87	84.31
1980	2850	79.36	33.24	46.12	85.63
1981	2765	76.43	32.33	44.10	85.53
1982	2802	78.19	33.57	44.62	90.39
1983	2793	79.16	33.39	43.77	93.12
1984	2593	78.84	35.81	43.03	80.84
1985	2612	81.18	37.25	43.93	83.40
1986	2725	84.21	37.87	46.34	92.33
1987	2809	89.47	41.10	48.36	96.99
1988	2822	88.31	40.30	48.01	98.55
1989	2876	90.70	43.29	46.98	105.72
1990	2909	92.85	44.62	48.23	109.62
1991	2929	91.71	43.81	47.90	114.35
1992	2947	94.07	46.23	47.84	115.22

Year	Energy (kcal)	Protein (gm)			Fat (gm)
		Total	Animal Protein	Vegetable Protein	
1993	3005	97.54	49.17	48.37	120.62
1994	3058	96.73	47.29	49.44	124.97
1995	3058	98.48	47.75	50.73	126.15
1996	3054	98.55	48.72	49.84	126.66
1997	3135	101.76	51.43	50.33	130.99
1998	2974	95.93	50.49	45.43	121.04
1999	3048	98.01	51.78	46.22	127.07
2000	3022	96.71	50.58	46.13	123.66
2001	2877	92.42	47.83	44.60	117.14

Source: "Taiwan Food Balance Sheet"(1956-1983)；" Food Supply & Utilization Yearbook"(1984-2001), COA, Council of Agricultuer, Chinese Taipei

Appendix 7. Quantity of livestock production in Chinese Taipei

Year	Cattle (m.t.)	Hogs (m.t.)	Goats (m.t.)	Poultry (X 1000 Head)				Eggs (X 1000 pieces)		Milk (m.t.)	Goat's Milk (m.t.)	Hides (m.t.)	Young Antlers Kg	Honey (m.t.)	Royal Jelly (m.t.)
				Chicken	Ducks	Geese	Turkeys	Chicken	Duck						
1953	3060	126417	501	12331	6206	2872	456	126493	155159	1585	...	813	...	113	...
1954	2634	130612	551	12851	6648	2600	474	128054	166211	1744	...	579	...	88	...
1955	2908	136815	377	13026	6647	2595	526	128577	166169	1857	...	635	...	133	...
1956	2897	146917	429	13443	6703	2675	515	129828	167564	2740	...	651	...	134	...
1957	2924	169933	425	13400	6888	2711	538	187399	172199	2885	...	676	...	214	...
1958	2746	198798	581	14621	7125	2856	572	191063	178137	3266	...	672	...	173	...
1959	2874	192123	585	15195	7703	2924	615	192785	192585	3665	...	703	...	182	...
1960	3252	181084	567	15300	7643	2874	624	193100	191084	4689	...	772	...	191	...
1961	3702	204866	615	15830	7822	2949	657	194689	195540	5824	...	811	...	269	...
1962	6171	217401	650	16200	7915	2874	662	239599	197885	4979	...	1303	...	256	...
1963	8538	211932	585	16386	8104	2855	697	279558	202603	8013	...	1853	...	221	...
1964	8531	224272	721	16988	8827	2903	736	341965	220671	11283	...	1797	...	206	...
1965	5053	241412	762	19737	10756	3082	819	235714	367042	13650	...	989	...	205	...
1966	5454	272110	852	21771	11100	3029	899	271830	372798	13834	...	1095	...	194	...
1967	6853	314627	1016	24560	11676	2794	945	317993	367699	13812	...	1395	...	390	...
1968	8894	322604	1018	27573	13466	3018	1004	426910	397484	14798	...	2549	...	333	...
1969	9028	348322	1170	28871	13177	2999	1044	529071	423562	14966	...	1899	...	296	...
1970	9070	392755	1243	29644	13597	2969	1093	574961	463518	16123	...	1872	...	352	...
1971	7564	400062	1305	33405	14606	2836	1098	600559	455098	17906	...	1574	...	407	...
1972	4425	428068	1196	44683	17003	2797	1152	715307	494833	22932	...	2897	...	415	...
1973	5592	522661	1334	48995	13819	2736	1209	762875	515494	37640	...	4076	...	614	...
1974	4754	462484	1188	50015	17518	2720	1245	797162	437014	41879	...	1866	...	1005	...

Year	Cattle (m.t.)	Hogs (m.t.)	Goats (m.t.)	Poultry (X 1000 Head)				Eggs (X 1000 pieces)		Milk (m.t.)	Goat's Milk (m.t.)	Hides (m.t.)	Young Antlers Kg	Honey (m.t.)	Royal Jelly (m.t.)
				Chicken	Ducks	Geese	Turkeys	Chicken	Duck						
1975	4294	395320	1340	56044	18599	2697	1314	980332	478756	46189	...	912	...	609	...
1976	10550	521968	1632	64776	20091	2705	1377	1209968	478849	45111	...	4432	...	2481	101
1977	15798	574656	1459	79112	23151	2793	1398	1377426	469254	45727	...	5167	...	2316	69
1978	9710	579327	677	91463	26407	2920	1398	1743175	517664	44615	...	3352	...	313	105
1979	8518	694822	639	94253	27381	2954	1409	1875003	524489	44418	...	4437	...	495	149
1980	5499	733589	633	104685	27585	2855	1381	2023649	475522	47740	...	3132	...	764	183
1981	5190	730511	649	115670	32026	2798	1310	2048760	476204	50154	...	4323	...	1070	193
1982	5740	753919	605	122353	33932	3144	1238	2119955	469376	55859	...	4241	...	742	178
1983	6619	804805	662	154815	35901	3334	1281	3070472	485235	58022	...	5273	...	3905	250
1984	6482	887816	765	155000	34456	3529	1274	3273463	476318	66933	...	7378	...	3247	234
1985	4351	1008143	678	154686	31894	3186	1163	3344729	453247	87879	...	14306	...	2062	285
1986	3883	1053801	644	155917	34347	3266	1383	3339487	429246	109723	...	14440	...	4230	200
1987	4172	1137918	677	174400	39745	3923	1111	3546186	450752	144390	...	27681	33369	1320	240
1988	4727	1105731	844	193018	37717	3942	920	3432113	404249	173407	...	17821	28649	4054	193
1989	6058	1112590	961	215940	39952	4140	899	3844170	393907	182421	...	19385	30537	4124	261
1990	4920	1224193	749	226556	39900	4777	758	4032185	422464	203830	...	20697	32710	4497	284
1991	4900	1366664	894	233971	36295	4628	636	3895379	393937	225656	10307	21852	32588	4938	312
1992	5324	1365340	1241	257666	40558	5683	543	4754761	391648	246281	11241	22566	28501	5175	322
1993	4754	1376193	3456	288243	45483	6397	521	4916374	455354	278476	13804	23951	28644	5895	301
1994	5189	1458904	5442	301914	40886	8521	458	5200777	472555	289574	19006	26228	26492	4172	133
1995	6113	1494572	8148	319820	42580	7744	415	5718589	517945	317806	27304	29850	24594	4400	126
1996	5968	1538611	10139	345509	41759	7078	398	6139072	538845	315927	31021	29160	25178	4791	128
1997	5898	1248300	9882	389966	41156	7503	429	7104433	531669	330469	32920	11799	25585	4138	107

Year	Cattle (m.t.)	Hogs (m.t.)	Goats (m.t.)	Poultry (X 1000 Head)				Eggs (X 1000 pieces)		Milk (m.t.)	Goat's Milk (m.t.)	Hides (m.t.)	Young Antlers Kg	Honey (m.t.)	Royal Jelly (m.t.)
				Chicken	Ducks	Geese	Turkeys	Chicken	Duck						
1998	5288	1080940	8871	389524	35719	7955	432	7157707	520188	338369	32912	4544	23437	3691	107
1999	5168	996780	8916	385563	35208	7464	488	7274451	485629	338005	32125	...	23441	6283	323
2000	4901	1115883	8213	389770	34099	6503	500	7270033	478452	358049	30006	...	23422	5839	299
2001	5057	1165998	7219	376196	32142	6330	458	7325125	481789	346079	25493	…	23931	2758	315

Source: "Agricultural Statistics Yearbook ", Council of Agriculture, Chinese Taipei

Appendix 8. Unit price for livestock products in Chinese Taipei (Unit price: NT$/kg)

Year	Yellow Cattle (NT$/head)	Yellow Cattle (For Slaughtered)	Hogs	Goats (Ram)	Simulated Native (Hen)	Broiler	Duck (Hybrid)	Geese (Live Weight)	Turkey (Ram)	Bee Royal Jelly	Eggs	
											Chicken	Duck
1964	...	...	...	...	36.82	...	21.41	...	...	...	23.78	20.22
1965	...	...	...	...	38.82	...	21.89	...	...	...	21.42	20.30
1966	...	...	...	...	38.99	...	21.54	...	...	...	21.31	19.57
1967	...	...	...	...	41.14	...	22.43	23.76	27.24	...	21.42	20.30
1968	7806	...	...	...	42.87	28.18	23.25	25.43	28.21	...	19.92	19.61
1969	7848	...	...	...	43.40	26.56	20.53	25.30	28.31	...	18.19	18.05
1970	8333	...	...	...	49.14	26.33	21.21	26.30	29.80	...	18.68	20.19
1971	8989	...	...	...	49.26	25.94	22.14	27.58	30.17	...	20.76	20.19
1972	11373	...	...	...	48.08	25.55	21.85	28.57	31.61	...	19.38	19.21
1973	14315	...	...	42.29	60.80	33.52	28.83	34.00	36.88	...	23.12	23.60
1974	19282	...	...	57.96	87.88	45.68	39.82	51.80	56.64	...	34.76	35.66
1975	19789	...	...	65.62	87.62	44.89	40.33	65.93	63.37	...	32.58	33.16
1976	16742	...	41.51	63.76	93.11	41.02	40.39	72.46	69.34	...	30.35	31.22
1977	12785	...	44.04	67.15	77.30	48.64	48.21	89.23	78.19	...	34.50	36.04
1978	18548	...	47.58	84.03	69.55	45.15	44.27	96.33	83.14	...	30.84	32.62
1979	25434	...	40.83	102.25	64.53	44.02	40.96	95.38	86.95	...	29.90	32.82
1980	29451	...	49.47	127.76	73.43	49.26	49.57	93.71	91.81	...	38.76	41.03
1981	34356	...	58.71	155.81	78.70	55.25	52.03	98.93	96.93	...	42.78	45.00
1982	36773	...	62.58	163.15	73.11	52.53	47.74	94.77	93.82	...	36.54	38.59
1983	36840	...	58.42	162.87	66.84	48.03	44.39	90.69	89.48	4169	34.00	36.04
1984	37591	...	49.41	155.04	61.34	47.01	45.75	88.68	85.28	3114	37.61	40.01
1985	40443	...	39.73	153.69	52.02	41.82	41.03	83.25	83.53	3094	32.82	34.78
1986	40648	...	50.13	151.25	57.88	47.67	43.84	83.37	84.76	3025	32.15	33.50
1987	40179	...	48.74	150.25	50.00	41.83	36.27	74.73	57.50	2881	26.97	29.55
1988	37451	...	47.48	129.63	46.07	39.97	38.41	66.03	67.28	2753	26.47	27.43
1989	36619	...	52.32	130.59	49.50	43.82	38.82	69.83	68.67	2547	34.43	34.53

Year	Yellow Cattle (NT$/head)	Yellow Cattle (For Slaughtered)	Hogs	Goats (Ram)	Simulated Native (Hen)	Broiler	Duck (Hybrid)	Geese (Live Weight)	Turkey (Ram)	Bee Royal Jelly	Eggs	
											Chicken	Duck
1990	35277	...	39.39	162.54	43.16	31.20	36.12	64.24	95.22	1910	23.47	26.71
1991	34875	...	38.94	159.61	38.87	32.40	35.57	68.88	125.00	1506	21.85	28.65
1992	...	128.44	46.42	181.72	38.31	33.79	31.94	75.26	80.17	1473	27.10	29.25
1993	...	98.86	49.74	173.62	42.79	37.14	28.99	56.42	76.85	1379	24.67	29.50
1994	...	93.8	51.43	154.44	42.09	36.21	41.74	53.82	65.00	1386	27.02	30.57
1995	...	90.14	59.53	149.88	36.83	32.81	34.19	50.12	...	1466	26.55	30.80
1996	...	82.31	57.59	125.04	39.61	36.56	37.36	68.57	...	1689	27.74	32.80
1997	...	77.13	35.81	114.23	40.02	35.36	41.91	54.33	...	1697	23.35	36.57
1998	...	74.84	45.20	140.02	45.35	35.95	40.02	57.80	...	...	28.11	30.49
1999	...	74.84	61.60	157.77	56.23	38.16	37.68	52.41	...	...	28.82	33.44
2000	...	73.35	46.75	149.71	36.49	32.21	31.81	48.33	50.39	...	23.41	29.19
2001	…	62.09	39.67	135.03	38.42	31.62	35.93	51.31	63.08	…	22.45	32.99

Source: Agricultural Products Wholesale Market Yearbook, Taiwan Area, Central Taiwan Division, Council of Agriculture,Chinese Taipei