Sheep and Goats

in Fiji and Papua New Guinea

A Success Story




ALAN QUARTERMAIN
and
VINESH KUMAR

Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources
Asia-Pacific Association of Agricultural Research Institutions
182 Larn Luang Road, Klong Mahanak Sub-District
Pomprap Sattrupai, Bangkok 10100, Thailand

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ALAN QUARTERMAIN
University of Goroka, Goroka, Papua New Guinea

and

VINESH KUMAR
Ministry of Agriculture, Suva, Fiji

Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources
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182 Larn Luang Road, Klong Mahanak Sub-District
Pomprab Sattrupai, Bangkok 10100, Thailand

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Cover page photo identity: *First row (L and R) Fiji fantastic sheep, Second row (L) Local goats at pasture, PNG University of Technology, (R) PNG goats Bougainville*

For copies, please contact:
The Executive Secretary
Asia-Pacific Association of Agricultural Research Institutions (APAARI)
182 Larn Luang Road, Klong Mahanak Sub-District, Pomprab Sattrupai
Bangkok 10100, Thailand
E-mail: apaari@apaari.org, Website: www.apaari.org; www.apcoab.org

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Foreword

Humans domesticated sheep and goat thousands of years before the cow. Initially sheep and goat were the livelihood source mainly for meat, milk and skin and now commercial production is order of the day. Global production of sheep meat is 9 million tons and developing countries are at the top of the list. Consumption of sheep meat is in fourth position after pork, poultry, and beef meat. Dairy products from sheep and goats is about 21 per cent and they make up to 1.3 per cent and 1.9 per cent of total milk production in the world, respectively. Traditionally known health benefits of consuming goat and sheep milk is established scientifically as well. The Asia Pacific region has over 50 per cent of 1.27 billion goats in the world. China, India, Pakistan, Bangladesh and Mongolia have major goat population in Asia, while in case of sheep China, India, Iran, Mongolia and Turkey dominate. In Oceania, Australia, Fiji, New Zealand, Vanuatu and French Polynesia had the most population of goats. Among the Pacific countries, Australia and New Zealand dominate and there are recent developments in Fiji and PNG. Fiji is also progressing in commercial production of sheep and goat, while PNG it is mainly for livelihood.

Success stories are published and circulated by the Asia-Pacific Association of Agricultural Research Institutions (APAARI) to inspire and guide the member countries to learn from the practical experiences within the region. I am happy that APAARI could motivate to build a success story on sheep and goat in Fiji and PNG. This success story is byproduct of the Regional Workshop on Underutilized Animal Genetic Resources and their Amelioration organized by the APAARI in Kula Lumpur, Malaysia.

The success story covers the introduction and historical account, livelihood keeping, semi-commercial and commercial farming,

development issues, consumption and marketing systems and regulatory policies. I congratulate both the authors for their contributions in building the success story and also Dr Rishi Kumar Tyagi, Coordinator, Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB) for his initiative, contributions and follow up to complete the task. It is hoped that the member countries take advantage of the documented success story to move forward in building livelihoods and in commercial farms establishment contributing to SDG goals of eradicating poverty and providing food and nutritional security.

Date: March 25, 2021

Ravi Khetarpal
Executive Secretary, APAARI

Preface

Sheep and goats are domestic animal species adopted into the agri-cultural economies of some Pacific Island Countries (PICs) since colonial occupation and retained to become useful components of food production in the post-independence era. As small-sized ruminant species their contributions to food security and commercial development contrast with those of the traditional pigs and chickens so widely associated with Pacific island cultures. Two contrasting countries have been chosen to document and illustrate the different ways in which the success story of the adoption and adaptation of sheep and goats has played out in different geographical, cultural and historical environments in the tropical Pacific. The story, therefore, takes a historical and anthropological as well as a zoo-geographical approach. Papua New Guinea (PNG) is geographically diverse but with a population still predominantly dependent on family gardening for their livelihoods. Fiji is more uniform as an island-based country but with a more advanced commercial economy with family farming as well as a village-based subsistence horticultural sector. The concept for the comparative approach arose from discussions in a Regional Workshop on Underutilized Animal Genetic Resources and their Amelioration, organized by the Asia-Pacific Association of Agricultural Research Institutions (APAARI) during 2019 in Kuala Lumpur, Malaysia.

Authors

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The authors wish to acknowledge the contributions of a range of students, farmers, government officials and institutional scientists in both countries who responded to request for information and opinions. Special thanks to Dr Rishi Kumar Tyagi, Coordinator, Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB), Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok, Thailand, who suggested the topic, developed the outlines of the document and the need for a success story on domestic livestock – sheep and goats in the Pacific region. His critical editing, valuable suggestions for improvement and continued encouragement enabled completion of this document.

Authors

Abbreviations and Acronyms

ACIAR	Australian Centre for International Agricultural Research
ADAB	Australian Development Assistance Bureau
AUSAID	Australian Aid
BBB	Barbados Black Belly (Sheep breed)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAL	Department of Agriculture and Livestock (PNG)
FAO	Food and Agriculture Organisation of the United Nations
FF	Fiji Fantastic (Sheep breed)
FJD	Fiji Dollar
FMIB	Fiji Meat Industry Board
GIP	Gastro-intestinal Parasite
LDC	Livestock Development Corporation (PNG)
MOA	Ministry of Agriculture (Fiji)
NARI	National Agricultural Research Institute (PNG)
NAQIA	National Agricultural Quarantine and Inspection Authority (PNG)
PD	Poll Dorset (Sheep breed)
PEM	Protein-Energy Malnutrition
PLC	Provincial Livestock Centre (PNG)
PNG	Papua New Guinea
PGK	Papua New Guinea Kina
SDA	Seventh Day Adventist
UNDP	United Nations Development Programme
USA	United States of America
WH	Wiltshire Horn (Sheep breed)

Executive Summary

Sheep and goats have become established as domestic livestock in the Fiji Islands and Papua New Guinea over the past 140 years. They complement the long-standing traditional livestock, pigs and chickens. In PNG, both species came to be targeted to village household ownership whereas in Fiji there is substantial commercial orientation in keeping with the greater commercialisation of the economy, with substantial influence from the Indo-Fijian community both as producers and consumers. In general, goats have been more successful than sheep in spite of official preference for the latter. This is due to the biological characteristics of the species as adaptable and self-reliant. In PNG, only the sheep population was subjected to major imports of temperate genotypes and current sheep are largely cross with original introduced tropical sheep known as PNG Priangan, whereas the goats have proliferated largely from very early introductions. However, in Fiji significant changes have occurred with the deliberate development of the Fiji Fantastic sheep from imported tropical and temperate breeds with desired genetic traits and the use of the Anglo-Nubian goat breed in crossing with the original Fiji goats. This sheep breed or these goat crosses now dominate production. Efficient meat production is the objective with both species in both the countries and hence, reproductive ability is important. Health problems including gastro-intestinal parasitism (GIP) appear manageable in small household flocks or herds with minimal inputs. In these smallholder or household operations the animals serve customary purposes, even replacing pigs in some circumstances, give security from the effects of natural disasters, supply needed protein and also enhance income as required. Marketing arrangements are well developed in Fiji, whereas in PNG sales and purchases are more opportunistic. In either case the economics are

favourable with low cost of production and high consumer demand fostered by years of significant mutton or lamb imports. Government policies and interventions are supportive of commercial production but have little impact on household production. Production is well integrated into or with food crop production and commercial crops such as sugarcane. Demand for animals seems to outstrip supply both for consumption and breeding. In conclusion, it can be stated that both species in both countries are well-established and increasingly meeting the needs of the people by contributing significantly to food security.

Introduction

Sheep and goats are not indigenous to the Pacific Islands but have become established over the past 140 years. This success story began with the advent of these small ruminant domestic livestock into the Pacific with colonization in the second half of the 1800s. The path to success has not been a steady climb but a story of ups and downs, small successes and failures, until the undoubted success situation found today. It is necessary to follow this history in order to understand the ultimate success, the defeat of the obstacles. Of course, the concept of success depends upon the objectives and goals of those in charge of the animals and those directing change. The story involves two contrasting nations and environments in which the story has played out – Fiji Islands and Papua New Guinea (PNG). There are some parallels begun earlier with the introduction of domestic animals into New Zealand and Australia but the only commonality with them has been the neglecting of the goat in all four countries, until a kind of awakening was made during the 1980s.

National government entities of both countries, responsible for agriculture, have gone through a sequence of name changes. Hence, to avoid any confusion and maintain consistency in this document, all government officers and activities are simply designated PNG Government or Fiji Government unless necessarily more specific.

The geography of PNG is extremely variable but for the purposes of this publication, it is only necessary to define highlands and lowlands, and wetter or dryer climate, understanding that there is much overlapping. Three broad zones are:

1. Permanently wet lowlands and mid-altitude areas up to 1200 m, with rainfall from 2000-5000 mm annually.

2. Dry or seasonally dry lowlands with rainfall less than 2000 mm and pronounced dry periods of up to six months of the year. This seasonality is particularly marked in the southern region and is reflected in the savannah woodland vegetation.
3. Highlands from 1200 m up to the limit of cultivation at about 2700 m. The highlands are cooler with an even temperate climate, occasional frosts above 1800 m and rainfall between 2000 and 3500 mm with slight or localized variation.

In comparison, the geography of Fiji is somewhat less variable, and the country can best be described as an archipelago consisting of some 300 islands and 540 islets scattered over about 3,000,000 square km. For the purpose of this publication, it is geographically defined into four divisions – Central, Northern, Eastern and Western Division. The climate is tropical maritime with three climatic zones:

1. Wet Zone falls on the windward sides of the main islands, where average annual rainfall can range from 3000 mm to 6000 mm.
2. Dry Zone is the rain shadow side, where average rainfall can range from 2000 mm to 2500 mm.
3. Intermediate Zone is the transition area between the wet and dry zones, where average rainfall can be around 2500 mm to 3000 mm.

Fiji has two distinct seasons – a warm wet season from November to April and a cooler dry season from May to October. The country enjoys a warm annual average temperature of 20-27°C.

Early Introductions of Sheep and Goats

It may be noted that archaeological remains of small ruminants have been reported from East Timor dated about 1000 BC, but they seemingly never got further East and Bellwood (1978) is clear that goats, although domesticated in Southeast Asia in prehistoric times, were never introduced into Oceania. The first records were probably of those liberated or presented to local inhabitants by the English navigator James Cook who certainly liberated goats of unknown origin in several places visited during his three voyages. Definitely, he introduced goats into New Zealand in 1773 and 1777. However, Captain Cook never visited the New Guinea coastline. The first recorded landing of Europeans on New Guinea was by the Portuguese, namely Jorge de Menezes in 1526, followed by a widely spaced series of explorers including Fernando Magelhaens, Alvaro de Saavedra and Louis-Antoine de Bougainville. During the last years of the 18th and first decades of the 19th centuries, there were many casual, largely unrecorded, introductions of livestock into the Pacific, among which goats were prominent, by whalers, traders, missionaries and others (Trotter and McCulloch, 2010). Clearly the early goat introductions were dairy type animals for milk production and hence, the PNG, Fijian and the feral populations in Australia and New Zealand were derived from this genetic material. Both traditional PNG and Fijian goats belong to heterogeneous populations derived in the main from these intermittent series of introductions and while most of these introductions were undoubtedly of European origin, there is a possibility that genes from tropical breeds also exist in both populations.

In Fiji, the first substantial number of goat introductions could have been during the sandalwood trading period from 1804 to 1814, as well as later during the onset of the beche-de-mer trade in the 1820s (The Fiji Museum, 2019). Walkden-Brown and Banks (1986) suggested that goats were already in Fiji in the 1840s. In the 1860s, large numbers of goats were reported to be raised by European settlers and missionaries (Lornie *et al.*, 1973; Laor *et al.*, 1977; ADAB, 1979). It is highly possible that some goats with characteristics of those from the Indian subcontinent could have been introduced during the Indian indentured labour period from 1877 to 1916 (Hussain *et al.*, 1983) which resulted in 60,000 Fiji-Indian settlers. However, the first commercial rearing of goats was reported in 1881 on the island of Yaqweta that lies about three km North of Naviti in the Yasawa Group. In 1870, two European settlers, Messers Milligan and Williamson, bought two areas on this island to start coconut farming along with livestock. By 1881 the farm is reported to have had 100 acres of coconut along with 350 head of goats (Parke, 2014). By 1941, feral goats, escapees from domesticity, were also reported on the islands of Makogai and Makodroga (Turbet, 1941, cited in Long, 2003), in the late 1970s on Wakaya (Chapman and Champman, 1980, cited in Long, 2003) and by the 1980s on Yaqaga, Devilan, Yadua, Yaduataba and Monuriki islands.

Recorded introduction of sheep into Fiji started as early as 1888 but the early importations were mostly of temperate breeds which could not adapt well to the Fijian tropical climate. However, sheep were already reported to be present on some of the smaller islands as early as the 1840s (Walkden-Brown and Banks, 1986). Sheep management and husbandry practices were a challenge. As a result, the sheep population remained significantly low during the period up to 1964. In 1963, Fiji only had a stock of around 50 sheep. Major sheep breeding and development started only in the 1980s with the importation of more wool producing breeds from the United States of America, Australia and New Zealand.

Early introductions into PNG were goats, followed by the influence of the development of plantation industries up until the onset of the Pacific War (1942-1947). The earliest reference to a goat introduction in New Guinea has been found by Miklоucho-Maclay (1975) who

recorded in his diary that he brought a pair of goats from Ambon or Macassar in 1883 and gave them to villagers on the Rai coast (North Coast) of the PNG mainland. There are many references to livestock importations in reports of the Niue Guinea Compagnie or the German Imperial Government from 1886-87 to 1912-13 (Sack and Clark, 1979) but no evidence of what breeds and wherefrom they came. However, it is known that sheep were imported from Java and hence, likely goats also. The renowned Anglo-German scholar, writer, musician and scientific botanist Richard Parkinson, who married Phoebe Cole in Samoa in 1879 and joined his sister-in-law Emma in East New Britain in 1882, helped manage her burgeoning network of plantations and over the subsequent years he and Emma imported horses and donkeys, cattle, sheep and goats as well as pigs and poultry (Parkinson, 1907, English Translation, 1999), again, it is not recorded what breeds they were and from whence they came.

Details concerning the Southeast Asian sheep introduced into PNG during the German administration prior to 1914 are scarce but the sheep clearly proliferated both in expatriate plantations and villages, being adapted to wet tropical environments. Many of these introduced tropical sheep were lost during the Pacific War. However, the remnants of the obviously tropical-type sheep in PNG that had survived the war were gathered together in 1971 at the Government Erap station in the dry lowland Markham Valley. Although, clearly of mixed breed and geographic origins, these sheep came to be known as the PNG Priangan after the Indonesian breed of the same name, but they more closely resemble the Javanese Thin-tailed sheep. Since sheep were imported by Parkinson and reared on New Britain and New Ireland plantations, it seems likely that significant crossbreeding had occurred in the past. However, since the 1971 rescue of the sheep, the PNG Priangan (Fig. 1) has been retained as a more or less distinct breed of tropical sheep different from the populations of temperate sheep introduced from the 1930s plantation development through until the major New Zealand funded sheep project at Menifo from 1975 to 2000. Further information on sheep introductions from the 1930s to the 1950s with some limited

Fig. 1. *Priangan sheep, PNG University of Technology*

descriptive and production data for the Priangan is given by Holmes et al. (1977) and Holmes (1980), while descriptions and production data on the Priangan sheep and PNG goats (Fig. 2 and 3) are given by Quartermain (2002).

Fig. 2. *Local goats at pasture, PNG University of Technology*

Fig. 3. *Local goats, University of Natural Resources and Environment, PNG*

Historical Developments

Sheep and Goats in Fiji

A comprehensive account of goat production and development in Fiji up until the early 1980s is given in Hussain et al. (1983). A Fiji government initiative to develop the goat industry started in the 1950s. Upon the recommendations of the Economic Review Committee, the first batch of Angora, Saanen and Toggenburg breeding bucks were imported. These imported bucks were crossed with existing local breeding females, the primary objective being to produce high yielding meat goats. However, the performance of the crosses with European milk type breeds was not encouraging as they did not thrive well in the Fijian conditions and it was soon found that the pure-bred Angoras were not suitable for grading up the local goats. Hence, after thorough reconsideration, the breeding programme focused on the Anglo-Nubian dual-purpose, milk and meat breed (Fig. 4). In early 1970, a small stock of Anglo-Nubian breeders was imported

Fig. 4. *Anglo-Nubian crossbred goats, Fiji*

from Australia. By 1975 the Fiji government, with the assistance of FAO and UNDP, initiated a major goat development programme known as the "Goat Development Scheme" which resulted in the establishment of 158 commercial farms and nearly a doubling of stock from 66,000 to 123,000 by 1978. In 2008, Palmlea Farms in Tabia, Labasa, imported 60 Boer goats from Australia. This was followed by another importation of 23 similar breeders in 2014 by another private farmer, Bobby Naidu from Momi in Nadi, to improve his breeding stock. In 2018, the government imported its own herd of Boer goats, 33 bucks and 39 does from Australia. The majority of the Fijian goats on the main islands came to carry some level of Anglo Nubian genetic influence while many herds in the northern part of the major island also show Saanen characteristics. The introduction of Boer genes has yet to have any effect.

In 1953 there had been discussions in Fiji on the introduction of a more adaptable tropical hair breed of sheep. However, the idea was shelved due to lack of quarantine facilities. After realizing the potential, however, the government intervened and aimed to develop a desirable tropical breed to cater for the large demand for sheep meat. Therefore, in 1964, the Fiji Government established a sheep holding facility in Nawaicoba, Nadi, with the aim of developing an appropriate sheep management system for Fiji. The facility was later known as the Nawaicoba Quarantine Facility. Later during the same year, the government imported 53 Corriedale sheep from New Zealand and placed them under on-farm quarantine at the Nawaicoba facility. There followed the well documented efforts to develop the tropical breed of sheep which culminated in the establishment of the Fiji Fantastic breed of sheep (Fig. 5).

Sheep and Goats in PNG

The earliest attempt at developing a major small ruminant production exercise in PNG was with sheep and the establishment of the Nondugl Experimental Farm in the highland Wahgi Valley. In August 1948, the Hallstrom Livestock and Fauna Trust, formed by the naturalist and philanthropist Sir Edward Hallstrom, purchased 340 acres from

Fig. 5. *Fiji Fantastic sheep*

the local people and two months later flew in the first plane load of some 1200 Romney Marsh sheep from Australia. Under the management of husband and wife team, Neptune and Olga Blood, the native kunai grass was replaced by alfalfa and the farm flourished. However, even within 2-3 years, health problems caused by gastro-intestinal parasites (GIP) became rife and control was inadequate to save the sheep as an economic enterprise. The Bloods left in 1953 and the Trust gave the property to the government administration for research on the highland fauna and flora (Baglin and de Courcy, 1988). The experiment of keeping temperate wool sheep in a single large enterprise was not repeated until the establishment of the

Government Farm at Menifo in 1975 which was more professionally managed with up-to-date technology.

Sheep and goats in PNG were never components of Australian settler nor foreign investment policy post-1945. Only the Nondugl experiment was an intervention of any size. Development for PNG nationals was supposed to be complementary to colonial settlement but settlement policy ended with independence in 1975. The emphasis then turned to smallholder development for families. There were no indigenous pastoral systems for grazing animals and hence, emphasis was on integration with cropping or gardening (Maika, 2009). There are some 300,000 ha of fallows within the horticultural systems as well as extensive plantations of tree crops suitable for under-grazing, as well as land unsuited to cropping but not forested. The potential roles of animals in fallows for the sustainable intensification of cropping systems can also be noted.

Viable populations of goats and the tropical sheep, recovered from villagers and the remnants of the plantation flocks and herds, were eventually consolidated and used to spread ownership. However, PNG highland sheep ventures were only successful when the tropical Priangan sheep were used from the late 1980s in a systematic crossbreeding programme with the temperate Corriedale and Perendale sheep at Menifo to produce what is now known as the Highlands Halfbred. This enabled proliferation of sheep throughout the highlands. The PNG goats, subject to the minor influence of a few spasmodic feral-type goat introductions from Australia and New Zealand, retained their adaptive characteristics and continued to spread, especially in the highlands.

A PNG Country Report on domestic animal genetic resources was presented to FAO by Kohun and Sivasupiramanim (2004). The Highlands Halfbred sheep now dominate most highland flocks, while lowland flocks are mainly Priangan sheep. The estimated number of sheep in the country was 15,000. Productivity of Highlands Halfbred and the Priangan sheep is well documented (Benjamin *et al.,* 1996; Holmes and Absalom, 1985; Kohun, 1988; Quartermain and Kohun,

1985; Manua, 2009 and Owen and Awui, 2000). The surviving goats from the early introductions remain in the hands of village farmers in favourable areas and are kept only for meat. Consequently, they resemble the feral goat populations of Australia and New Zealand, which have similar origins. Flocks were accumulated at the PNG University of Technology in 1975 and subsequently on Department of Agriculture and Livestock (DAL) stations at Erap and Benabena. More recently, there were small introductions of feral-type goats from Australia and New Zealand into the Benabena herd to reinforce the highland herds. In spite of this, it is thought that the goats constitute a unique PNG genotype developed by selection over the past century. There may be some 30,000 goats altogether and their performance too is well documented (Benjamin, 2001; Benjamin *et al.*, 2009; Holmes and Mott, 1989; Quartermain, 1982; Quartermain and Kohun, 1985).

Goat Keeping Development – Fiji

Although, goats were kept in Fiji by the European settlers and missionaries as early as the 1800s, the development of the industry only started in the 1970s. Goats in Fiji have been kept mainly for meat, however, some early attempts were made to introduce milk breeds. Fiji has a large Indo-Fijian population with major religious divisions such as Hindu (majority), Islam, Sikh and others, including Christians. Due to their religious and customary beliefs, Hindus do not consume beef and pork so that the only other sources of red meat for them are goats and sheep. Goat meat does not have any religious restrictions for any denomination and as such it is preferred as the most widely consumed red meat after mutton. Over the years, local goat meat has not been able to establish its place in the formal market, mainly due to inconsistent supply and price. Hence, goat meat has remained more of a 'ceremonial meat' which is only consumed during special gatherings and functions. It is still common for families to collectively buy a goat and slaughter it for meat and many families still rely on village or local slaughtermen to slaughter the goat for consumers. In return, the slaughterman would be given the head and offals such as the stomach and intestine for his services. From early days the Western and Northern Divisions have predominated with the highest number of goats. This is because the two divisions are major producers of sugarcane and the sugarcane farmers have kept goats as sidelines, in many cases serving as 'cash-reserves' for hard times. Historically, sugarcane was also grown in the Central Division until 1959 but, due to wet conditions, goats did not do well on these farms. Over the years, the goat industry has evolved to establish many large commercial goat farms. The Ministry of Agriculture (MOA) classifies a farm with over 120 does as a commercial farm, those with over 70 but

below 120 as semi-commercial farms and below this stock number as a subsistence farm. According to an MOA Report of 2017 there were a total of 1351 goat farms (commercial and semi-commercial) in Fiji with a total stock of 58,019. The Northern Division had the highest number of 571 farms, equivalent to 43 per cent of the total goat farms in Fiji, followed by the Western Division that had 40 per cent (544) of the farms. The Central and Eastern Divisions made up the remaining 17 per cent of the total goat farms in Fiji. Although, the Northern Division had the highest number of farms, the Western Division had the highest number of stock (30,562) as well as the highest number of female breeding stock (13,738 does). Currently, there are a total of 25,203 breeding does on the 1351 semi-commercial and commercial farms. An analysis of the industry for the last eight years shows an increasing trend both in farm numbers and stock numbers (Fig. 6). However, the subsistence sector has the

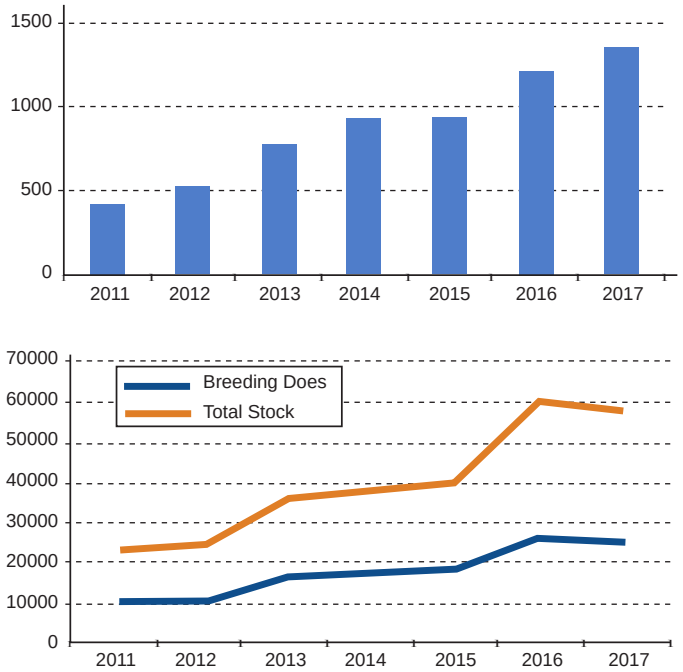


Fig. 6. *Number of commercial/semi-commercial Fiji goat farms (bar diagramme in blue) and total number of animals 2011-2017 (line diagramme in orange and blue) (Source: Fiji Agriculture Rural Statistics)*

highest number of goats. The goat is now one of the most common livestock species kept by nearly every household in the rural parts of Fiji. Most farmers and even farm labourers keep at least 5-10 goats which would normally be tethered on the farm boundaries and fallow land. These animals are mainly kept for home consumption and for quick 'cash'. Currently, it is estimated that there are around 200,000 goats in the subsistence sector, and collectively it is estimated that the total goat population in Fiji is around 265,000.

Goat Keeping Development – PNG

The goat can be productive with low labour requirement on the grass, root-crop tops, vegetable wastes and abundant browse found in and around PNG village sites. Hence, it might be expected that the goat will continue to have increasing importance in PNG village agriculture. Apart from possessing traits (meat and milk) of high economic value, its smaller size facilitates handling and goats fit well into the village livestock production system. However, the varieties of dairy goats introduced during the early colonial period were never very successful and subsequently the Australian administration adopted a policy of not encouraging goats and no further introductions were made for some 60 years.

The first major initiative with goats after independence of PNG was the purchase in 1975 of 17 female and four male goats from villagers in the Sialum area of the Morobe Province North-east coast by the University of Papua New Guinea, Department of Agriculture (located at the PNG University of Technology in Lae) with the unofficial assistance of government extension officers. This remote and rugged coast appeared unaffected by Australian plantation settlement under the League of Nations Mandate and neither by Japanese activities during the Pacific war of the 1940s. Hence, the people had been keeping goats since the German colonial days. A sample of these goats was swapped, again unofficially, for Priangan sheep with the Government Erap Beef Cattle Research Centre, with the Officer-in-Charge Dr John Holmes and the University's Dr Alan Quartermain working together on characterizing and promoting both species during the latter half of the 1970s. Several small experimental goat populations were established in the Huon Peninsular North of Lae but it appears that these have now vanished. However, in the 1980s goats became officially accepted by government and a

goat breeding and multiplication centre was established in 1987 at Benabena in the Eastern Highlands Province.

There were, therefore, two major efforts at support for goat keeping initiatives in PNG, the establishment of the institutional herds in the 1970s and the activities at Benabena in the 1980s (1988-1992). The government imported Australian Feral and New Zealand Kiko goats into the Benabena breeding and multiplication centre in 1988 for crossbreeding (Benjamin, 2001; Benjamin *et al.*, 2009). The Kiko goats are a derived breed originating from the New Zealand feral population and subjected to an organized selection and genetic improvement scheme devised by New Zealander Garrick Batten. The Australian and New Zealand feral goats originated from a mix of introduced breeds dating back to European colonisation and are similar in most characteristics to the original goats of PNG and Fiji.

Data are available on the crossbreeding work at Benabena from 1988 to 1992. The idea was to identify suitable genetics for smallholder units as well as conduct research and provide training to the farmers. The numbers of Australian Feral and Kiko goats were small (around 30 does of each type in successive years) and the project suffered from inadequate numbers and no clear objectives for the crossbreeding. Although, the imported goats were on an average larger than their local PNG counterparts, however, there were no significant differences between the local PNG, imported and crossbred animals for a range of reproductive traits. Eventually, the goat population at Benabena was lost both through theft and through distribution to an integrated village-based livestock development programme, which failed. However, goat production proliferated.

A limited survey of famers (5 villages) was conducted in Sialum by Maika (2001). Sialum had a long history of goat keeping and was the source of the original goats of the University of Technology. Two large herds were in the sample (260 and 322 goats). The steep limestone ridges are suitable for extensive systems restricted only by night housing for safety. Control was only needed to prevent dog and pig attack and protection of gardens. All five farmers were

happy with income and protein plus gifting, skins, weed control under coconuts, adequate land and feed and no disease problems. They needed access to breeding stock, finance, extension and training, and control of theft and demand by relatives.

According to a survey of 31 goat owners with a total of 218 animals in three highland provinces by the PNG National Agricultural Research Institute (NARI), Dua (2006) concluded that goat keeping is a family activity and not gender-specific. The majority of owners belong to the Seventh Day Adventist (SDA) church and are subsistence smallholder farmers. SDA members substitute goats for the traditional PNG pigs. The primary motivation is for meat and cash income, but also for traditional prestige and gifting. In addition to the previous most common practice of day-time free range with night housing, one third of the owners now practiced tethering during the day. Common constraints were the lack of information, especially on appropriate feeds, and availability of breeding animals for expansion. Diarrhoea was the most frequent health issue, which supported a conclusion for motivating a study of parasitism.

During 2009-10, NARI carried out an assessment of the milk producing potential of the current PNG goats (Aguyanto and Ayalew, 2011). It was concluded that PNG goats are able to produce milk at satisfactory levels to meet household needs like other tropical goat breeds, and hence, they can be promoted for household milk production. Milk yield tended to increase with litter size and parity while does with extended udders have the capacity to produce more milk, suggesting udder size as a selection criterion.

Sheep Development Programmes

The Fiji Fantastic-Sheep in Fiji

In 1980, the Fiji Government imported a parent stock of 37 Black Belly Barbados (BBB) rams from California, USA. The selection of this breed was based on documented tropical performance and sheep were selected on the basis of fecundity, being light framed and hair coated. Upon arrival these animals were placed in a high security quarantine facility on Makogai Island for a planned 10 years. During the quarantine period, the animals were screened for the following diseases of concern: Bluetongue, *Brucella abortus*, Maedi-visna, Jaagsickte, Contagious Caprine Pleuro-pneumonia, Caseous Lymphadenitis and Scrapie (Manueli, 1997).

Two years later, in 1982, the Fiji Government imported a flock of 51 Wiltshire Horn (WH) crossbred ewes from New Zealand into its Makogai Quarantine Facility. In the middle of 1982, the Nawaikoba stock of Corriedales was also moved to Makogai. Later, a large consignment of 200 Poll Dorset (PD) stud ewes were imported to Makogai from Australia under an AUSAID programme. Hence, in late 1982, an intense cross breeding programme began in Fiji on Makogai Island. Initially the breeding programme was based on two traits, growth rate and wool shedding ability. Performance of various offspring from the different crosses were evaluated for these traits. By mid-1983, a new breeding policy was developed whereby selection was based on certain characteristics: (i) the offspring should not require shearing, (ii) must reach a target weight of 35 kg live weight at the age of six months, and (iii) ewes should be non-seasonal breeders. Other characteristics included tolerance to internal parasites and foot-rot. Subsequently, it was realized that crosses of BBB and WH had superior performance. Hence, these breeds formed the basis of the

sheep breeding programme in Fiji and the eventual development of the Fijian tropical type crossbred sheep named as the Fiji Fantastic (FF) breed (Fig. 5). After three decades of quarantine and as a result of controlled and natural breeding through two-way crossbreeding and intense sheep breeding research, the superior proven F_1 performance of the BBB × WH enabled the new FF breed to be confirmed.

After the completion of the quarantine period, the next two phases of the project involved the distribution of breeding rams, fattening stock and breeding ewes to Government Sheep Stations at Nawaicoba, Wainigata, Batiri and Seaqaqa, and the Mua Sheep Station in Taveuni. These stations were tasked to maintain the breeding lines and to carry out mass multiplication. A new phase in the era of sheep development in Fiji began in 1991, named as the Extension Phase – wherein the effort was to introduce sheep onto private farms. Under this phase, a total of 20 pilot projects were established through the supply of breeding stock from the Ministry's Breeding Stations. This phase continued for the next five years with the establishment of 40 more private farms. Since the sheep were a new commodity with management challenges still an issue, the Ministry decided in 1996 to release only a maximum of 10 male weaners to each potential farmer to fatten for market. The objective was to allow farmers to familiarize themselves with sheep and to gauge their sheep rearing ability. During the second year, a maximum of five ewes were released to those farmers who had shown satisfactory performance in rearing the fatteners. By 2018, there were 685 smallholder farmers in the country with a population of approximately 28,000 sheep and a breeding stock of 13,000 adult ewes. Around 72 per cent of these animals are being raised in a subsistence level production system. Sheep rearing is mostly concentrated in the drier areas of the two main islands with 50 per cent of the total stock in the Northern and 42 per cent in the Western Divisions. The remaining eight per cent is in the maritime areas.

Although, the FF population grew with continuous effort from the Fiji Government to establish a sustainable population, in recent years a drop in performance of the sheep has been noticed. This

is generally attributed to lack of structured and focused breeding programmes on farms, ultimately leading to a high probability of inbreeding. In mid-2014, with the help of an Australian consultant, the lack of new sheep genetic material was identified as one of the major constraints to production and growth of the sheep population. Hence, in early 2015 the Fiji government started the process of importing new sheep genetic material. In April 2016, a total of 32 Dorper rams, three Australian White rams and 42 Dorper ewes were imported from Australia. After initial on-farm quarantine, the imported breeding stock was distributed to the three major sheep breeding stations around Fiji. Selected FF ewes were mated by the Dorper rams with anticipation that the improved offspring would have 50 per cent each of FF and Dorper genes. In 2019, the Fiji government distributed 93 male and 38 crossbred female weaners to sheep farmers in the Western Division. The broad objective of this initiative was to create a new breed of tropical meat sheep with higher growth rate, meat to bone ratio and fertility than the FF.

The Menifo Project-Sheep in PNG

The first post-independence attempt to promote and establish a sheep industry in PNG began with the Menifo project in Eastern Highlands Province which started in 1975 with the purchase in New Zealand of 1000 Romney, 1000 Corriedale and 1000 Perendale sheep. The aim was to determine if temperate wooled sheep could enable establishment of a village-based meat and wool industry in the PNG highlands. Only 790 sheep made it alive to form the founding flocks of the Menifo Sheep Research Station. A further importation of 130 Border Leicester × Merino sheep from Australia was made in 1979. Over subsequent years little progress was made and sheep numbers rarely exceeded 1000. Early problems were lack of day length seasonality, affecting reproduction, and screw worm (*Chrysomya bezziana*). The idea was to find a sheep that could thrive to enable large number of villagers to have flocks of about 10 sheep each, producing meat and wool for a cottage industry. The Romney sheep failed to reproduce at acceptable levels but it was established that crossbred sheep from the Priangan cross with Corriedales or

Perendales could thrive with extensive grazing in small flocks, even without anthelmintics. An elite flock of Priangan sheep was maintained at Erap and used to produce rams for subsequent crossing with the temperate origin ewes at Menifo. This crossbred was eventually stabilized by interbreeding of the crossbreds at both Menifo and Tambul in the high-altitude highlands and this crossbreeding led to the establishment of the Highlands Halfbred (Benjamin *et al.*, 1996). Most, if not all, highland sheep now belong to this synthetic breed. The idea of a wool industry was abandoned and there do not appear to have been any definitive breeding objectives set for the Highlands Halfbred (Quartermain, 2009). Data on lambing and weaning in 1984 and 1985 for Corriedale, Perendale and Crossbred sheep derived from use of Priangan rams showed no significant variation except for effect of year (Manua and Malik, 1988). Under inadequate management, breed effects are swamped by environmental factors. The true potential of the crossbreds was not demonstrated but they have spread throughout the highlands.

An unpublished report on the Sheep Industry Expansion Project Phase 11 stated that New Zealand's support, since the mid-1970s, had resulted in approximately 3200 sheep imports and a range of technical assistance and training. It had been demonstrated that:

- Large parts of the highlands are suited to sheep.
- Sheep are suitable smallholder livestock.
- Demand is for meat rather than wool. However, there is potential for a wool cottage industry.
- The Highlands Halfbred is a suitable sheep but more emphasis should be on Priangans for low altitudes.
- Production by Highland Halfbreds is successful under moderate levels of management.
- The industry is not growing rapidly, with inadequate production of breeding stock for expansion.

Final reporting in 1988 on the New Zealand input into Menifo and the development of a sheep industry concluded that the foundation for an industry existed but that smallholder participation had been

limited in spite of demonstrated potentials. The importations of sheep had been of questionable success with smallholder development not given high priority by government with preference given to poultry and cattle. However, paternalistic efforts to promote all species had failed in terms of the smallholder project model. Dependence had been on the efforts of a few committed individuals. However, strong interest was shown in sheep once awareness of benefits had been created and the conclusion was to let development grow at its own pace since social and environmental impacts were likely to be positive and demands for sheep continually exceeded supply. The Menifo sheep flock was finally disbursed in mid-2000 with the sheep, along with goats, going to stock smallholder integrated or mixed enterprises under government sponsorship. At this time there may have been up to 8000 sheep, mainly in the highland provinces.

Grossman (1981) carried out a useful in-depth survey of 16 smallholder sheep projects in the Kainantu District of Eastern Highlands Province. There was an average of 9.4 sheep per owner (range 1-28) kept on small enclosed areas averaging one hectare and 5-25 sheep per hectare. The people's perception is that they were short of land in this rugged environment with a high population density. Hence, the sheep were enclosed on prime agricultural land close to the hamlets and larger sheep numbers could cause land disputes. However, it was shown that sheep could graze under mature coffee without causing damage. The level of management was low including maintenance of infrastructure and provision of water, with pigs and dogs a problem. Invasion of gardens was less of a problem than with pigs or cattle and the sheep were treated as customary animals in fallow land similar to pigs. They were fed or grazed on fallow sweet potato and the main use was in ceremonial exchange. The wool was hardly used. Extension input lessened over time but the survival rate of the projects was good.

The slow growth of sheep keeping in spite of the enormous potentials could be attributed to weak or ineffective extension, starting from a base of novice owners and a lack of support services including assistance with marketing (Supiramaniam, 2001). In 1993, about

30 per cent of the estimated 10,000 sheep were still on government farms. An emphasis on small to medium farms would take the burden of actual sheep raising off government leaving the central agencies to concentrate on extension and support.

Sheep and Goats – Health Issues

Since parasitism proved the initial downfall of the earlier established temperate breed flocks in both countries, the topic is worth further discussion as to how health issues are an important factor in rearing of sheep and goats.

Fiji

In Fiji, GIPs have been an ongoing constraint to goat and sheep production since the animals' introduction into the country in the 1850s (Turbett, 1929; Despeissis, 1922) and remain a major challenge to the small ruminant industry until present times (Walkden-Brown and Banks, 1986; Manueli, 1996; MOA, 2013; MOA, 2014; MOA, 2015). According to Manueli (1996; 2004), the early literature lacked mention of GIPs as a constraint to the goat industry due to the fact that goats were raised in small herds under close supervision. In comparison, sheep were raised in an extensive Australian and New Zealand model where large flocks of sheep were raised in large paddocks (Manueli, 2004).

However, it became clear before the end of the 1900s that worm infestation was the most important reason for failure of sheep farming. This view is still prevalent today with unacceptable mortality, reduced production and increasing costs of anthelmintic treatments. There is some development of anthelmintic resistance and hence, it is necessary to rely on sustainable control measures through stock management. Research on the Nawaicoba Government Sheep Farm (1965-1969) found rotational grazing to be effective (Baker, 1970). Subsequent projects by the Australian Centre for International Agricultural Research (ACIAR) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) from 1984 onwards could conclude that anthelmintic resistance means the necessity for development of

sustainable control measures. Some CSIRO/ACIAR research was undertaken into biological control using nematophagus fungi.

The two species *Haemonchus contortus* and *Trichostrongylus colubriformis* have been found to be the most common amongst the seven different species of GIPs present in Fiji. GIPs retard growth, reduce productivity, cause mortality in all ages of animals and increase costs of production. Occasionally goats are also affected by psoroptic mange. The parasite, *Psoroptes cuniculi*, which causes skin conditions on the ears, poll and neck of goats, was first recognized in 1977 and a study by Munro and Munro (1980) found that the disease was widespread across Viti Levu but localized to two spots on Vanua Levu. A new disease, Scabby Mouth (contagious ecthyma; orf), was found to affect a number of sheep farms in the Western Division in 2017 and 2019. Although, there is conflicting information on its introduction into Fiji, scabby mouth is a highly contagious, viral disease of sheep, goats and occasionally humans.

During 1997-2000, the goat and sheep industries also noted a high incidence of foot rot and foot abscess. These diseases cause severe lameness in one or more feet and this results in loss of condition as affected animals cannot move around to graze. In severe cases, death may have occurred. In many cases the rams and ewes are unable to mate and this may result in delayed pregnancies, and affected mothers during lambing have a high probability of losing their lambs.

PNG

Results were reported from 2011-12 surveys in two contrasting sites at coastal Situm in Morobe Province and in the Eastern Highlands above 1500 m altitude (Yual and Quartermain, 2018). The main purpose of the surveys was to collect faecal samples for parasite egg analysis and preparation of a summary of findings. The most common health problem is diarrhoea, as was also found by Dua (2006), probably associated with parasitism, and health issues caused by GIPs remain significant problems, even with goats mainly browsing in dryer areas. Most of the goat farmers expressed the need for access to an extension service office where they could obtain advice and

supplies for their goat health management. Research is required to evaluate the efficacy of traditional medication. Otherwise, NGOs and government agencies need to consider in which ways the current and potential goat farmers can be assisted.

Routine data on GIPs have been collected since the 1960s and a review of published data on internal parasites of small ruminants in PNG was undertaken by Quartermain (2004). In the Priangan flock established in 1971 at Erap in the drier Markham Valley of the lowlands, the sheep have shown either resistance or tolerance and it has been concluded that parasites are a minor problem with these sheep in both wet and dry lowland sites. Holmes and Absalom (1985) concluded that internal parasites are a minor problem of Priangan sheep at low stocking rates and that a system of herding by day and penning at night, even in hot, extremely wet environments, is capable of producing satisfactory growth rates and adequate carcass finish. Low stocking rates and monthly drenching have appeared adequate in both highland and lowland institutional flocks. Strategic drenching based on faecal egg counts is effective (Owen and Awui, 2000). Manua (1994), in a survey of smallholder sheep and goats in the highlands, found that although animals were not drenched, they were healthy and losses from parasitism were small. The general conclusion is that GIPs are only a problem with intensive grazing or set stocking and smallholders of both sheep and goats seem to manage without any drug treatments. However, it is suggested that one reason for the overall relative greater success of goats over sheep may be due to less resistance or tolerance in highland sheep. Additionally, the marked browsing habits of goats may protect them from the infestation effects of intensive grazing. Other health problems include pneumonia, various foot conditions, external parasites and pink eye (Supiramaniam, 2009). Priangan sheep appear resistant to screw worm and it seems that screw worm is not a problem above 1,600 m. Note that there is also a lack of on-going veterinary support.

Regulatory Policies and Development Strategies

In spite of the shortage of veterinarians, the PNG National Agricultural Quarantine and Inspection Authority (NAQIA) is actively responsible for all matters to do with domestic animal health as well as "one health" concerned with zoonotic diseases and the maintenance of PNG's enviable status of freedom from major exotic diseases of livestock. Similar care and responsibility is taken by quarantine authorities in Fiji as evidenced by the protocols used for sheep importation and the development of the FF breed. There are no other specific regulatory controls over sheep or goat keeping in either country except for certain urban areas in which livestock keeping is restricted. Also, NAQIA and the Fiji MOA have regulations with respect to slaughter with carcass inspection in the commercial abattoirs which are owned by the Fiji Meat Industry Board (FMIB) and the PNG Livestock Development Corporation (LDC). However, this is largely ineffective since most slaughtering takes place on farm or in villages.

The current PNG Medium Term Development Plan III, 2018-2022 (Department of National Planning and Monitoring, 2018) makes no specific mention of sheep nor goats in the section on Livestock. The expressed goal is to have a commercially viable livestock industry strategically established and expanded to meet the growing domestic demand in partnership with private sector and rural farmers. The clear emphasis is on commercialisation and import substitution of meat products. There are clear roles for all species in meeting the ever expanding meat consumption demand. The sector strategy includes the establishment (actually re-establishment of a previously failed concept) of breeding and distribution centres, support for research,

training programmes, disease and border surveillance, cooperative marketing and private sector processing and marketing. There are plans for national cattle breeding farms and a national cattle breeding programme.

The PNG LDC was established in 1983 to take over the commercial management of eight government-owned cattle ranches and five regional abattoirs. It was and remains the mandated government agency responsible for the commercial development of all forms of livestock production including sheep and goats. However, it never functioned as intended, although it still operates five large cattle ranches and three abattoirs. There is current activity to restructure and revive the corporation but still with almost a sole focus on cattle production and meat import replacement. A National Livestock Strategic Development Plan 2019-2022 is still under preparation. Draft supporting documents so far include a Project Formulation Document 2008 (LDC 2008) for a goat breed improvement, production, multiplication and distribution project and a National Sheep Development Programme (Teka n.d.). These plans include re-visiting the importation of sheep and goat breeding stock but there are no definite plans concerning how this might be done, what breeds might be useful and where the animals might be located, and there are specific proposals to import 4000 breeding ewes from Australia and New Zealand, develop four sheep breeding stations and develop networks of sheep cooperative farmers at District and Provincial levels. The programme goals are to develop viable industries in PNG that will create means for alternative cash income opportunities in the rural communities, provide alternative protein sources, create rural employment and improve rural livelihoods. These are more realistic aims focused on smallholder farmers and villager's nutritional and economic needs. The intention is to give public sector support to what is happening on the ground through local family or community initiatives.

Funding was made available in 2008 for a five year project but there was no further support and the initiative has lapsed until now. The concept was in line with central planning in that it proposed breeding and distribution centres to enhance accessibility to increased numbers

of breeding stock by farmers and act as demonstration and training centres, especially in the sustainable management of animals and feed resources. The initial centre was established in Goroka, Eastern Highlands Province, central to goat keeping in the highlands with plans to use the output to establish a further central highland centre in Simbu Province and two centres in the Central Province of the dryer Southern Region with savannah grassland suitable for goat production. One of these sites coincides with the plans for government cattle ranch rehabilitation with possible cooperation. It remains to be seen whether or not the plans for such centres will be successful this second time around. Otherwise, there are no current plans for subsidies or incentives by the governments of Fiji or PNG for structured commercialization, marketing policies, meat quality testing and conservation or breeding for genetic improvement. Recommendations that might be suggested to the governments of Fiji and PNG are that farmers should be left to pursue their own initiatives with support limited to research, advice and training related to proven favourable technologies with emphasis on animal health and possible new initiatives such as milk production. Solid continuing support is needed from the government agencies for quarantine, veterinary monitoring and meat inspection.

Development Issues and the Current Situation

Goats are found in most of the Pacific Island Countries and Territories except on atolls, Wallis and Futuna and Nauru. The large and important populations are those found in Fiji and PNG but there are significant numbers estimated to be in Vanuatu, New Caledonia, the Federated States of Micronesia, Tonga, Cook Islands and French Polynesia (Quartermain, 2019). Only PNG retains the original genotype from colonial introductions with numbers increasing due to on-going adoption, especially in the highlands, and the genotype is well adapted and worthy of conservation. While Fiji retains high numbers of the original, well documented Fiji goat, the crossbreeding programme started in the 1980s using Anglo-Nubian stock (Hussain *et al.*, 1983), has meant that there may be now two apparently separate genetic populations in production. There is a danger that new un-researched crossbreeding initiatives will occur with interest in the South African Boer goat, currently being imported from Australia.

In spite of the proven utility of the goat in the Pacific, it appears that sheep are preferred for further development at least by respective governments. They are not so widespread being found only in PNG, Fiji, Vanuatu, New Caledonia and Samoa (Quartermain, 2019). In PNG, the well documented Priangan breed can now be regarded as endangered with only two known flocks in the lowlands (Table 1). There may still be other sheep in villages but conservation needs to be taken seriously on priority. Highlands Halfbred sheep are quite well distributed across the highland region in small village flocks but there is only one known institutional flock which is that of NARI. The most important initiative was the development in Fiji of the FF breed, fast growing and parasite resistant under the wet tropical conditions. It is now likely that all 16000

sheep in Fiji are FF. Vanuatu has imported these sheep from Fiji as has Samoa also.

The two FAO State of the Animal Genetic Resources Reports from Fiji and PNG (Government of Fiji, 2003; Kohun and Supramaniam, 2004) contain discussion relevant to the small ruminant populations in the two countries. What is important is that the unique qualities of the small ruminant animals in all the various Pacific populations are not well researched and documented.

Fiji

The sheep and goat industry in Fiji faces similar challenges as the other livestock sectors, namely, beef and dairy. In early 1997 the industry started facing a major shock with the first small-farm land leases expiring and many of these leases not being renewed. By the late 2000s, many livestock farmers were forced to abandon their farms. As a result, a large number of productive stocks were either culled or sold to other small farms and individuals. For the next decade the goat industry continued to face a shortage of breeding stock as a direct result of closing down of many large privately owned goat farms. These were the major suppliers of goat breeding stock and often carried good genetic material. Shortage of breeding stock also resulted in inbreeding and in many cases, since farmers were not doing any selective breeding or culling, many desirable traits were lost. The sheep industry on the other hand was not that much affected as most of the breeding and multiplication was concentrated on the government stations but there may have been a significant level of inbreeding also on these stations.

The displacement of farmers also resulted in mass rural to urban drift and, in the process, a large number of displaced farmers and labourers were absorbed by the service and construction industries. Hence, the livestock industries faced a major shortage of labour. Since there was less replacement of farmers or new farmers taking up livestock farming, the aging of farmers became a major challenge. Currently Vanua Levu, the second largest island of Fiji, has the highest number of sheep. However, there is no public slaughter house on the island and, as a result, most of the meat produced does not enter the formal market. Recently,

the Minster for Agriculture stated in parliament that the government is exploring the possibility of providing a guaranteed market for the sheep farmers in the North through a government established Agro Marketing Authority. Also, recently in 2018 the Fiji MOA signed an agreement with ACIAR for the next four years (July 2019-March 2023) to address current problems of the GIP burden in sheep which causes high mortality on farms. The collaborative research will explore best Integrated Pest Management methods to reduce dependence on use of deworming drugs.

Compared to neighbouring small Pacific Island countries, Fiji has a strong and more developed sheep and goat industry. In the past, Fiji has exported live animals to these smaller countries for breeding. In April 2004, Fiji exported a herd of 44 Fiji bred sheep, 40 ewes and 4 rams, to Samoa. In 2005, Fiji exported another 40 ewes and 4 rams to the Kingdom of Tonga and in October 2014 another 100 ewes from a private multiplication centre and 10 rams from a government station. In 2018, Fiji exported 100 breeding goats to the Kingdom of Tonga. Recently, there has been interest in creating commercial niche markets for goat milk.

PNG

Large-scale growth of sheep and goat ownership, especially in the highlands, has only occurred over the past 30 years. This growth is a consequence of deliberate government policy in the case of sheep, but goat numbers have increased without significant encouragement by the government. Sheep and goat numbers are small compared to cattle and pigs but the number of goats at least is slowly increasing, especially in highland environments (goats may now be more numerous than cattle overall) and there is potential for household milk production. The advantages of the small ruminants over cattle in the prevailing human and biotic environments are clear with small size and high fertility, an abundance of suitable diet items, ease of handling, growth in familiarity among smallholders, adaptation to traditional systems and customs, convenience in utilization, demand for meat, an ability to keep reasonable numbers and maintain a rational herd or flock structure for security and

sustainability on limited areas of land and low initial or replacement costs. Success has depended on advanced thinking regarding parasite control, effectiveness and cost (Danbaro, 2009).

The 1990 national census had 3,148 households keeping sheep and 9,642 keeping goats. This translated to a total of 10,000 sheep and 30,000 goats (Supiramaniam, 2009), mostly integrated with subsistence cropping but with major losses due to pigs and dogs. The highest number of sheep owners were in Enga province, followed by Simbu, Eastern Highlands and Morobe provinces, whereas the highest numbers of goat owners were in Eastern Highlands and Simbu, followed by Enga. These provincial distributions may have changed dramatically. Similar data have not been available from the 2000 and 2011 censuses, and for the present situation in 2020 no reliable national ownership data are available. To assess numerical success, it is necessary to rely on observation and local knowledge and in a large informal survey of student and other informants, therefore, the results were mixed. During travels in the highlands many more goats than sheep are seen on roadsides and farms.

Extension and farmer training support and supply of breeding stock to smallholders were the responsibility of Provincial DAL through Provincial Livestock Centres (PLCs). There are or were at least 10 such centres but only six with sheep and five with goats; it appears now that none of these are functional. All highland provinces have sheep or sheep and goats in their provincial development plans. The idea arose that the problem of breeding stock supply of sheep to smallholders could be addressed by the concept of semi-commercial farms with flocks of 20-50 breeding ewes plus a number of institutional or farmer group flocks with 50-100 or so sheep, allowing for a surplus of offspring for distribution. However, these developments have not persisted.

Once there was no further injection of sheep from New Zealand, the total numbers remained mostly stable or slightly declined. The use of PLCs proved very expensive and ineffective. Extension services failed to define priorities and deal with known and logistical problems. Organised sale of live animals only happened in Simbu. Social impact

reviews such as that of Grossman (1981) have shown that sheep integrate well into traditional highland village systems, especially in poorer areas. Benefits include increased household meat intake but there is much new entry and rapid turn-over of ownership. Subsistence food production benefits from the use of manure, but production is financially marginal in semi-commercial units unless stock losses can be reduced and revenue increased. Investigation has been proposed into the feasibility of large-scale private sector commercial sheep production, mainly perhaps for availability of breeding sheep for smallholders. It may be that this is what current proposers of live sheep imports have in mind.

Problems in achieving numbers of sheep for distribution or on centralized farms seemed to involve low reproductive rates, high mortality (especially lamb losses) and continued high demand for consumption. There is good evidence that sheep distributed from provincial centres to smallholder projects for breeding were often consumed. Two attempts to overcome the problems were the Morobe Province Semi-commercial Sheep Development project (Bilong, 2009) and a French-funded Smallholder Community Sheep project in the Kopiago District of the Southern Highlands (Mindiria, 2009). A similar extensive community project was set up at Gere in the Simbu Province. The concept was to promote a commercial philosophy with sheep ownership clustered in larger groupings with technical support and more cost effectiveness than the earlier approach through government stations. Early results were promising but there is no recent data available.

The last definitive collection of information on small ruminants was the NARI Sheep and Goat Workshop, with proceedings edited by Quartermain (2009). The only significant studies since then are those of Aguyanto and Ayalew (2011) and Yual and Quartermain (2018). Most research work on sheep and goats was done in the 1980s and 1990s. The workshop recommendations suggested that both species deserve equal attention but there has been little attention given to either species. It was also recommended that hair coated sheep be given preference as in Fiji since wool is a liability rather than an asset as had been earlier supposed. There is a clear need for better information on the current on-farm situations and future policies should emphasise subsistence,

with some return to dairy goat production, rather than commercial production. Nevertheless, financial viability is feasible for smallholders and village producers to generate income as desired.

There are only a small number of effective institutional breeding, educational and research flocks or herds as shown in Table 1, with numbers fluctuating due to sales or occasional distribution.

In the 2011-12 surveys (Yual and Quartermain, 2018), 45 goat farmers were questioned regarding current management practices. Common practices are communal housing with cut and carry systems and tethering or free range after sunrise until late afternoon but with avoidance of rainy periods. It is clear that a range of low-cost management systems work for farmers in both the coastal areas and the highlands of PNG. Pressures on land use in the highlands, however, are causing a significant increase in the adoption of cut and carry systems with the consequence of increased labour requirements.

Holmes and Mott (1980) stated that since there were not many adapted (i.e. Priangan) sheep in PNG and that many attempts to develop a smallholder sheep industry had failed, hence, distribution should begin only slowly and each project development carefully checked by relevant technical officers. One of the possible problems with the small numbers of animals in the foundation populations of both Priangan sheep and the PNG goats is an accumulation of

Table 1. Current number of animals in PNG research and teaching flocks and herds

Institution	Sheep	Goats
University of Natural Resources and Environment	–	24
University of Technology	35	15
University of Goroka	–	22
NARI Lowland Labu	51	59
NARI Highland Tambul	50	–
NAQIA Veterinary Laboratory	30-40 for disease monitoring	–

inbreeding (Sumpa, 2009). However, the overall success of the development of smallholder sheep and goat production in PNG is that the major constraints identified as holding back adoption and proliferation have been understood and steady progress is being made in the utilization of the benefits from keeping small numbers of these adaptable ruminants. The comparative success of goats relative to sheep and to cattle and buffalo should be noted. Cattle numbers have declined by some 40 per cent since the peak in the 1970s while swamp buffalo have almost completely vanished. The goats have proliferated due to hardiness, adaptability, reproductive ability and utility under successive smallholder agriculture policies. It is a tribute to the quality and capacity of the goat as a domestic animal species that they have been successful and continue to expand in ownership in spite of the obstacles in terms of poor husbandry and uncooperative officialdom.

Goats are cheaper and easier to look after in comparison to pigs and hence, there is a growing interest in them for traditional ceremonial, wealth display and exchange. However, the numbers of both species killed in ceremonies outnumber the rate of replacement, causing decline due to popularity. The traditional demand for pigs in PNG society creates a demand on resources that dominates over other species. Hence, the importance of the SDA church whose members cannot keep or eat pigs. Sheep, although popular and successful, are constant or slightly declining in numbers following the overall dramatic decline in ruminant animal production especially in the last decade, but this trend is not observed in case of goats which are easier to care for and rear, are more adaptable and are competitive with pigs.

Central to any discussion on the success of sheep and goats is the issue of what is meant by an industry. Government speaks glibly of developing a sheep or goat industry based on commercialisation as if the keeping of these animals in small numbers for subsistence by large numbers of families is unimportant. Central to their thinking is the matter of meat imports and import replacement with little thought about diet and the protein needs of growing children. Recent

suggestions (2019) have included the importation of large numbers of both species to establish production industries with no indication as to how this could be done. If an industry is required then this is not possible relying only on smallholders with less than 10 head of breeders per owner. All that matters for the present discussion is that there has been over the last four decades a successful introduction into smallholder agriculture of goat keeping, partially as a replacement of pigs, and accumulation of knowledge concerning what is required to raise sheep successfully, laying the foundation for any developments to come.

Consumption and Marketing Systems – Fiji

Fiji has predominately two forms of sheep market setup, formal and informal. The formal markets are those commercial outlets where products are presented in the public domain and transactions are well-documented. In the formal market, the products presented have to meet quality standards set by regulatory agencies. The informal markets have mostly private sales that occur on-farm (on-hoof) and in many cases in backyards, lacking documentation and with the quality of the product not guaranteed. The local mutton production in both the formal and informal markets during the last eight years has shown a fluctuation that has ranged from 50 to 200 tonnes of product per year with the highest production of 199 tonnes achieved in 2013 (Table 2). On the other hand, imports of lamb over the last five years have shown an increase in fresh chilled meat with demand ranging from 4000 to 7000 tonnes valued at FJD28-46 million annually. Apart from this, Fiji also imports 2-5 tonnes of prepared sheep meat, commonly known as canned mutton, with a value of FJD25-65,000 annually. Some of these products are also re-exported to smaller Pacific Island countries with this re-exporting in the value chain valued at around FJD250,000-300,000 over the five years (Table 2).

The Fijian goat industry has a formal as well as a much more important informal market structure (Fig. 7). In the formal market structuring the most important links are the middlemen. These middlemen move around the country buying the stock off farmers. In most cases the middlemen already have supply contracts with hotels, supermarkets, restaurants and butcher outlets. The collected animals are processed through registered slaughter houses. In Fiji, there are only two government registered abattoirs which are located on the main island

of Viti Levu. These abattoirs are owned by the FMIB since one of the functions of the Board is to construct and operate public slaughtering facilities. A rural slaughter house caters to the requirements of the other main island of Vanua Levu.

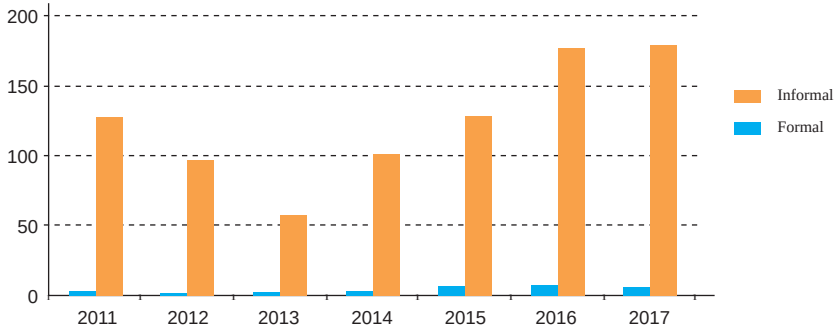
Table 2. Fiji sheep meat production and imports during 2013-2017

Year	Production (tonnes)	Import (tonnes)	Value (FJD $)	Export (tonnes)	Value (FJD $)
2013	199	4,489.9	27,609,456.00	1.88	11,512.00
2014	41	4,460.6	31,315,050.00	59.72	142,386.00
2015	74	4,855.6	30,790,263.00	10.80	84,259.00
2016	80	7,222.1	41,425,957.00	0.26	3,168.00
2017	70	5,824.9	45,662,665.00	0.20	14,400.00
Total	**464**	**26,853.2**	**176,803,391.00**	**72.9**	**255,725.00**

Source: Fiji Agriculture Rural Statistics

It is evident that the demand for goat meat in Fiji is seasonal. The demand is high during festive seasons such as Easter, *Qurbani*[1] and Christmas. The 2017 production figures show that only 402 goats were slaughtered in the two abattoirs and rural slaughter house producing 5.5 tonnes of goat meat (chevron) while in the informal market 9,964 goats were sold on-hoof. Based on the MOA estimate of 18 kg per animal (relatively high) there was 179 tonnes of goat meat produced through informal markets (Fig. 7).

[1]Muslim festival where animals are sacrificed for religious purposes



Source: Fiji Agriculture Rural Statistics

Fig. 7. *Comparison of output of two market structures for goats in Fiji (tonnes of meat produced)*

In 2017, Fiji imported only 5.8 tonnes of goat meat which was three per cent of total consumption (Table 3). This was a significant drop in importation compared to 2016 imports. According to the Fiji Minister for Agriculture in his 2019 parliamentary statement "*This (reduction in import of goat meat) could be attributed to the Ministry's ongoing demand-driven approach memes which have supported goat development over the years*".

Table 3. Fiji goat meat production and imports during 2013-2017

Year	Production (tonnes)	Import (tonnes)	Value (FJD $)	Export (tonnes)	Value (FJD $)
2013	154	111.8	569,018.00	0.0	–
2014	105	118.6	534,955.00	0.0	–
2015	84	130.7	807,661.00	0.065	550.00
2016	77	81.9	352,036.00	0.091	910.00
2017(p)	184	5.8	64,109.00	0.0	–
Total	**604**	**448.7**	**2,327,779.00**	**0.2**	**1,460.00**

Source: Fiji Agriculture Rural Statistics

Consumption and Marketing Systems – PNG

No new large herds of either species for distribution of breeding stock to smallholders have been founded since disbursal of the Menifo flock. A major reason for slow growth in numbers is that more and more animals are consumed. Meat from either species is a highly desired dietary component, partly due to many years (since the 1980s) of availability and consumption of cheap sheep meat imports from Australia and New Zealand. Imports of 8,000 tonnes in 1983 rose to 43,000 tonnes by 1994 but had fallen to 23,000 tonnes by 2003 (Bourke *et al.*, 2009) and 13,000 tonnes by 2017 (Regina Nukundj pers. comm.). Beef imports were 8,500 tonnes in the same year. All meat imports rose from around 25,000 tonnes in 1983 to 60,000 tonnes in 1994 but declined thereafter to around 30,000 tonnes by 2003. Current levels of all types of meat products are about 45,000 tonnes.

Total meat production from all species has been estimated at 58,000 tonnes (Bourke *et al.*, 2009). To this can be added the 45,000 tonnes in imports, giving total meat consumption in PNG of 103,000 tonnes. Thus, average meat consumption may be about 13 kg/person/year but is likely declining due to population increase. However, meat is an extremely variable commodity, ranging from whole carcasses or bone-in cuts through boned meat of variable fat content, to processed and tinned products. Available statistics are inadequate to enable all this to be expressed on a comparable basis. Regardless of the accuracy and composition of the estimates, consumption is very uneven due to feasting and custom. Both rural and urban people will spend income on meat whenever possible but

most of the traditional or village production of pig, poultry, sheep and goat meat never enters formal markets. In the 2000 census, 175,000 households claimed to sell meat in local markets or on roadsides.

Mature live goats are currently selling in the PNG Highlands for PGK 300-400 (US$ 87-116). At carcass weights of 12-15 kg this works out at PGK 20-33 per kg (US$ 6-10). Imported lamb sells at around PGK 30-35 per kg depending on cut and supermarket outlet with shoulder chops currently at PGK 35 per kg and the cheapest lamb flaps at PNGK 25. Pork prices are equivalent to lamb but chicken is only about half the price of lamb or pork. However, sale and purchase of live animals is mainly for festive occasions so that the price is more dependent on variable supply and demand. Also, the liveweight has much more traditional value than simply for carcass meat. Offtake from a breeding herd of either sheep or goats is around 30 per cent (Bourke *et al.*, 2009), that is the number of animals sold or slaughtered per year from a base breeding herd or flock. Hence, a base herd of 20 breeding females could produce a sale of six animals per year with a value of about PGK 2,100 (US$ 609), equivalent to 4.3 months of paid labour at the legal minimum wage. Hence, with current and increasing demand, it is clear that the raising of sheep or goats is viable and profitable in the PNG highland social and economic environment.

Economic Benefits for Smallholder Farmers

In a paper contrasting goat keeping by villagers in the Zambesi valley of Zambia with pig keeping by villagers in PNG, Quartermain (1977) concluded after consideration of the possible expanded role of each species in the alternative agricultural system that the goat could become important in the agriculture of PNG. The success story is that this has happened and is paralleled in the Fiji Islands. That the same level of success has not been achieved by sheep in spite of substantial effort in both countries is due to the biological nature of the goat species in addressing villager and smallholder farmer needs for improved livelihoods, food security and enhanced incomes. In Fiji, sheep have been adopted by settled smallholder farmers and commercially oriented flocks but this has not happened in PNG.

The practical and economic benefits of goat or sheep production by either smallholder farmers or household animal keepers, especially in contrast to cattle for meat production, are substantial and can be summarised as follows:

1. They are easy to rear and care for over a shorter time scale, convenient for women and children.
2. There are fewer or less inputs required in terms of land areas and fodder requirements per breeding unit.
3. The carcass is of convenient size for a family without refrigeration facilities.
4. The meat is of high quality and is acceptable by all current religious and ethnic communities.
5. There are substantial income earning opportunities as indicated in the preceding sections on consumption and marketing systems.

6. They conveniently fulfil needs for food security, especially in times of stress aggravated by climate change, and can play a substantial role in satisfying the requirements for healthy diets and satisfaction of hunger for "protein". In PNG, protein-energy malnutrition (PEM) and child stunting prevalence are two of the nutritional related health issues that are affecting children.

In PNG, it is estimated that the childhood stunting prevalence is 49.5 per cent which is the fourth highest rate in the world and PEM is regarded as the most important form of malnutrition according to the 1982-83 PNG National Nutrition Survey and as discussed in the PNG National Nutrition Policy (Government of Papua New Guinea, 1995), affecting both children and adults.

Hence, the introduction of these animals into the Pacific has been successful and production is expected to increase in line with population increases and aspirations for improved lifestyles.

Conclusions

Sheep and goat flocks and herds can expand where conditions allow using now locally available genotypes. Probably the FF sheep are underutilized and the adapted Fiji goat may be eventually swamped by the Nubian crosses, calling for conservation plans. Attempts should be made to conserve the Priangan in PNG but reliance will be on the Highlands Halfbred sheep and the adapted goats. On-going research can be on the integration of small ruminants with horticulture, since horticultural crops are predicted, especially in the Pacific, to be the future means to ensure food security with ever increasing populations. There is also the milk production initiative to consider.

It is clear that official preference remains with cattle in both countries since the expansions in the 1970s. But the major problems remain including land disputes and disruption of traditional power structures and fragmented land holdings, usually of small size. Small ruminants do not have or are not affected by these problems. This has been recognized more in Fiji with support given to both sheep and goat species, with the dominance of the latter supported by the Indo-Fijian community. There have been a number of policy and planning initiatives in both countries but they have not been sustained, nor in PNG directed specifically at income generation. There are advantages in that these ruminant animals are not constrained by custom or tradition as is the commercialization of pig production, but they are seen to be participating in custom and ceremonies. Total number of animals can only be estimated but are likely in the region of 265,000 goats and 28,000 sheep in Fiji and 30,000 goats and 12,000 sheep in PNG. The sheep and goat industries in Fiji are well commercialized with income streams for farmers while in PNG commercialization has been slow in conventional terms. However, in both countries

the achievement of the advantages for smallholder and subsistence farmers and food security can be seen as clear successes.

Goats have spread in both countries due to their own competitive advantages over other livestock species except poultry, without any schemes or plans. Number of beneficiaries are not restricted as in other livestock development schemes and only village chickens are competitive in this respect. Apart from the FAO/UNDP goat project in Fiji (Hussain *et al.*, 1983) goats have spread more rapidly in spite of sheep being given official preference.

Sheep and goat meat as important sources of protein have become so popular that demand continues to increase every year. They continue to play a primary role in improving nutrition and providing other services to meet socio-cultural obligations for farmers, especially in the rural and peri-urban areas. Goats in particular have contributed significantly to people's livelihoods. While income has not been measured as a component of livelihood, it is clear that such a component is significant in the more commercialized environments of Fiji, and PNG farmer surveys have consistently indicated income as a benefit (Dua, 2006; Yual and Quartermain, 2018; Maika, 2001). From a nutritional point of view, it is abundantly clear that people want to eat meat and make obvious choices of poultry or meat from sheep and goats. The latter is partly due to the sustained affordable imports but meat is sought due to perception on the need and desire for "protein". Small ruminants are used:

For feasts

Many farmers, especially those in the more traditional rural areas, raise livestock purposely for feasting involving ceremonial purposes such as bride price payment, compensation payments, religious ceremonies and birthdays.

As sources of protein

As people become more educated, they realize that domestic animals are very good sources of protein. They no longer use them just for feasts or because they taste good. They look after animals because

they want their children to have better balanced diets with protein included to overcome PEM.

As sources of income

Some villagers may sell their animals when they need money to pay for school fees or for other requirements such as cement or roofing iron for housing improvement. Sale of livestock becomes a back-up means for survival and mitigation of natural disasters such as drought, cyclones and floods.

As a source of inorganic fertilizer

Animal manure is a good source of organic fertilizer which can be applied to the bases of growing vegetables to supply the essential nutrients needed for plant growth and development.

In developing countries, especially in the Pacific countries where the majority of the population are subsistence farmers whose source of income, if any, relies mostly on smallholder crop and animal farming, the need is to learn about and adapt suitable and economically affordable farming techniques to raise these livestock. The need is to research, assess and introduce alternative farming systems, including the raising of sheep and goats, able to turn available local resources into valuable assets that can contribute to improving livelihoods and raising standards of living by enhancing the income of smallholder farmers and contributing to food and nutritional security.

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61. Success Stories on Information and Communication Technologies for Agriculture and Rural Development (2015)
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74. Lentil Improvement in Bangladesh (2004/1), Ashutosh Sarker *et al.*
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76. Hybrid Rice in China - A Success Story (1994), Lou Xizhi and C.X. Mao
77. Tilapia Farming in the Philippines - A Success Story (1994), Rafael D. Gurrero III
78. Dairying in India - A Success Story (1994), R.P. Aneja

Status Reports

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Asia-Pacific Association of Agricultural Research Institutions
(APAARI)
182 Larn Luang Road, Klong Mahanak Sub-District,
Pomprab Sattrupai, Bangkok 10100, Thailand
E-mail: apaari@apaari.org
Website: www.apaari.org; www.apcoab.org