Regional Status Reports and Strategic Papers

REGIONAL WORKSHOP ON UNDERUTILIZED ANIMAL GENETIC RESOURCES AND THEIR AMELIORATION

4-6 March 2019
MARDI, Serdang, Malaysia

MINISTRY OF AGRICULTURE & AGRO-BASED INDUSTRY

Australian Government
Australian Centre for International Agricultural Research

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Citation:

M. Ariff Omar, Rishi K. Tyagi, Amie Marini Abu Bakar, Habsah Bidin, Siti Masidayu Mat Saad, Noraini Samat, Ainu Husna M.S. Suhaimi and Ravi K. Khetarpal (2019). **Regional Workshop on Underutilized Animal Genetic Resources and their Amelioration – Regional Status Reports and Strategic Papers**. Asia-Pacific Association for Agricultural Research Institutions (APAARI), Bangkok, Thailand; March 4-6, 2019, xix+150 p.

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Published by:

Asia-Pacific Association of Agricultural Research Institutions (APAARI)
2nd and 4th Floor, FAO Annex Building
202/1 Larn Luang Road
Pomprab Sattrupai District, Bangkok 10100, Thailand

Under the:

Food and Agricultural Organization of the United Nations (FAO)

ISBN : 978-616-7101-20-0

For copies, please contact:

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Technical Session III

Foreword

Asia Pacific Association of Agricultural Research Institutions (APAARI) under its program on Asia Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB) organized a *Regional Workshop on Underutilized AnGR and their Amelioration* from March 4-6, 2019 at MARDI Malaysia. The Workshop attended by more than 60 participants from 14 countries of the region provided a platform for sharing experiences and knowledge relating to underutilized AnGR of Asia-Pacific that have food and nutritional value. The Proceedings of the Workshop has been duly published.

Impressed by the very useful deliberations and recommendations that have emerged from the deliberations on conservation, improvement and use of underutilized AnGR, on value addition, marketing and export, on partnership and capacity development, on use of biotechnological methods for enhancing utilization and on knowledge sharing, it was decided to collect, compile and publish the information that relates to the regional status reports and strategy papers presented during the Workshop.

The compilation has a total of 15 chapters. It covers in detail the status of underutilized AnGR for Food and Agriculture in South and West Asia, Southeast Asia, East Asia, the Pacific. The different chapter for each sub-region brings out the status of AnGR utilization in different countries of each of the sub-region, highlights the unique AnGR in the sub region and provides information on their economic and socio cultural importance, production and consumption, import and export statistics, inventorization and future thrust areas for their optimal utilization and research. These chapters thus give a comprehensive profile of AnGR in the region and the need for intra-regional exchange of genetic resources of these AnGR and the collaborative research programs that need to be envisaged.

The chapter on regional scenario on genomic application highlight the new genomic resources to unlock the genetic basis of disease resistance and agro-climatic adaptation in AnGR. The chapter on inventory, characterization and monitoring of underutilized AnGR focusses on proper system of administration to manage underutilized breeds of livestock that are under threat as they lack utility and are perceived to be lacking in economic potential. The chapters on breeding strategies for underutilized AnGR and on utilizing molecular approaches for underutilized AnGR highlights the challenges and opportunities in obtaining genetically superior breeds and population.

There is a separate chapter dealing in AnGR in the ASEAN and the three objectives of the Convention on Biological Diversity which emphasizes the need to further strengthen the interface between AnGR and CBD objectives and recommends that biodiversity mainstreaming in AnGR may be pursued to carry out these various areas of interface. The comparison of small holders and large producers and their respective advantages, issues and challenges have been discussed in the chapter on market-driven approaches to conservation and utilization of AnGR. The chapter on reproductive biotechnologies for underutilized AnGR highlights the in vivo and in vitro reproductive biotechnologies available as tools for sustaining the underutilized AnGR as potential alternative sources for food production. Finally, the chapter on avian genetic resources: conservation and improvement discusses on the number and examples of avian species available around the world, their genetic diversity which is becoming threatened, and on some avian species, breeds and strains that are underutilized. To protect the erosion of diversity it highlights the needs to conserve these valuable genetic materials in both in-situ and ex-situ and discusses the methods to improve the genetic potentialities.

On behalf of APAARI I gratefully aknowledge the contributors of various chapters and the editorial team members **M. Ariff Omar, Rishi K. Tyagi, Amie Marini Abu Bakar, Habsah Bidin, Noraini Samat, Ainu Husna M.S. Suhaimi** who have done a meticulous job. I would like to specially thank my colleague **Dr Rishi Tyagi (Coordinator, APCoAB)** for conceiving this compilation after having successfully printing the proceedings and for ensuring that it comes out timely for the benefit of all the stakeholders. We sincerely hope that the information would be of great relevance to different stakeholders of AnGR in the region and would help policy makers to take note of their national status on AnGR and revisit the policies and legal framework for efficient conservation and sustainable use of underutilized AnGR in the region.

Ravi Khetarpal
Executive Secretary, APAARI

Preface

This publication entitled `Regional Status Reports and Strategic Papers' is the second document, the first being `Proceedings and Recommendations' which was published earlier, coming out of the Regional Workshop on Underutilized Animal Genetic Resources and their Amelioration, held at the Malaysian Agricultural Research and Development Institute, Serdang, Malaysia, on 4-6 March 2019.

This is a compilation of the papers on status of underutilized animal genetic resources in the various regions of Asia and the Pacific and specific technical topics which provide the impetus to further enhance the management of animal genetic resources at the country level. Many authors as listed in the content were involved in the preparation and presentation of these papers. It is the aspiration of the organizers of the Regional Workshop that the information gathered in this publication is beneficial to the stakeholders entrusted with the conservation and utilization of specifically underutilized animal genetic resources in many countries within the Asia-Pacific region.

As presented in the regional status reports, there is great diversity of animal genetic resources of both livestock and avian species found in Asia and the Pacific region. The rich fauna heritage presents vast opportunities to the local populace to capitalize on their unique product properties and genetic capacity to adapt to local micro-climatic conditions and feeding environments, especially their usefulness in improving present-day breeds when they face with survival challenges arising from climate change. Currently, many of these non-main stream livestock breeds are neglected and untapped for commercial exploitation.

Many approaches in the appropriate management of animal genetic resources, including inventory procedures, characterization and preservation of genetic materials are shared in the strategic papers. There are many examples in the region which could provide management templates in the process to better manage the animal genetic resources.

The editorial team takes this opportunity to thank APAARI and MARDI for consigning the preparation of these two documents which proved to be positive outcomes of the Regional Workshop on Underutilized Animal Genetic Resources and their Amelioration.

Editors

Acknowledgements

On behalf of APAARI, and its program APCoAB and my own behalf, I would like to thank the Co-Organizers, Malaysian Agricultural Research and Development Institute (MARDI), Council of Agriculture (COA), Taiwan, and Australian Centre for International Agricultural Research (ACIAR) and collaborators, Department of Veterinary Services (DVS) Malaysia, Department of Wildlife and National Parks (WILDLIFE) Malaysia and Ministry of Agriculture and Agro-based Industry (MOA) Malaysia. for their whole-hearted support in organization of the Regional Workshop on Underutilized Animal Genetic Resources and their Amelioration, which was held on 4-6 March 2019 at MARDI Headquarters in Serdang, Malaysia.

Sincere thanks are due to Dr Zunika Bt Mohamed, Deputy Secretary General (Policy), Ministry of Agriculture and Agro-based Industry, Malaysia for gracing the occasion and delivering very inspiring speech during the Opening Session.

We place on record, our immense gratitude to Datuk Dr Mohamad Roff Bin Mohd Noor, Director General, Malaysian Agricultural Research and Development Institute (MARDI), Malaysia, for his meticulous planning of organization of this workshop and unstinted support. We are equally thankful to Dr Chung-Hsiu Hung, Director General, Council of Agriculture (COA), Taiwan, for his benign presence during the opening session and for providing the financial support to APCoAB program under which this workshop was organized. Constant support provided by Dr Ravi Khatarpal, Executive Secretary, Asia-Pacific Association of Agricultural Research Institution (APAARI), Bangkok, is thankfully acknowledged. Our sincere thanks also extended to all the Co-Chairs, Rapporteurs, speakers, panelists and participants.

Sincere appreciation is extended to all committee members of MARDI and APAARI Secretariat, for their concerted, untiring efforts and invaluable contributions in the preparatory phase as well as during the event who were the key players behind the success of the Workshop. They have worked constantly behind the scene to manage with all technical, financial, logistic and administrative aspects of organization of the Workshop.

Sincere thanks are accorded to all the Co-editors, especially Dr M. Ariff Omar and his team from MARDI, for their intensive involvement in collation, compilation and critical editing in giving shape to this document.

My sincere appreciation is extended to all the APAARI staff members especially Mr V.K. Sah and Ms Thansita Tanaphatrujira for their concerted efforts and valuable contributions in preparatory phase as well as during the event.

This publication contains the regional status reports and available strategy papers presented during the Workshop. I hope that the information presented in this document will draw the attention of the policy makers, administrators, researchers, farmers and other stakeholders towards efficient conservation and sustainable use of underutilized animal genetic resources in Asia-Pacific region.

Rishi Tyagi
Coordinator, APCoAB

The Organizers

Asia-Pacific Association of Agricultural Research Institutions (APAARI)

http://www.apaari.org

The APAARI, with its headquarters in Bangkok, is a unique voluntary, membership-based, self-mandated, apolitical and multi-stakeholder regional organization in the Asia-Pacific region. It promotes and strengthens agriculture and agri-food research and innovation systems through partnerships and collaboration, capacity development and advocacy for sustainable agricultural development in the region. Since its establishment in 1990, APAARI has significantly contributed towards addressing agricultural research needs and enhancing food and nutritional security in the region. The close links, networks, partnerships and collaboration with stakeholders that APAARI has developed over the years, as well as its goodwill, authority and focus on results, make the Association an important actor in the region. The ultimate aim of APAARI is to help realizing sustainable development goals in Asia and the Pacific.

Malaysian Agricultural Research and Development Institute (MARDI)

http://www.mardi.gov.my

MARDI is an agency under the purview of the Ministry of Agriculture and Agric-based Industry with the main objectives of generating and promoting appropriate technologies towards the advancement of the food, agricultural and agric-based industries. MARDI is mandated to fulfill the following functions: (1) to conduct research in the fields of science, economy and social science with regards to the production, utilization and processing of all crops (except rubber, oil palm and cocoa), livestock and food, and integrated farming, (2) to serve as a center for collation and dissemination of agricultural and food technologies, (3) to provide technical and consultancy services in food, agricultural and agric-based industries and (4) to provide technical training to cater for the development of the food, agricultural and agric-based industries. MARDI also provides grant-in-aid for scientific, technical and economic research and development related to food, agricultural and agric-based industries. MARDI has evolved from capacity building, establishment of farming and cropping systems to technology commercialization, total quality management and culture of excellence in attaining national and international recognition.

Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB)

http://www.apaari.org/web/our-projects/apcoab

The APCoAB, established in 2003 under the umbrella of APAARI, has the mission to harness the benefits of agricultural biotechnology and bioresources for human and animal welfare through the application of latest scientific technologies while safeguarding the environment for the advancement of society in the Asia-Pacific region. APCoAB's main objectives are to (i) serve as neutral forum for the key partners engaged in research, development, commercialization and education/learning of agricultural biotechnology as well as environmental safety in the Asia-Pacific region; (ii) Application of biotechnological tools for bioprospecting, conservation and sustainable use of bioresources; (iii) facilitate and promote the process of greater public awareness and understanding relating to important issues of IPRs, sui generis systems, biosafety, risk assessment, harmonization of regulatory procedures, and access and benefit sharing in order to address various concerns relating to adoption of agricultural biotechnology and sustainable use of bioresources; and (iv) facilitate human resource development for meaningful application of agricultural biotechnology and use of bioresources to enhance sustainable agricultural productivity, as well as product quality, for the welfare of both farmers and consumers.

Council of Agriculture (COA)

http://www.tari.gov.tw/english

The COA, Taiwan, is the competent authority on agricultural, forestry, fishery, animal husbandry and food affairs in Taiwan. Its responsibilities include guiding and supervising provincial and municipal offices in these areas. Under the council, there are Department of Planning, Department of Animal Industry, Department of Farmers' Services, Department of International Affairs, Department of Science and Technology, Department of Irrigation and Engineering, Secretariat, Personnel Office, Accounting Office, Civil Service Ethics Office, Legal Affairs Committee, Petitions and Appeals Committee and Information Management Center respectively in-charge of related affairs.

Australian Government
Australian Centre for International Agricultural Research

Australian Centre for International Agricultural Research (ACIAR)

http://aciar.gov.au

The ACIAR is a statutory authority within the Foreign Affairs and Trade portfolio operating under the ACIAR Act. ACIAR contributes to the objectives of advancing Australia's national interests, promoting economic growth and increasing sustainability through assisting and encouraging Australian scientists and institutions to use their skills to develop solutions to agricultural problems in developing countries. Its mandate is to plan, fund and manage projects across a broad range of agricultural and development areas. Approximately three quarters of the Centre's research budget is allocated to bilateral collaborative development-related research between Australia and developing countries. The remaining quarter of the research budget is allocated to multilateral development related research through contributions to international agricultural research centres. Besides, ACIAR provides training and development activities, including fellowships and support for training courses, as well as training provided within research projects, to help build capacity in research application and implementation in partner countries.

The Department of Veterinary Services (DVS) Malaysia

http://www.dvs.gov.my/

The **Department of Veterinary Services** (Malay: Jabatan Perkhidmatan Veterinar) Malaysia was established in 1888 as an agency to control exotic and domestic animal diseases. Over the years, the structure and functions of the organization have evolved to meet the growing demand for veterinary services. The department is under Ministry of Agriculture and Agric-based Industry Malaysia The DVS current objectives are (1) to strengthen and maintain the health status of animals believed to be conducive to industrial animals, (2) to ensure public health through the control of zoonotic diseases and the creation of clean and safe animal-based foods, (3) to promote sustainable livestock production and value-added industries, (4) to explore, develop and promote optimal use of technology and resources in animal-based industries and

(5) to organize animal welfare practices in all aspects of preservation and production. The department carries out enforcement duty on animal welfare through Animal Welfare Act 2015 (ACT 772). It also provides consultation, enforcement, research and development, surveillance and training for the livestock industrial benefit.

The Department of Wildlife and National Parks (DWNP) Malaysia

http://www.wildlife.gov.my/

PERHILITAN - **The Department of Wildlife and National Parks Peninsular Malaysiav** (Malay: Jabatan Perlindungan Hidupan Liar dan Taman Negara Semenanjung Malaysia), is a governmental organization that is responsible for the protection, management and preservation of wildlife and national parks in Peninsular Malaysia. The department carries out enforcement duties on biodiversity conservation through the Wildlife Conservation Act 2010 (ACT 716) and International Trade in Endangered Species Act 2008 (ACT 686). The department is under the purview of the Ministry of Water, Land and Natural Resources (Malay: Kementerian Air, Tanah dan Sumber Asli, abbreviated KATS), PERHILITAN is committed to the conservation of wildlife and its habitat for future generations of Malaysians. Amongst its objectives is to strengthen wildlife conservation programs through management, enforcement, enrichment and research of wildlife. Maintaining the integrity of Protected Areas for the benefits of research, education, economic, aesthetic, recreation and ecological function have always been its priorities. PERHILITAN has always strived to enhance knowledge, awareness and public participation towards wildlife conservation.

Acronyms and Abbreviations

ABS	Access and Benefit-Sharing
ACB	Asean Centre for Biodiversity
AI	Artificial insemination
AHP	Asean Heritage Parks
ANCC	Article Numbering of China
AnGR	Animal Genetic Resources
APAARI	Asia-Pacific Associations of Agricultural Research Institutions
ART	Assisted Reproductive Technologies
CAS	Certified Agricultural Standards systems
CBD	Convention on Biological Diversity
CGRFA	Commission on Genetic Resources for Food and Agriculture
CHM	Clearing House Mechanism
CNFIA	China National Food Industry Association
FAO	The Food and Agriculture Organization
FMD	Food-and-Mouth Disease
FSTS	Food safety traceability system
ICSI	Intracytoplasmic sperm injection
ISAG	International Society of Animal Genetics (ISAG)
IVD	*in vivo* derived
IVF	*in vitro* fertilization
IVP	*in vitro* produced
LDDB	Livestock and Dairy Development Board
MOA	Ministry of Agriculture, China
mmt	million metric tonnes
MOET	Multiple embryo transfer
NGS	New generation sequencing
NIAS	National Institute of Agrobiological Sciences, Japan
NEI	National Ecology Institute Korea
OPU	Ovum pick up
PGC	Primordial germ cells
PLDDB	Punjab Livestock and Dairy Development Board
PNAD	Philippine Native Animals Development
PPRS	Parentage Performance Recording Scheme

QTL	Quantitative trait loci
TAGC	Taiwan Animal Germplasm Center
TAP	Traceable Agricultural Products
SCNT	Somatic cell nuclear transfer
SNP	Single nucleotide polymorphism
WTO	World Trade Organization

Executive Summary

The Regional Workshop on Underutilized Animal Genetic Resources (AnGR) and their Amelioration was held at MARDI Headquarters in Serdang, Malaysia, on 4-6 March 2019. The Workshop was organized by the Asia-Pacific Association of Agricultural Research Institutions (APAARI), Malaysian Agricultural Research and Development Institute (MARDI), Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB), Council of Agriculture (COA), Taiwan, and Australian Centre for International Agricultural Research (ACIAR) in collaboration with Department of Veterinary Services (DVS) Malaysia, Department of Wildlife and National Parks (Wildlife) Malaysia and Ministry of Agriculture and Agric-based Industry (MOA) Malaysia. The objectives of the workshop were to assess the current status of underutilized AnGR at regional level and R&D status of priority native breeds that are needed to promote the use of underutilized AnGR in the Asia-Pacific region, to identify the knowledge gaps and way forward in defining regional priorities concerning AnGR and create awareness on the role and value of underutilized AnGR that have potential for diversification of the food basket and to formulate strategies to strengthen the institutional, legal and policy framework for sustainable utilization of underutilized AnGR.

A total of 63 participants from 14 countries (Bangladesh, Bhutan, China, India, Iran, Kenya, Laos, Malaysia, Nepal, Philippines, Pakistan, Sri Lanka, Taiwan, Thailand) mainly of the Asia-Pacific region attended the workshop. The participants were from a number of national organizations such as research institutes, universities and research councils dealing with the management and conservation of underutilized AnGR.

The workshop comprised of presentations from 15 speakers who provided the background and status of AnGR in the region as well as presently available technologies in enhancing the management and breeding of underutilized AnGR delivered in three sessions: Technical Session I on **The Status of Underutilized AnGR for Food and Agriculture at Sub-regional Level**, Technical Session II on **Thematic Presentations of Underutilized AnGR** and Technical Session III on **Strategies for Conservation and Utilization of Underutilized AnGR** followed by, Technical Session IV on **World Café Discussion – Regional Priorities for Underutilized AnGR** in five key areas: (1) conservation, improvement and use, (2) value addition, marketing and export, (3) partnership and capacity development, biotechnology for enhancing utilization, (4) biotechnology for enhancing utilization and (5) regional information sharing system and focal points for the conservation and utilization of AnGR and Technical Session V on **Panel Discussion on Legal and Policy Framework Support to Promote Utilization on Underutilized Animal Genetic Resources**.

The **Major Recommendations** arising from the workshop were:

1. **Conservation, improvement and use of underutilized AnGR:** Each country within the Asia-Pacific region is recommended to have in place an enabling policy to protect and conserve AnGR. The assessment of underutilized AnGR has to be carried out at national level to gather information on geographical distribution, population dynamics, risk status and indigenous knowledge and experience in the management of underutilized AnGR. The rights of smallholder farmers owning these underutilized AnGR are to be safeguarded

through filing of their intellectual property rights and agreement on sharing of future benefits.

2. **Value addition, marketing and export:** Improvement of technology, facility, training and education on value-added products of indigenous AnGR are highly recommended. Farmers engaged in keeping these underutilized species should be provided with enhanced skill and knowledge to enable them to develop and commercialize these value-added products. Development of brand and national certification to promote products derived from indigenous species is important to be initiated. The public should be exposed to these products through awareness campaign to promote these products. The governments of APAARI member countries are recommended to provide the legal provisions to protect the originality and exclusivity of indigenous animal products. The marketing of products from indigenous animals should be enhanced and their production be made more consistent and of high quality through R&D and training modules.

3. **Partnership and capacity development:** It is recognized that many stakeholders of special groups, NGOs, entrepreneurs, farmers and research institutions are to be included in the management of underutilized AnGR. To ensure sustainable partnership, the stakeholders need to be identified and engaged at national and regional levels based on priorities on underutilized AnGR. To build partnership, a networking of interest groups and institutions could be initiated to collaborate on selected key issues such as expertise development, methods/technologies, deliverables and budget and identify areas of common interest or current challenges of underutilized AnGR. Sharing of data and knowledge in specific areas of AnGR management including food security, is recommended to be strengthened through involvement of country personnel in workshops, seminars and training courses. A centralized data bank, also acting as repository of contributed information on AnGR, could provide easy access to member countries. Exchange of genetic materials of indigenous breeds is very crucial and should be given priority. For capacity building, awareness on the importance of status, risk issues and conservation methods of AnGR should be shared through seminars, workshops and hands-on trainings on modern biotechnologies. Selected advanced technologies in the preservation of genetic materials and multiplication of breeding animals may aid the sustainable management of underutilized AnGR in member countries.

4. **Biotechnology for enhancing utilization:** The issues constraining the use of biotechnological methods in livestock production are lack of expertise, data, financial support and facility. The setting up of an Asia-Pacific Regional Genebank for gametes and embryos to facilitate regional sharing of genetic materials and enhance the mechanism for intra-regional exchange of AnGR is highly recommended. A consortium for Asia-Pacific for underutilized AnGR is to be set up as a common platform for regional collaboration and networking in knowledge and data sharing of underutilized AnGR. Collaborative projects among countries in the Asia Pacific region are proposed on specific areas such as breed characterization, genomic profiling, sexing and cryo preservation of gametes and value-added products of underutilized AnGR. Hands-on training for researchers, extension agents and farmers can be organized to upgrade skills and knowledge in the multiplication and management of AnGR. Knowledge in management of AnGR could also be imparted through the conference, seminar and newsletter. Awareness programs could be conducted to expose farmers to biotechnological methods in the identification and breeding of underutilized AnGR. APAARI is proposed to facilitate the scoping for partners and fund providers from public and private sectors for financial support

through regional-wide proposals in the conservation and utilization of underutilized AnGR.

5. **Regional information sharing system and focal points:** There is a need to tailor the AnGR information system based on each country's specific attributes. A regional information system should have defined objectives (kinds of data to share, end users and involvement of local communities), be user friendly in its usage and promote public awareness to educate the local community on AnGR, including schools, universities and extension agencies. An Asia-Pacific AnGR information system which meets the regional requirements be established. The information system is suggested to be linked to DAD-IS and DAGRIS to facilitate the systematic gathering of AnGR information in the region.

Status of Underutilized Animal Genetic Resources for Food and Agriculture in South and West Asia

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[5]Pakistan Agricultural Research Council, Islamabad, Pakistan
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Introduction

Man has domesticated plants and animals for the last 10,000 years and has regulated their breeding for meeting his food and agricultural needs. Utility-based breeding has resulted in the development of larger genetic diversity of animal genetic resources across the globe. As of today, man has domesticated 15 non-carnivore species for food and agriculture purposes. Among these, cattle, sheep, goat, pig and chicken are considered major global species. Other species, although domesticated earlier, are either restricted to a region or are thinly distributed. Nevertheless, a large number of the animal species provide diversification of food basket of animal origin, thus, providing global food security to billions of people.

South Asia region includes Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, India, Pakistan and Sri Lanka. India is the largest country in the region, expanded in half of the total geographical region of South Asia. The region shares nearly 4% of the world's land surface area, sustaining one-fourth (about 2 billion) of the world's human population. West Asia countries are Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Occupied Palestinian Territory, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Turkey, United Arab Emirates, and Yemen (FAOSTAT).

South Asia has varied terrains, habitats and climatic conditions. Countries like Maldives and Sri Lanka are completely surrounded by the ocean, with very small elevated surface. Larger area of South Asia – mainly of India, Pakistan and Bangladesh – is characterized by sub-tropical type of climate. Northern part of South Asia, including Nepal, Bhutan, Northern India, Northern Pakistan and Northern Afghanistan is characterized by high surface elevation and temperate and sub-temperate climate. Desert, with arid or semi-arid condition is spread in some parts of India and Pakistan. South Asia gets sufficient quantity of precipitation in most of the parts. The region, specifically Indian subcontinent, gets seasonal "Monsoon" precipitation during May to September. South Asia is the most diversified region in flora and fauna. It holds about 16 and 12% of flora and fauna of the globe. Indian subcontinent is specifically rich, having three biodiversity hotspots among 36 across the world. India of South Asia region is also included among 18 mega-diverse countries in the world (Biodiversity a-z). At same time, the region is also facing severe biodegradation and has shown depletion of larger biological diversity and habitat.

Asia is rich in animal genetic resources, comprising the largest number of animal species as well as maximum animal population for most of the species. However, the continent is also characterized by the unequal distribution of various animal genetic resources in the different regions. A large genetic diversity has been observed in South Asia for the animal genetic resources and has the highest proportion of cattle and other big five species. India and Pakistan dominate in the region in terms of animal genetic resources. On other side, West Asia is slightly poor in animal genetic resource number and their diversity. Both of the regions comprise the countries with developing economies. Some of the economies are growing with high rate due to increasing market and other global factors. However, the dependence on agriculture is higher in the South Asia region.

During 2018, South and West Asia regions sustained 1.89 and 0.27 billion of people, respectively, and cumulatively it was 28.3% of total global population. Both of the regions comprise almost half (47.7%) of the human population in Asia. Major population – 24.8% of the world and 41.6% of the population of Asia – is residing in South Asia alone. Predicted population of South Asia also indicates that by 2050, almost same proportion, i.e., one fourth of total global population will reside in the region (FAOSTAT). Importantly, the population growth will slow down in both parts of the region. Rural population, which is largely dependent on agriculture and animal husbandry, will decrease more drastically in South and West Asia in the near future (Table 1).

Table 1: Predicted human population in South Asia and West Asia regions (billion)

Year	South Asia		West Asia		Asia		World	
	Total	Rural	Total	Rural	Total	Rural	Total	Rural
2018	1.89	1.19	0.27	0.08	4.55	2.25	7.63	3.38
2020	1.94	1.19	0.28	0.08	4.62	2.23	7.79	3.38
2030	2.13	1.21	0.32	0.08	4.95	2.13	8.55	3.37
2050	2.38	1.09	0.39	0.08	5.26	1.85	9.77	3.21

Importance of livestock in economy and food security of the sub-region

Livestock significantly contributes to world economy across the region. However, some of the regions have shown higher dependency on agriculture and livestock. Worldwide, most developing countries share higher contribution of livestock to their national economies. South Asian countries have also shown the same pattern. Almost in all countries of South Asia, agriculture and livestock contributions are more than 20 and 4%, respectively, to their national economies. In Nepal, the contribution of livestock in the national economy is more than 15%. In West Asia, the percentage-wise contribution of livestock in national economies is comparatively less.

Further, this importance of livestock is multifarious in almost all of the countries of South Asia. Livestock is not only the great source of food but also provides agricultural and transport power, manure as bio-fertilizer and energy fuel. In most of the countries, the by-products like skin, bones, horns and blood are also utilized very well for different purposes, contributing more to the economy. Utility of animal genetic resources (AnGR) in agricultural operations is also important in South and West Asia. Many countries in South Asia are dependent on animal draught power for agricultural field work for various purposes including ploughing, weeding, puddling of fields, thrashing and transportation of agricultural commodities. Farmers utilize castrated males usually from cattle and buffalo species. Some parts of the region also use yak, donkey, mules, camel and mithun for the same purposes in specialized agric-ecosystems. However, the trend of using animal draught power is declining in the South Asian region, causing a major decline of specialized populations of these species. Still, the highest number of draught animals is found in South Asia region.

Contribution of livestock towards food is quite high (Table 2). Animals account for one fifth of the world's food. About 12% of the global population is solely dependent on animal food. South Asia is the highest milk producing and consuming region in the world. India and Pakistan have very high priority for diary production and the dairy growth in these countries is also noteworthy. However, the productivity of the animals is far below some of the best countries.

Table 2: Total milk, meat and egg production (in million tonnes) in different regions of the world during different years (1970 – 2017)

Region	Commodity	1970	1980	1990	2000	2010	2017
South Asia	Milk	32.8	46.4	75.9	116.1	170.8	234.9
	Meat	3.5	4.6	6.8	8.8	12.5	15.6
	Eggs	0.5	0.9	1.8	3.2	5.1	7.3
West Asia	Milk	9.3	12.6	13.7	17.5	23.6	32.5
	Meat	1.1	1.6	2.8	4.2	5.9	7.7
	Eggs	0.3	0.5	0.9	1.5	1.7	2.3
Asia	Milk	49.6	69.9	108.4	169.4	266.1	336.9
	Meat	17.0	28.6	50.9	91.2	123.2	141.7
	Eggs	5.4	8.1	15.8	32.9	42.7	56.3
World	Milk	391.9	465.8	542.5	579.5	723.7	804.8
	Meat	100.7	136.7	179.5	233.3	294.6	334.2
	Eggs	20.4	27.4	37.4	55.2	69.5	87.0

Production and consumption

Animal production from these regions is of mixed type. South Asia is leading in milk production in the world but has poor production in meat and egg production. At the same time, West Asia has shown poor production of different animal produces. Future prospects for milk and meat production are also more positive in South Asia in comparison to West Asia.

In 2017, world's total meat production was 334 million tonnes, of which 42% (141 million tonnes) was produced in Asian countries. However, there is high disparity in meat production among the different sub-regions of Asia: the share of meat from South and West Asia is very low in comparison to the other parts of Asia. Combined meat production of South Asia (15.6 million tonnes) and West Asia (7.6 million tonnes) is even less than that of China alone.

Importantly, growth in meat production as well as consumption in both of the sub-regions is also very low, and well below the overall meat growth in Asia and world. In South

Asia, India and Pakistan are the major countries for meat production, and both countries are also having good growth rates. Major species for meat in the region are cattle, buffalo, goat, sheep and chicken. Although, pig has great importance in the world, its production is very low in the South and West Asia. Likewise, beef is much restricted in India due to religious predisposition. However, South Asia is contributing about 70% of total buffalo meat of the world, and production is also growing fast in the region. India, Pakistan and Bangladesh are net exporters of buffalo meat, mainly to West Asia, East Asia and African countries.

Similar to meat production, the egg production is also poor in both of the regions. In 2017, South Asia and West Asia produced only 7.3 and 2.3 million tonnes of eggs, respectively. Both combined South and West Asia produced only 11% of the total egg production in the world (87 million tonnes) in 2017. Importantly, the growth in egg production is also very low in comparison to overall growth in the Asian continent as well as in the world.

The scenario of milk production is much better in South Asia. South and West Asia sub-regions produced 235 and 32 million tonnes of milk, respectively, in 2017. Share of world's milk production (805 million tonnes) from these sub-regions was 29 and 4%, respectively. Growth in milk production in South Asia countries, specifically in India, has remained above 4% annually for the last three decades, which also enhanced the global milk growth rate towards positive side. The signs are more positive in South Asia, although milk production in West Asia is still moderate. Almost all of the buffalo milk production in world is coming from the South Asia only, where India and Pakistan are the two leading countries in buffalo milk production.

Table 3: Average animal food supply quantity (in kg/ capita/year) n different regions in 2013

Region	Milk	Meat	Egg
South Asia	85.9	6.7	2.8
West Asia	122.9	39.7	7.4
Asia	60.3	32.6	9.4
World	90.0	43.2	9.2

Progress in food and nutritional security in South Asia countries has been phenomenal in recent years. The level of malnourished-stunting in children below five years has declined significantly in some of the countries including India (UN Report, http://in.one.un.org). But still a large proportion of total world undernourished population is found in South Asian countries especially in the Indian sub-continent. Protein consumption is also at critical levels in most of the countries of South Asia, far below to world averages.

Table 4: Average protein supply (g/capita/day) as 3-year averages in different regions of the world

Region	1999-2001	2003-05	2011-2013
South Asia	46	47	53
West Asia	69	73	84
Asia	59	62	71
World	71	74	80

Imports and Exports

The last century remained most crucial for both sub- regions, specifically South Asia as far as import and export of livestock and their products is concerned. Most of the germplasm exchange, including live animals, happened in this period. South Asia observed large immigration of high producing cattle breeds in different parts of the region. These breeds were Holstein Friesian, Jersey, Brown Swiss, Red Dane cattle, Merino and Rambouillet sheep, Landrace, Yorkshire and Berkshire pig, and White Leghorn, Cornish, Plymouth Rock chicken. These breeds influence the native populations of these specific species which are forced to be underutilized.

Table 5: Import and export of livestock and livestock products in South and West Asia in 2016 (value in ,000 million USD)

Commodity	Import				Export			
	South Asia	West Asia	Asia	World	South Asia	West Asia	Asia	World
Live animals	0.2	3.3	6.2	19.6	0.2	0.5	1.8	19.3
Meat total	0.6	7.9	44.0	120.8	4.1	1.0	12.9	121.5
Milk (condensed + powdered + fresh)	0.9	3.4	12.6	32.2	0.2	1.6	3.2	30.6
Eggs (in shell)	0.06	0.7	1.1	3.6	0.05	0.4	0.8	3.4
Dairy products + eggs	1.1	6.4	19.9	69.4	0.3	2.6	4.8	67.8
Food and animals	29.0	69.9	297.9	928.0	27.8	26.4	170.2	898.6

Status of AnGR

South Asia is the most dynamic region as far as AnGR is concerned. The region remains the point of origin and domestication for many species, including Zebu cattle, goat, chicken and mithun.

Status of AnGR in some important countries

Bhutan

Livestock are reared traditional in remote pockets of the Bhutan. Native germplasm of cattle, yak, mithun, horse, sheep, goat, swine and poultry are well distributed in the country. There are more than five cattle breeds, three horse types, 10 native chicken types, three sheep types, three yak types spread across many populations in the country. Recently, the population of traditional AnGR is declining at a rapid rate. Pig, sheep and horse are hard hit due to socio-economic development, religious taboo on slaughter and declining utility of the species, respectively. Conservation initiatives including cryopreservation of semen at animal gene bank, *in situ* conservation and nucleus farm for selected AnGR species are under way for traditional AnGR breeds in the country. National Animal Gene Bank was also established in 2005. Presently, the government has given due importance to the characterization of native animal germplasms and database development, so that it can be used for developing national strategy and management plan for conservation and sustainable utilization of native AnGR in the country.

Table 6: Livestock population in different regions in year 2017 (FAOSTAT)

Region	Ass	Buffalo	Camel	Cattle	Chicken	Duck	Geese[1]	Goat	Horse	Pig	Rabbit	Sheep	Turkey
West Asia	1.5	0.6	1.9	24.6	953.5	0.7	1.9	34.2	0.4	0.9	0.3	92.2	9.4
South Asia	8.3	158.1	1.7	271.9	2689.4	78.4	0.9	300.1	1.3	10.2	-	150.1	-
Asia	14.9	195.8	4.7	470.2	12857	1014.2	313.8	551.3	15.5	557.6	263.0	508.0	15.2
World	45.8	200.9	34.8	1491.7	22847	1150.9	371.4	1034.4	60.6	967.4	308.9	1202.4	459.4

[1]including guinea fowls

Iran

Iran has been rearing and raising more than 62 indigenous livestock breeds with diverse characteristics and abilities. There are 10, 27, 12, 6 and 7 native breeds of cattle and buffalo, sheep, goat, camel and horse, respectively, in the country (Tavakkolian, 1999). Downward trend is seen for native cattle, buffalo, camel, sheep and goat populations in recent years. The existing problems and constraints and the reduction of socio-economic incentives of breeders have led to more than 14 populations which are categorized as in danger or endangered. Caspian or Khazar, a miniature horse, native to Northern Iran, is now endangered. A conservation and research complex on Caspian horse for the purpose of applied research and optimal use of existing capabilities for its protection and management has begun. In recent reports and studies, Dareh Shori, Ghareh Bagh, Kurd, Sistani and Caspian horses, Najdi, Adani and Markhoz goats, Sangsari, Kalkohi and Gharegol sheep, Sistani, Najdi and Sarabi cattle and Bactrian camel are underutilized and even at the risk of extinction. A valuable breed, Golpayegani cattle, has been extinct for the past several years. In recent years, measures such as germplasm collection, characterization, evaluation, conservation and documentation have been taken for underutilized breeds (Animal Science Research Institute of Iran, 2015; Bahmani et al., 2015; Asadi et al., 2017). Food safety incidents have gradually changed Iranians' consumption habit. The consumers are more inclined to purchase healthy and organic agricultural products. Production traceability system of industrial livestock products have been introduced by the relevant agencies. The difficulty in traceability of the traditional livestock products has negatively impacted their market. In Iran, the share of animal husbandry from the agricultural value added was 24% in 2015. About 1.6 million persons are directly engaged in livestock production in the country as per latest general agricultural census (Statistical Centre of Iran, 2017). Growth has been observed in livestock products over the past decade. Milk, red meat and poultry meat have been raised from 7024, 686 and 1565 thousand tonnes in 2008 to 10184, 835 and 2237 thousand tonnes in 2017. The share of export of live animals and livestock products from the total agricultural sector was 20.79% in comparison to import share of only 8.5% in 2016 with positive trade balance for most cases.

At present, three groups of research, executive and extension activities are in place to protect and increase the quantity and quality of native livestock production in the country. Training livestock owners and transferring research findings are the country's most important programs to protect underutilized native breeds. Existence of large amount of knowledge and research data transferable to producers, implementation of the new system of agricultural extension, providing a suitable platform for communication among stakeholders, special attention to local resources and potential in the context of the Resistance Economy and the Sixth Vision of National Development, simultaneous ratification of laws and regulations concerning the conservation and exploitation of genetic resources, the increasing demand for organic and healthy livestock products have all provided a positive environment for effective research, extension and implementation in recent years to protect and improve underutilized breeds.

Nepal

Livestock contributes to about 8% of the total GDP of the Nepal. The country is enriched with 26 breeds of domestic animals - 7 breeds of cattle, 4 breeds of buffalo, 4 breeds of goat, 4 breeds of sheep, 3 breeds of pig and 3 breeds of chicken. A large proportion of native animals are underutilized in the region. Lulu is high valued taurine native cattle and performs well in harsh climate of mountain region of Nepal. It is said to produce 4 litres of milk per day in extensive system of management without the supplementation of any concentrate. Lime and Parkote buffaloes are very important livestock in the hilly region of Nepal, however, people preference for Murrah buffalo for high milk production may pose a threat to local buffalo populations in the region. Bampudke pig is a dwarf breed, having lower back fat thickness. The breed can perform very well in scavenging system of management without supplementation of concentrate. Sakini breed of poultry is the most predominant breed of native poultry reared by the farmers of Nepal some years ago. The breed has found to possess unique characteristics of high growth rate and high fecundity and performs best in scavenging system of management and has good taste of meat. However, this breed has nearly been replaced by New Hampshire and Giriraja chickens. Processing of the milk from Yak to make cheese, churpi and ghee has been initiated on large scale in the country. Selling and exporting yak milk product - churpi, as chocolate and organic yak product have given new opportunities to make native AnGR more utilizable. Processing and branding of the A2 milk of Lulu cattle is another aspect to increase utility of native livestock in the country.

Pakistan

Livestock contributed approximately 58.6% to the agricultural value added and 11.6% to the overall GDP during 2015-16. Gross value addition had increased to 3.63% during 2014-15 and 2015-16 (Anonymous, 2015-16). The estimated livestock population of cattle, buffalo, sheep, goat and camel during 2015-16 was about 171 million with increasing trend of about 5 million per annum. The livestock sector produced 54.328 million tonnes milk, 3.873 million tonnes meat, 45.1 thousand tonnes wool, 26.5 thousand tonnes hairs, 271 thousand tonnes fat, 1207 thousand tonnes dung and 3940 thousand tonnes edible offals during 2015-16. A total of 46.242 thousand tonnes of red meat was exported during 2015-16, however, Pakistan shared about 0.26% of the global meat market. Over 80% of the producers are smallholders with six or less animals.

Ten distinct breeds of cattle, two of buffalo, 30 of sheep, 37 of goat and 21 of camel have been described in Pakistan (Afzal and Naqvi, 2014). All these breeds are well adapted to harsh climatic conditions and produce milk, meat and wool/hairs far below their production potential mainly due to shortage of feed resources. Nili-Ravi and Kundi are the most important dairy buffalo breeds. Ten breeds of cattle probably make up only 30% of the population and the rest of the population is generally classified as non-descript. Sheep farming is an important economic activity in areas like Baluchistan, where about 44% of the total sheep are raised.

Livestock sector of Pakistan, as in other developing countries, is also facing some much evident constraints - insufficient feed resources, primitive husbandry practices, prevalence of different diseases, small number of animal holdings, different natural disasters, limited adoption of modern technologies, scattered livestock population, poor financial resources of the farmers and calamities, etc. (FAO 2005 and 2006; Stur et al., 2002; Afzal and Naqvi, 2014). These constraints hit one or another way to livestock sector and result in high impaired livestock productivity leading to huge economic losses in Pakistan. The milk and meat industries are not well organized and are much fragmented. There is a need for valuation and strengthening of progeny-testing program of Nili-Ravi buffalo and Sahiwal cattle. Similarly, breed improvement programs for Kundi buffaloes and Red Sindhi cattle are also needed. Undefined buffalo breeds like Azakheli, white Nili-Ravi and Bhuri Kundi need to be studied for their production potential. Selective breeding programmes for important sheep breeds, i.e., Lohi, Kajli, Thalli, Sipli, Bibrik, Baluchi, Rakhshani, Waziri, Hashtnagri, Damani, Kacchi, Kooka, Dumbi and Kail, need to be started. Goat breeds of Beetal, Kamori and Dera Din Panah should be developed as dairy-cum-meat breeds. Dairy camels of Pakistan are also very famous.

Government of Pakistan has taken some initiatives for uplifting livestock sector through constitutional amendment and continued regulatory measures like allowing import of high yielding animals, semen and embryos for the genetic improvement of indigenous dairy animals, allowing import of high quality feed stuff and micro ingredients for improving the nutritional quality of animal and poultry feed and allowing import of veterinary, dairy and livestock machinery and equipment at reduced duty rates in order to encourage establishment of value addition industry in the country. Highest industry body in Punjab, where more than 60% of total livestock is found, is the Punjab Livestock and Dairy Development Board (PLDDB), a section 42 company. PLDDB has a mandate to develop a centre of excellence for the development of Sahiwal and exotic breeds. It is in the process of establishing state of the art Semen Production Unit, training over a thousand AI technicians and also provides numerous training courses in the livestock production industry. Livestock and Dairy Development Board (LDDB) was also established in 2005 by the government. In the country, presently there are six research/vaccine production institutes, 963 veterinary hospitals, 2869 veterinary dispensaries, 2875 veterinary centres and 72 diagnostic laboratories.

Other important initiatives – establishment of mobile veterinary clinics, establishment of LDDB, updating Livestock Policy, establishment of research dairy farms, technology transfer – are being taken for improvement of health at national level. Pakistan Agriculture Research Council was successful in many of the livestock health and production related programs to uplift livestock sector in Pakistan. Success stories in control of Hydro-pericardium Syndrome: a fatal disease of poultry, control of Highly Pathogenic Avian Influenza (Bird Flu) in Pakistan, preparation of balanced feed for dairy animals, introduction of Coordinated Avian Diseases Surveillance System, multi-nutrient urea-molasses blocks for livestock are well evident. The Pakistan Agricultural Research Council under Animal Sciences Research has prioritized the research in animal production area through research on the productivity enhancement of small and large ruminants, including extinct livestock indigenous breeds, improvement of production performance of backyard poultry and development of feedlot fattening model to enhance quality meat/beef production with efficient enhancement of forage/fodder supply.

Sri Lanka

The livestock resources of Sri Lanka include cattle, buffalo, goat, sheep, pig and poultry. Populations of each breed are 1.2 million, 0.4 million, 0.38 million, 0.009 million, 0.089 million, and 14 million, respectively. Sri Lanka has defined indigenous cattle (Sri Lanka cattle, Kappa Harak cattle, White cattle), buffalo (Sri Lankan buffalo), goat (indigenous and Kottukachchiya breed), sheep (Jaffna sheep), swine and jungle poultry as indigenous farm animal resources which are under threat and some of these breeds have become extinct, *e.g.*, Kottukachchiya breed of goat and Kappa Harak cattle. Cattle population is distributed in the Up Country Wet Zone (WU), Up Country Intermediate Zone (IU), Mid Country Wet Zone (WM), and part of the Mid Country Intermediate Zone (IM), Low Country Wet Zone (WL), Low Country Intermediate Zone (IL), mainly contribute to the national milk production. Dairy buffalo population is mostly scattered in the Low Country Wet Zone (WL). Goat population is scattered all over the country while the population is denser in Anuradhapura and Kurunegala districts representing Low country dry and intermediate zones, respectively. The pork production is mainly accomplished by the area called Pig Belt located in the Gampaha and Puttalam districts representing Low Country Wet and Intermediate Zones. The poultry farming is popular in all over the country while the population is highly concentrated in Kurunegala, Puttalam, Colombo, Gampaha, and Kalutara Districts.

Sri Lanka is targeting towards the self-sufficiency in milk and hence a rapid expansion of upgrading program in cattle and buffalo is underway. Likewise upgrading programs are being implemented in the other livestock species such as goat, swine and poultry. Over 200,000 artificial inseminations are performed annually for cattle, buffalo and goat, and swine upgrading program is mainly focused on natural service using exotic breeds. Chicken and egg production are carried out using exotic breeds of poultry. In 2017 a total of 1,487,320 kg meat and meat products were imported to the country to the value of SLR 800,809,413. Other imports included milk and milk products amounting to 98,863,896 kg valued at SLR 48,145,436,281. Likewise, 2,081,730 kg of meat and meat products were exported and SLR 220, 010,240 earned. In addition, 1,048,411kg milk were exported and SLR 405,051,456 income gained. Small scale milk processing is being done at the field level and marketed in the same locality. Yoghurt, curd, cheese and ghee are the value-added products produced in such processing plants. Some farmers are processing the milk produced from their own farms while there are separate milk processors who procure milk from other producers. With increasing human population and increasing pressure on land has limited the availability of land area for livestock farming. On the other hand, urbanization has led the young generation to give up livestock farming and acquire white collar jobs. National Artificial Insemination (AI) Program and Natural Service (NS) Program are implemented for cross breeding of the local cattle, buffalo, goat and swine. Approximately 20% of the national herd is covered by AI program and NS program is implemented in the areas where AI is not feasible. Milk recording programs are underway with Parentage Performance Recording Scheme (PPRS) and Station method milk recording program for progeny testing in selected government farms. Dairy development is the main concern at present in the country. A 20,000-cattle importation project is under way and 5000 Jersey x Friesian crossbred cattle have already been imported and distributed among middle scale and large scale livestock farmers.

Unique underutilized AnGR

A number of species, which are regional in presence are mostly underutilized in their local area and almost neglected. These species are sometime more adapted to the local environment and remain underutilized due to their limited utility to that region only. Similarly, there may be some populations of established species also which were productive to a specific production system only and after changes in production system their utility decreased with the time. Different authors have given varying reasons for underutilization as – useful traits may not be known, there may be little scope of processing and marketing of products, utility could have faded with time, might not be able to compete with other species in terms of production, or may be lack of interest by farmers and researchers also.

Under-utilized AnGR can be classified at species, breed or population level. There are certain micro species, specifically in South Asia, which are low in number as well as they are declining very fast in number. Furthermore, there are some other livestock species, such as pig, camel, horse and donkey which have greater potential for utilization in both of the regions. There are many livestock species and their specific populations and breeds, which were utilized very well in recent past but have now become underutilized or even unutilized in today's perspective. Species like camel, horse, donkey and draft cattle, once used extensively, are now facing large decline in the population after development of alternate and sophisticated transport facilities.

Underutilized species in the region

Camel

Camels (*Camelus* Spp.) are widely distributed in most parts of West Asia and a small part of South Asia. The species is well known for its survival in arid climate both in hot and cold deserts. The species had great utility up to the mid-20th century which has now gone down due to mechanized transport and adoption of alternate sources for meat and fiber. Its population has declined rapidly in large part of the region. Dromedarian (single humped; *Camelus dromedarius*) and Bactrian (double humped; *Camelus bactrianus*) are two different species of camel, which have been domesticated by humans. Most of the camel populations in West and South Asia countries belong to Dromedarian type. Only, a small region of South Asia, specifically Ladakh of India and North Frontier region of Pakistan, has a small population of double humped camels. Dromedarian camel is native to West Asia, while Bactrian camels are native to Central and East Asia. Camel has excellent ability to survive in arid region and can withstand changes in body temperature and can live without water for a long period. They also provide invaluable draught power in the desert conditions and additional milk and meat to the camel rearers. The camel milk is a rich source of proteins with potential antimicrobial and protective activities (Thies, 2000).

Photograph 1. A common single humped camel of West Asia

Photograph 2. A rare double humped camel of Pakistan

Yak

Yaks (*Bos grunniens*) are the bovines of high-altitude regions and distributed largely in Trans-Himalayan subregion. More than 90% of the yaks are found in Tibet area of China. In South Asia, yaks are present in India, Pakistan, Nepal and Bhutan. This unique species is well-adapted to high altitude climatic conditions including low oxygen level, low barometric pressure, low temperature, high ultraviolet exposure and scarce fodder. Local

Photograph 3. A yak in the Himalayan area

people use the species for food (milk, meat), draught, transport, manure, fiber and skin and also possess cultural importance in the society. Presently, yak population is decreasing in South Asia due to varied reasons including people migration from high altitude region and apathy of new generation for the animal husbandry practices. People's preference for hybrids of yak and local cattle for increased milk production is also a major cause of decline of yak population in the region. It is estimated that about 30 to 40% of the yaks are crossbreds or hybrids in these countries, with majority in India.

Mithun

This semi domesticated bovine, *Bos frontalis,* is largely found in the North-East region of India in South Asia. It has high nutritional and socio-economic importance in local tribes in the region as it is used for meat purpose and sometimes for draft. During the last century the population of mithun dwindled because of indiscriminate slaughter by the native people. However, due to government efforts, the population of mithun has stabilized in recent time. The species has high potential for meat as well for milk production, if fully domesticated.

Photograph 4. A mithun in a wild habitat in South Asia

Pig

Pig is the most important meat animal worldwide, however, it has very less impact in South and West Asia as people do not prefer the pork due to social stigma and religious issues. Most of the pigs are reared in extensive production systems, and remain very low in productivity and production as compared to the European pigs. Pig has a greater chance of utilization in the South Asia, if people from the region start accepting the meat.

Swamp buffalo

Swamp buffalo (*Bubalus bubalis carabensis*) is another potential population in South Asia. The animals are reared in hot humid climate for meat and draught purposes. It has very good potential for meat production as well agricultural works in swamp areas.

Non-chicken poultry

Quails, geese, ducks and turkey are the non-chicken poultry species, which have importance in certain parts of the South and West Asia.

Rabbit

Rabbit has high potential in both South and West Asia. It can be alternatively used for meat purpose, where pressure to fulfil meat demand by chicken is very high. The species has high adaptability to tropical to temperate climate and can be reared in larger part of South and West Asia.

Underutilized local breeds

A large number of indigenous breeds of cattle, sheep, goat, buffalo and poultry in rural parts of South and West Asia are underutilized. Cattle breeds, once known for draft power in South Asia, are now no more in utility due to extensive mechanization of agricultural work as well as transport.

Germplasm collection, characterization, evaluation, conservation and documentation

South Asia region harbours the highest genetic diversity for almost all the domesticated species. A number of native breeds have been reported from different countries in the region, which are supposed to have attributes like disease resistance and better thriving ability. India has already registered 184 breeds of indigenous livestock and poultry species. Similarly, other countries have enhanced their efforts to identify and characterize new breeds and populations from their respective state. South Asia has a higher number of breeds of livestock and poultry species than that of West Asia. More than 600 breeds have been reported in this region, though it is less than 10% of total breeds in the world, despite having about 20% of world's livestock population in the region (FAOSTAT).

Inventorization of AnGR in India

India has started registering its native germplasms since 2008. At present, there are 184 registered indigenous breeds of farm animals in India, which include 43 of cattle, 16 of buffalo, 34 of goat, 43 of sheep, 7 of horse and pony, 9 of camel, 8 of pig, 2 of donkey and one of yak in livestock and 21 of chicken, one each for goose and duck in poultry. During last 20 years, more than 50 new populations were identified across the country and 39 breeds of different farm animal species were registered. However, there is still sizable undefined populations, particularly those of cattle and goat. The country targets to characterize the undefined cattle and buffalo populations in the next 6 years. FAO also predicted about 275 livestock breeds in the country. There is one breed per million animals in the world against one breed per 3.5 million livestock population in India (0.28 breed/million), which is much lower than world average. At present total non-descript livestock population in India is 54%; of the species wise population 60% cattle, 45% buffaloes, 38% sheep, 62% goats and 73% pigs are not covered under any breed status.

Programs for germplasm exploration and characterization are limited in South and West Asia regions due to lack of government sensitivity and people awareness, financial constraints, inadequate infrastructure and technical knowhow in most of the countries. Most of the countries do not have proper inventorization process. In South Asia, India has developed proper inventorization of germplasm and has an established setup to register new indigenous breeds in the region, although it is not adequately covering the whole of the population as more than half of the livestock population is not described yet (DAHDF, India). Only a few countries have created databases and developed information system for the AnGR. However, it is also not properly interlinked with different agencies within the country as well as among the countries in the region.

Conservation of underutilized populations is also being conducted through government programs with limited financial funding. There is almost no funding from the private sector in this region.

Processing, value addition and product development

Underutilized AnGR of these two important regions of Asia have great scope for the presence of unique bio-molecules of therapeutic importance as these genetic resources have evolved in a particular production system over thousands of years. Presence of such unique genetic property will make them ideal model for processing and value addition to their products. There is a good potential for tapping these resources for milk, meat, manure and egg to improve the production as well as profitability of those who keep them.

Challenges and opportunities

Declining population of most of the native animals is a major concern in the Asian sub-regions. In South Asia, population of most of the species has declined due to decreasing utility of conventional breeds. Besides, pressure of enhanced production has also caused the replacement of native population by high yielding breeds. This phenomenon is much more prominent in the Indian sub-continent, where about 20% of cattle has been converted into crossbreds. In the coming future, there are impending threats and challenges of climate change, water scarcity, increased disease incidences, increased food and land competition, and land and habitat degradation. In most of the regions, established production systems for endemic population has been altered substantially. Minor species available in specific regions were important to create biological and production homeostasis, but due to change in their utilization pattern whole of the production system is affected.

Asia has emerged as potential market for animal food, although the consumption of animal products is still low in the region as compared to European and other developed countries. With growing food demand, there is now concern over increased production of animal-based food as well as its quality. Underutilized species and populations have the potential for producing a variety of food, thereby decreasing the pressure on a few species or breeds. Generally, underutilized species are well harmonized with local niche and production system; therefore, they do not put any stress to the local habitat. Moreover, most of the underutilized species are reared by the marginal farmers or poor people in a very stable geo-climatic region, therefore, the production of the animal food from underutilized species can be increased.

The most impending challenge that the world faces today is that we have to feed about 8 billion people for which a large part of food has to originate from animals. Even in some parts of developing countries, about 20-25% of food basket has animal component. Though, meat consumption is low in South Asia, but due to changing food pattern and enhanced purchasing power, the meat-based food demand would increase enormously. Signs of milk production and consumption are already good in the region. However, the dependence on milk will increase multi-fold because of large population (about 20% of global population) and high birth rate. In West Asia, challenge to feed the population with food of animal origin is much more severe because of low population and low growth rate. The demand of meat and milk will increase in the region, although quality and variety of animal foods may be of concern in the West Asia.

At present, cattle and buffalo are the major species for milk in South Asia, whereas cattle are the only source of milk in West Asia region. India and Pakistan are the two major milk producing countries, where almost half of the milk is produced by buffaloes. However, there are other dairy animals like goat, sheep, camel and yak which have been underutilized for milk production in the South Asia. For meat, major dependence remains on cattle, buffalo, sheep, goat, pig and chicken species. Number of species involved in animal food production seems to be less, as far as impending challenges of climate change and increased diseases are concerned. The diversity or genetic base of the species involved in production is also very low and even decreasing in time to come. In both West and South Asia, there are religious restrictions for culling of certain species, which restricts selection process and limits the selection intensity.

South Asia, which is a hot spot for AnGR diversity, is more vulnerable for genetic erosion. Almost 20 to 30% of the breeds of domesticated animals are under threat in the region. Populations of species like camel, horse, donkey, yak and mithun are shrinking continuously and a threat of extinction is impending in most of the South Asia countries.

Marketing, commercialization and trade

Marketing and trade of animal products is low in South Asian countries as compared to West Asia, despite, being an important driver of change of animal dynamics in the region. Most of the trade is carried out for the dairy and meat products. South Asia has very large domestic market for the dairy, meat and eggs, and most of the commercial activities are regulated by unorganized sectors. However, in recent time, large commercial animal farms have also been established in India, Pakistan, Sri Lanka and Bangladesh which are contributing to local and foreign markets. Meat in raw form from South Asia, specifically from India, Pakistan and Bangladesh, is exported to West Asia, South-East Asia, Africa and South American countries. But because of sanitary conditions and presence of residues, the animal products from South Asia also face challenges for export to developed countries. South Asia also faces greater restriction of live animal and other germplasm movement across the countries. Though the region is a big internal market for animal products, but there is a need for flexibility of trade rules for germplasm movement at international level.

Strategies adopted to harness their potential

South Asia is a reservoir of many animal species, which are adapted to local climate and optimized to their production systems. These species would also have future potential for the production of animal food. The region occupies a unique position about the diversity of native farm animal population. Efforts are being carried out to harness the potential of underutilized animal genetic resources by exploring their genetic potentials. In Indian subcontinent, all major and minor species are being researched separately for improving these local species and making them more utilizable.

Major focus areas

Globally, production of diversified animal-based food is the main focus area specifically with the concern of climate change. Livestock diversity is important for the sustainable production of all three animal foods – meat, milk and egg. There is moderate change in demand for livestock products in terms of quantity and quality. Demand for all animal foods - milk, meat and egg has increased in view of burgeoning human population, increased purchasing power and increased awareness for requirement of animal-based products. The trend is more prominent during last 3-4 decades, when a change of utility pattern of major species of AnGR has been observed. The utility of AnGR for food is likely to increase with a shift towards production of more milk and meat. Increased purchasing power has also resulted in demand of quality products, e.g., A2 type milk.

Table 7: Important traits in underutilized farm animal species

Native species	Potential region	Potential trait for utility
Cattle	South Asia	Heat tolerance, disease and tick resistance, draft power
Buffalo	South Asia	Milk and meat quality
Sheep	South & West Asia	Coarse carpet, worm and disease resistance, migration ability, meat quality
Goat	South & West Asia	Meat and milk quality, prolificacy
Camel	South & West Asia	Milk, thermo-tolerance
Horse & donkey	South & West Asia	Draft power and transportation, high endurance
Mithun	South Asia	Meat quality, thermo-tolerance
Pig	South Asia	Meat quality, prolificacy, disease resistance
Duck and goose	South Asia	Meat quality, disease resistance
Rabbit	South & West Asia	Meat quality

Characterization and inventorization of underutilized AnGR of minor species should be a priority of the region. Despite having specific utility in production system, a large population of underutilized animal genetic resources in South and West Asia has not yet been characterized. Because of unknown status, some of the specialized population of these species are at risk of extinction. Therefore, it should be a priority to explore and characterize such germplasms in these two regions, especially in South Asia.

Infrastructure, capacity building and financial investment

South Asia is having poor to moderate infrastructure and technical manpower for AnGR management. Financial investment is also limited in most of the region.

Case studies for improvement of health and livelihood

Camel milk in India

Camel is generally utilized for transportation and drought purposes in desert and arid areas. Camel milk and meat also provide nutritional support to the rural people of some parts of the region. Camel milk is comparatively low in fat and protein content, however, ratio of b-casein to k-casein is considerably higher. There are reports on antibacterial and other therapeutic properties of camel milk. Recently, camel milk evaluation is under progress for anti-diabetic, anti-cancerous and other medicinal properties. Therefore, value addition and evaluation of camel milk for its therapeutic values and exploitation as functional food should be a top priority. Milk production from camel has tremendous opportunity. Recently, demand of camel milk has increased in Rajasthan and Gujarat states of India. Milk production may be envisaged as an emerging opportunity to make camels more utilizable livestock. In Kachcha region of Gujarat, camel breeders have formulated an association for popularizing and marketing camel milk and milk products. The world's largest milk cooperative, AMUL, has also initiated production of various dairy products of camel milk.

Donkeys in Pakistan

Recently, donkey's utility for transport purpose has increased in Pakistan, causing a large population growth in the country. Donkey, which is generally used for transport and agricultural works also has medicinal value in its produces. Milk, meat and skin are highly specialized products and used for preparation of various medicines. Presently, donkey population is above 10 million, which is third highest in the world. Pakistan has initiated donkey development program and is planning to establish a number of commercial breeding farms to increase the donkey population in the North-Eastern region of the country. The country will export about 80,000 donkeys to China during first three years. The donkeys will be used for different purposes as well as selling to neighbour countries for skin and hide. The project would improve socio-economic status of donkey rearing communities in the region (https://www.presstv.com/DetailFr/2019/02/02/587503/).

Future thrusts

Large genetic base of agricultural biodiversity including underutilized AnGR can be exploited for sustainable food production and sustained livelihood to the people of South as well as West Asia. Diversification of the animal species in the region and diversification of specific populations of a species will significantly increase the food security as well as healthy nutrition. Specialized and value-added diet from underutilized genetic resources can reduce the risk of malnutrition, by compensating essential nutrients requirement in a larger perspective. Involvement of private sector is much required in animal husbandry such as conservation and protection of underutilized populations and management of ecosystem of these populations are also a concern, which need to be addressed in the future.

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Status of Underutilized Animal Genetic Resources for Food and Agriculture in Southeast Asia

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Introduction

Agriculture is viewed as the backbone of the economy of many developing countries in which, livestock is a major contributor to its output. Diversified utilization of livestock contributes roughly 10-50% of the gross domestic product (GDP) (Belew et al., 2016) in most of these countries (CIA World Fact Book, 2019). In 2018, the livestock (includes poultry) industry of the Philippines contributed 33.92% of the gross value added (GVA) in agriculture. The contribution of agriculture to the country's GDP in the same year was estimated at 8.5% (Saili et al., 2017). In Malaysia, the contribution of livestock represents 11.4% of its GVA in agriculture in 2018 (Department of Statistics Malaysia, 2019). Figure 1 illustrates the relative contribution of agriculture to the GDP of Southeast Asian countries (CIA World Fact Book, 2019). These figures suggest the importance of livestock production particularly in developing countries.

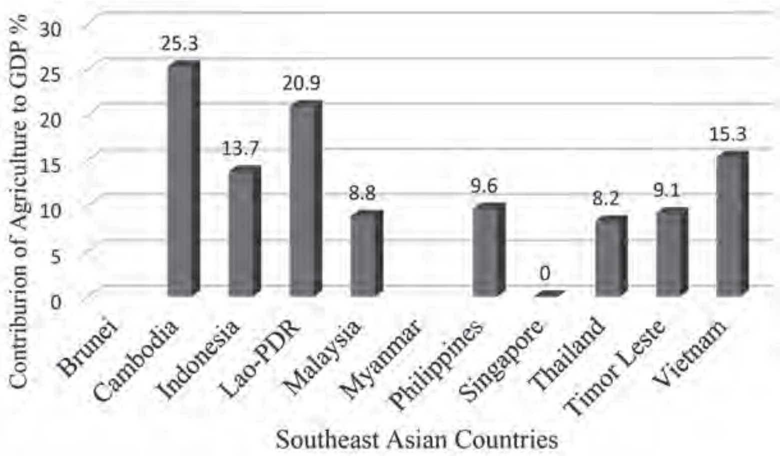

Figure 1. Contribution of agriculture to GDP of SEA countries

In developing countries, production of livestock is categorized as commercial or smallholder (referred to as backyard in some countries) based on the scale of operation and/or the system of production implemented in the farm (Duangjinda, 2018). Commercial livestock production is characterized by the use of exotic hybrid animals, adoption of high-end technologies and elaborate systems in farm management (Belew et al., 2016), use of high quality feeds and other inputs, sophisticated animal housing facilities and organized input supply and output marketing systems to achieve high productivity, production efficiency, product quality and most importantly profitability. Commercial livestock production is certainly capital intensive both in terms of financial and non-cash resources (Belew et al., 2016).

On the other hand, smallholder or backyard animal production utilizes production inputs that are mostly available in the locality (Chaweewon, 2018; Monleon, 2017). These include feeds and materials for housing and confinement of the animals. High utilization of indigenous production technologies (Charoensook, 2018) and simple management practices are commonly seen in smallholder production systems (Lee et al., 2010). Input supply and product marketing and distribution is simple and is often unorganized (Hoang et al., 2017).

Contrary to commercial livestock production, financial and technical requirements of smallholder animal production system is low (Philippines Statistics Authority, 2019). However, it is also viewed as inefficient and less productive (Belew et al., 2016). It is worth noticing that more than 50% of livestock production in developing countries are in smallholder system of production (Lee et al., 2010; Philippines Statistics Authority, 2019; Monleon et al., 2010). It is also in this production system that indigenous or native animal resources are commonly used. In the context of animal production, domesticated native animals are considered the underutilized animal genetic resources (AnGR) in the region. Incidentally, native animals are common features of small rural farm landscapes and are providing economic and socio-cultural services to financially challenged farmers (Belew et al., 2016; Lee et al., 2010). AnGR comprises all animal species, breeds and strains that have economic, scientific and socio-cultural value to man in terms of food and agricultural production for the present and the future (Belew et al., 2016).

Economic and socio-cultural importance of native animals

Within the context of the Philippine Native Animals Development (PNAD) program, native animal is defined as a product of indiscriminate crossbreeding between domesticated stocks that descended from the wild and introduced exotic breeds that are introduced into the country a long time ago. Native animals are able to survive and reproduce under natural environments with no known infusion of exotic blood during the past 10 generations. Through a long process of natural selection these animals develop unique characteristics and behavioral patterns that enhance their fitness to the natural environment (Monleon, 2017; Narvaez, 2016).

Raising of native animals is among the age-old animal production activities of smallholder farmers in developing countries (Belew et al., 2016; Lee et al., 2010). More often than not, these animals are raised under marginalized farming conditions (Bett et al., 2014; Philippines Statistics Authority, 2019) with minimal management intervention. Traditionally, depending on the species, these animals are let loose in the field to fend for themselves (Philippines Statistics Authority, 2019). They feed on naturally occurring materials that are available in their ranging areas. Native animals are able to digest and utilize nutrients from low quality feed materials that are almost of no value to commercial hybrid animals (Lee et al., 2010). They are also resilient to extremes of weather. Although, their absolute productivity is generally low (Belew et al., 2016; Salces et al., 2015) but they produce products that are preferred and paid premium prices by consumers (Duangjinda, 2018; Hoang et al., 2017; Lee et al., 2010; Molee, 2018). These are the likely reasons why they remain to be an integral part of a small farming scenario. Despite the aggressive promotion of intensive and technology-driven commercial hybrid animal production systems by both government and big private corporations, smallholder farmers continue to raise native animal resources (Lee et al., 2010). However, a declining trend in native animal inventory is already observed. More than 50% of the genetic diversity of ancestral breeds are lost in commercially produced breeds today (Duangjinda, 2018). Nonetheless, they continue to exist and to provide benefits to smallholder farmers and make significant contributions to the rural economy (Belew et al., 2016; Lee et al., 2010; Philippines Statistics Authority, 2019).

In traditional smallholder production systems where a few heads of different animal species are raised, the economic and socio-cultural value of these animals is based on the products and services that they provide to rural farming communities. Among these are: (1) as source of high quality protein food to rural farming families, (2) as source of additional income, (3) provide insurance during urgent need for cash, (4) serve as financial buffer during failure in crop production (Baguio and Capitan, 2008; Bett el al., 2014), (5) provide draft power (depending on species), (6) serve as gifts to friends and relatives and (7) as offering during rituals and cultural ceremonies (Falvey, 1982) . Moreover, in the Philippines native animals also provide raw materials for the production of animal product-based ethnic delicacies, i.e., "lechon" (roasted whole pig) and "balut" (boiled embryonated duck egg). Through these functions the native animals are also supporting the tourism industry up to a certain extent.

Considering that production of native animals is largely marginal, distribution and consumption of its products is limited to the area where they are produced. To some extent, marketing and utilization of native animals' products would cover different cities and provinces within the country (Hoang et al., 2017; Monleon et al., 2010; Narvaez, 2016). Export of these native animals and/or their products is negligible, if ever there is.

Status of native animal genetic resources

Animal genetic resources comprise all animal species, breeds and strains that have economic, scientific and cultural value to mankind in terms of food and agricultural production for the present and the future (Belew et al., 2016). Literatures reviewed for this report suggest that AnGR diversity in the Southeast Asian region is still rich. Several breeds of native chickens have been reported and evaluated in Cambodia (Taniguchi, 2018), Indonesia (Hidayat et al., 2016; Salces et al., 2015), Lao-PDR (Bouahom et al., undated , the Philippines (Narvaez, 2016; Sari et al., 2017; Santiago, 2017), Thailand (Aphirak et al., 2012; Charoensook, 2018; Chaweewon, 2018; Duangjinda, 2018; Molee, 2018; Seng, 2017) and Vietnam (Doan et al., 2017a, 2017b; Nguyen et al., 2017; Nguyen T.P., 2017; Nguyen T.X., 2017; Nishibori et al., 2018). Similarly, a number of native pig breeds from these countries were also reported (Bondoc et al., 2017; Chaweewon, 2018; Herold et al., 2010; Monleon et al., 2010). Japan has also reported an extensive genetic characterization work on native chickens and pigs (Nunome et al., 2018). The number of reports suggested that chickens and pigs are the most popular in the Southeast Asian region. However, reports also indicated the presence of several breeds of native ducks (Doan et al., 2017a, 2017b; Nguyen T.N.M., 2017; Sari et al., 2017), cattle (Doydora et al., 2014; Monnen, 2018; Valdez et al., 2017), buffalo (Flores, 2017; Sawasdee et al., 2015) and goat (Narvaez, 2016). Moreover, models for effective conservation of genetic resources were also developed (Phangsavanh et al., 2011). However, statistics on the inventory and production of these native animal resources are either difficult to access or not available at all. Perhaps due to the marginal status of native animal production in national livestock industries (Monleon et al., 2010; Philippines Statistics Authority, 2011) and due to its minimal monetary contribution to the GDP of developing countries (Belew et al., 2016), monitoring of the inventory, and volume and value of production is perceived as immaterial by policy and economic planners. In addition,

Photograph 1: Native pigs of Asia

the lack of a functional data database that is available to native animal stakeholders can also be cited as among the barriers to the access of information (Estrella, 2017). Nonetheless, these important but underutilized AnGR are still being kept and are continuously providing various economic (Duangjinda, 2018; Taniguchi, 2018) and socio-cultural benefits to rural communities (Falvey, 1982; Kagami, 2018).

R&D projects to characterize the phenotypic and genetic traits of underutilized AnGRs are implemented by many countries in Asia (Charoensook, 2018; Duangjinda, 2018; Kagami, 2018; Molee, 2018; Nunome, 2018; Phensavanh, 2011). Substantial information on genetic potentials and unique characteristics of these AnGRs, which are vital in developing sustainable conservation and profitable utilization strategies are being generated (Lee et al., 2010). Technologies and systems to hasten their improvement and commercial utilization are also being developed (Duangjinda, 2018; Molee, 2018; Sari et al., 2017). However, access of these information and technologies by animal raisers and industry players remains limited (Ayalew et al., undated; Belew et al., 2016; Estrella, 2017).

Photograph 2. Pateros ducks of The Philippines

Challenges and opportunities

The current trend of shifting consumer preferences towards: (1) organically or naturally produced food products, (2) animal products with unique taste, texture and flavor that contain higher values of functional nutrients and (3) consumer awareness on food safety (particularly on the ill effects of antibiotic residues) opens an opportunity for the conservation and profitable utilization of native animals (Duangjinda, 2018; Molee, 2018). Moreover, increasing concern on animal welfare and environmental protection (Duangjinda, 2018) seem to favour native animal production.

However, the unpredictability of production performance and inconsistent product quality of native animals (which are generally mongrels) pose as a major barrier to their commercial production. Moreover, unstable supply (often unavailability) of native animal breeder stocks is a major deterrent to its commercial production and utilization (Lee et al., 2010). Although, native animals are endowed with genes that make them more tolerant to extremes of weather (Lola et al., 2016) and disease challenges (Vasupen et al., 2008) but emergence of new diseases and more irregular and extreme climatic perturbations are real threats to commercial native animal production (Philippines Statistics Authority, 2011). Native animals are raised on range to comply with the animal welfare requirements and to save farmers from high costs of housing and feeds. However, range management systems would expose the animals more to potential disease vectors and inclement weather conditions.

The challenge, therefore, is to develop a breeding program that would produce native animals that are uniform in phenotypic characteristics, predictable in production performance and consistent in product quality while maintaining their relative tolerance to disease (Vasupen et al., 2008), and resilience to unfavorable climatic conditions (Duangjinda, 2018; Lola et al., 2016). Other important traits of native animals that need to be conserved are their ability to utilize low quality feeds and the higher concentration of functional nutrients (Lee et al., 2010) in their products, in addition to taste and flavour. Native animals possess unique traits that are used for purposes other than food (Charoensook, 2018). Moreover, they may also serve as repository genes that might be of high importance in the future (Nunome et al., 2018). Theoretically, breeding for too many traits slows down the rate of genetic improvement. However, with the availability of molecular methods of breeding and selection, improvement of specific traits is expected to be faster than the traditional breeding.

Marketing, commercialization and trade

Commercialization and efficient marketing of native animals and their products are drivers of sustainable native animal conservation and profitable utilization. The current state of native animal production in most countries of the region does not support large scale commercialization and marketing. The unstable volume of production and inconsistent quality of products from native animals (Gulland and Clayton, 2002) limits the distribution of these products to bigger and wider markets. However, indicators and important elements of successful commercialization of native animals and their products are becoming apparent. Among these are the development of native animal breeds and/or lines that show higher production performance with uniformity in physical characteristics, predictability in production performance and consistent product quality (Duangjinda, 2018; Molee, 2018; Narvaez, 2016; Sari et al., 2017). Moreover, technologies and systems that support sustainable production of these animal resources are being developed and are continuously being improved. In addition, the introduction of the breed-brand concept to native animal products (Duangjinda, 2018) is expected to facilitate promotion to widen markets and achieve the desired marketing efficiency.

Strategies to harness the potentials native animals

Native animal genetic resources are recognized to possess traits that allow them to survive and reproduce even in marginal farm conditions. Compared to commercial hybrid animals, the production performance of native animals is generally low. But their products are known to have unique taste, texture and flavor that are preferred and paid premium prices by consumers. Therefore, to harness these potentials, an organized breeding program to create significant improvement on the productivity of these AnGRs while keeping in mind the conservation of traits that are associated to their adaptability to the natural environment and to the quality of their products. New technologies in molecular breeding and selection, assisted reproduction (Nishibori et al., 2018) and genetic material conservation (Baguio and Capitan, 2008; Tongsima, 2019), would fit well into the strategies and actions leading towards translating the AnGR's potentials into economic gains. Moreover, active participation of private industry players (Duangjinda, 2018; Sari et al., 2017) in the development and implementation of programs and projects to enhance the performance of native animals should be encouraged to facilitate adoption and commercialization of R&D outputs.

Focus of development areas

As most of the current concerns on native animal production and utilization are linked to their genetic quality, development efforts should be focused on selection and breeding to develop breeds and/or lines that are responsive to both the producers' and consumers' needs. Alongside with breed development, programs to develop technologies and systems pertaining to feeding, disease prevention and control and farm production management should also be implemented. In support of production, branding of native animal products should also be considered in development programs to facilitate promotion and marketing, thereby ensuring adequate income for the farmers. Processing and packaging to add value to native animal products should also be pursued in line with branding and marketing.

Infrastructure, capacity building and financial investment

At the current state, expertise on breeding and genetics, which are critical in the development and implementation of sustainable breed development and/or genetic improvement programs is still wanting (Belew et al., 2016). Most of the researchers implementing breeding and genetics R&D projects are connected with universities and government R&D institutions that have limited contact with industry players. Thus, the risk of generating information or developing technologies that are less responsive to needs of industry is high.

Fund limitation also poses as major barrier to many developing countries to invest in infrastructure and facilities necessary in the implementation high-impact R&D in native animal improvement, production and profitable utilization.

Future thrusts

Considering the economic and socio-cultural importance of native animal resources both for the present and the future, focused and deliberate efforts to conserve and utilize these resources have to be put in place. Future native animal development programs should be in the following areas:

1. Breeding and selection to enhance the productivity of native animals while keeping traits that enhance their fitness to the environment and their ability to produce products with unique attributes.
2. Develop feeding, healthcare and management protocols that are appropriate for native animals and for small farm conditions.
3. Pursue branding of native animal products.
4. Develop processing and marketing strategies to optimize income from native animals.
5. Pursue capability building both for human resources and facilities.

Conclusions

Native animals are considered as the underutilized animal genetic resources in the Southeast Asian region. These animal resources possess unique characteristics and behavioral patterns that enhance their ability to survive and reproduce under marginal farm conditions even with minimal management interventions. These characteristics fit them well with the small rural farm scenario and with the limited capacities and capabilities of financially-challenged farmers in developing countries. Native animals also produce products with unique taste, texture and flavor that are preferred and paid premium prices by consumers.

These AnGR are providing various economic and socio-cultural products and services to rural farming families and communities. Therefore, efforts to conserve, improve and profitably utilize these animal resources have to be pursued. New technologies and protocols to hasten genetic improvement are available and are continuously being improved. However, utilization of these technologies would require adequately trained human resources facilities and financial investments. Effective and efficient marketing of native animal products is also necessary to ensure income from these animal resources and sustain conservation activities. Hence, future activities and R&D investments should be focused on these areas if the potentials of AnGR are to be translated into economic gains.

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Status of Underutilized Animal Genetic Resources in East Asia

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Introduction

Livestock and poultry breeds are an important part of the biological genetic resources. They are renewable or changeable, and are influenced by the natural ecological environments and by social development. Having been subjected for long historical periods to varied environments, the survivors of the original local animal and poultry breeds have acquired many excellent characteristics. They are not only well adapted to their own local environments, enduring to extensive management and resistant to diseases, but also have acquired the properties of early maturity, high meat and hair production, high milk production, good reproductive performance and meat quality, all of which are of great economic importance. Doubtless, these genetic resources are of great significance both to mankind and nature.

East Asia is at the forefront of global trends of increasing livestock demand and production (Pingali and McCullough, 2010). A global "revolution" in demand for animal-based products has been predicted (Delgado et al., 1999). As wealth increases, especially in less developed countries, the annual consumption of animal products is predicted to rise in 2020 to 303 million metric tons (mmt) of meat and 654 mmt of milk. This is an increase from levels of 168 and 391 mmt in 1993, respectively. In East Asia, the livestock sector is experiencing consistent growth. The annual growth of meat consumption is 3% for China and 2.4% for other East Asian countries. Growth levels for milk are predicted to be 2.8 and 1.7%, respectively. This growth in consumption creates great opportunity for livestock sector development in the countries of the East Asia.

China is one of the countries that have the richest animal and poultry breed resources as a gene pool in the world. The genetic diversification of domestic animal species in China, especially the excellent germplasm characteristics of native breeds, was left over by our ancestors under several thousand years' diversification in natural and ecological environment. These native breeds played an important role in history, for example, Chinese native pig breeds were introduced to Rome as early as 2,000 years ago, Chinese Langshan Chicken were introduced to the United Kingdom in 1970s. More than 30 Chinese superior domestic animal and poultry breeds such as Beijing duck, Meishan pig, Guanzhong donkey, and Qinchuan cattle have been exported to some countries in Asia, Europe, America and Oceania. These native breeds exert a profound influence on the development of the genetic diversification of domestic animal and poultry breeds and animal industry throughout the world. They are essential raw materials in developing new bio-types and new breeds and will be contributing to the sustainable development of animal production in the future.

Japan is located between longitudes 123° and 149° east and latitudes 24° and 46° north. Situated in East Asia, the country is made up of a group of islands surrounded by the Pacific Ocean to the east and the Japan Sea to the west, extending far longer in the south-north direction than in the east-west direction. It has a natural land area of 378,000 sq km. The climate differs greatly between the southern and northern regions; some regions belong to the subarctic zone while others are subtropical. Rice cropping is the mainstream agricultural practice in Japanese agriculture, though the form of cultivation varies from region to region.

Livestock and poultry species sanctioned by the Taiwan government include pig, dairy cow, sheep, horse, rabbit, chicken, duck, goose and turkey (Council of Agriculture, Taiwan, 2017). Other major poultry raised by local farmers include quail and ostrich yet to receive government sanction. Due to high land prices and rising environmental awareness, most local farmers operate on a small scale in rural areas of Central and Southern Taiwan. Coupled with import-dependent feeds and expensive labour, the local livestock industry operates at a rather high production cost. Fortunately, local livestock farmers are highly diligent, and have advanced feeding and breeding skills. As a result, domestic livestock products such as pork not only meet domestic demand but also supply foreign markets. Since the outbreak of the Food-and-Mouth Disease (FMD), however, government policy priorities have been shifted to the domestic market, reducing livestock export to a role of balancing production surpluses. Despite the challenges, livestock farmers and the government have been working closely throughout the years to readjust the structure of the industry and to modernize its production and marketing. Such efforts have seen fruitful results, particularly over the past three years. Therefore, it is expected that the overall livestock industry in Taiwan will maintain its edge in the face of global competition.

Given the high population density in Korea, the destruction of habitats caused by development and industrialization is the primary threat resulting in biodiversity loss (CBD, undated). The need for sustainable development for shelter and social advancement is extremely crucial. Although various environment conservation programs have been carried out nationally, there still prevail the conflicts between conservationists and those in favor of continuing economic development. Strengthening environment policies such as environmental impact assessment and discharge system for pollutants in order to minimize the effects on natural habitats, and promoting the integrated national plans for the restoration of ecosystems will be essential. Agriculture and fishery, which have extremely high level of dependence on the ecosystem, require special measures to protect biological diversity. Environmental changes due to the loss of species and reduction of genetic diversity can bring catastrophic results. Due to degradation of traditional agriculture, the destruction of habitats and excessive inshore and coastal fishing, biodiversity essential for human livelihood has been threatened. The food security and sustainable use of biological resources must be executed through safe use of biodiversity, and excessive harvesting and over-fishing practice must be refrained.

Importance of livestock in economy and food security of the sub-region

An analysis of livestock production shows dramatic increases throughout the region over the past 15-20 years. Demand for and production of livestock products in East Asia has been increasing significantly over the past 20 years and this trend will continue. This growth is in almost all types of livestock, although variation is significant. Sheep and beef have not been an overall large source of growth, while pigs, eggs, poultry and milk (dairy sector) have all been significant sources of growth. Trade has not been a significant source of overall growth for the livestock sector, with most products produced domestically being consumed domestically and relatively small overall imports. Predictions of livestock product consumption indicate that domestic demand can largely absorb any further production increases.

We must pay serious attention to the fact that local livestock breeds and varieties are now being improved through cross-breeding and substituted by some “specialized” high yielding breeds. Livestock and poultry breed resources are diminishing drastically at present in the developed countries, causing the reduction or even exhaustion of genetic resources and placing an alarming situation before mankind. We must take emergency measures in a planned way to protect the indigenous livestock and poultry breeds, especially those resources of great significance. Ill-considered methods of protection or preservation and improper utilization could cause the exhaustion or complete extinction of these resources and irretrievable loss (FAO, 2018).

Taiwan

Under the influence of maritime climate, the subtropical island of Taiwan features high temperatures and humidity. Despite adverse environmental factors, domestic animals including livestock and poultry grow well. As a result of continuous economic development and improved living standards in recent years, the demand for animal protein in the daily diet of local citizens has increased sharply, making animal husbandry one of the most prominent industries in local farming villages (Lee, 2000).

Production and consumption

With Taiwan’s entering the World Trade Organization (WTO), livestock products are bound to suffer tremendous pressure under global competition. Major challenges for production and consumption facing include:

1. As certain types of meats in Taiwan have long enjoyed a price advantage over imports, it will take time for us to adjust to new market parameters for domestic livestock products. For example, the imported drumsticks, chicken wings and pork bellies, which cost little in the U.S., could be sold at a much higher price here, while the chest meat and other pork cuts are on the reverse. The opening up of the domestic market to foreign imports therefore will prompt the prices of the whole hogs and chickens to drop and result in serious losses to the local farmers.
2. Taiwan’s livestock farms remain largely small in scale and large in number; therefore, to compete with multi-national enterprises, further consolidation is required.
3. Because Taiwan is surrounded by oceans and has long coastal lines, smuggling is difficult to curb, which poses a risk of the invasion of exotic diseases. Local farmers hence have no complete control over the safety of the animals they raise.
4. The limited availability of pastoral land has resulted in heavily concentrated livestock farming in Taiwan. The vast amount of solid waste thus generated poses yet another difficulty for farm operators.
5. With consumers’ product safety awareness on the rise, effective elimination of residual hazardous substances in food has become a pressing need.
6. Given the growing awareness of animal welfare, highly concentrated animal breeding will no longer be acceptable. However, renovation of animal houses involves new investment and will increase the production cost.

China

According to “Animal Genetic Resources in China and Asia” (Wu, 1998) by1996, the livestock and poultry genetic resources in China mainly include the following 12 species: pig, yellow cattle, yak, water buffalo, sheep, goat, horse, donkey, chicken, duck, goose, special fowl, totaling 282 breeds (Table 1, the figure obtained from “Animal and Poultry Breeds in China” in 1986, not including other breeds from provinces of the country), of which, there are 194 native breeds (accounting for 68.8%), 45 developed breeds (accounting for 16.0%) and 43 introduced exotic breeds (accounting for 15.2%).

China has a large livestock population, with pigs and poultry being the most common. China’s pig population and pork production mainly lie along the Yangtze River. In 2011, Sichuan province had 51 million pigs (11% of China’s total supply). In rural western China, sheep, goats, and camels are raised by nomadic herders. In Tibet, yaks are raised as a source of food, fuel, and shelter (Number of Livestock.stats.gov.cn). Cattle, water buffalo, horses, mules, and donkeys are also raised in China, and dairy has recently been encouraged by the government, even though approximately 92.3% of the adult population is affected by some level of lactose intolerance.

Table 1. Status of China’s animal and poultry genetic resources*

Species	Original native breeds	Developed breeds	Introduced exotic breeds	Total
Pig	48	12	6	66
Yellow cattle	28	4	7	39
Yak	5	0	0	5
Water buffalo	1	0	0	1
Sheep	15	7	8	30
Goat	20	2	1	23
Horse	15	11	7	33
Donkey	10	0	0	10
Chicken	27	9	11	47
Duck	12	0	2	14
Goose	13	0	0	13
Special fowl	0	0	1	1
Total	**194**	**45**	**43**	**282**
% in the total	**68.8**	**16.0**	**15.2**	**100.0**

*According to “Animal Genetic Resources in China and Asia”

Increased incomes and demand for meat, especially pork, have resulted in demand for improved breeds of livestock, mainly breeding stock imported particularly from the United States. Some of these breeds are adapted to factory farming. In China, with the development of a commodity economy in animal husbandry, the challenge faced by the local breeds has been increased. Large numbers of foreign breeds introduced from abroad for cross-breeding and improvement have caused a reduction in the number of breeds or species, making some of the breeds become endangered livestock.

Japan

Agricultural production in Japan is valued at 9.12 trillion yen, 72.3% of which is accounted for by field husbandry (CBD, undated). That is to say, 26.9% (2.45 trillion yen) of the value of total production is generated by livestock farming, which exceeds the figure for rice production (25.5%). The population of Japan is 127 million, with 47.06 million dwellings. Of these, the farming population totals 13.46 million people with 3.12 million dwellings, while households involved in livestock farming account for 160,000 dwellings. Agricultural households account for 10.6% of the population and 6.6% of all dwellings, while households involved in livestock farming account for 5% of these figures, which is equivalent to 0.7% of the total national figure. The self-sufficiency rate of animal products:

- **Beef cattle:** The percentage of Japanese Black in beef cattle breeds is increased after the import liberalization of beef started in 1991. As a result, the proportion of Japanese Black among beef breeds, which accounted for approximately 85% from around 1970 to 1991, rose to 93% in 1999, resulting in the sharp decrease in other breeds. In 2000, beef production amounted to 3.64 million tonnes and of which derived from breeds reared specifically for beef accounted for 1.67 million tonnes, with national self-sufficiency for beef being 33.5%.
- **Dairy cattle breeds:** Domestic milk production amounted to 8.41 million tonnes in 2000, with the imported volume in the form of dairy products amounting to 4.00 million tonnes on a fresh milk basis, 70% of which is cheese.
- **Pig:** Consumption of pork produced in Japan is currently 8.78 million tonnes and consumption of the imported pork amounts to 6.51 million tonnes, with a 57.4% rate of self-sufficiency.
- **Chicken:** Domestic production and self-sufficiency rate of chicken and eggs in 2000 were 1,195,000 tonnes (67.6%) and 2,540,000 tonnes (95.5%), respectively.

Livestock raising is a minor activity. Demand for beef rose in the 1900s, and farmers often shifted from dairy farming to production of high-quality (and high-cost) beef, such as Kobe beef. Throughout the 1980s, domestic beef production met over 2% of demand. In 1991, as a result of heavy pressure from the United States, Japan ended import quotas on potatoes as well as citrus fruit. Milk cows are numerous in Hokkaido, where 25% of farmers run dairies, but milk cows are also raised in Iwate, in T□hoku, and near Tokyo and Kobe. Beef cattle are mostly concentrated in western Honshu, and on Kyushu. Hogs, the oldest domesticated animals raised for food, are found everywhere. Pork is the most popular meat. Most of the imported beef comes from Australia, since beef from the USA and Canada was banned after the first cases of BSE in those countries. Those bans were lifted in 2006. In Japan, according to the information given by the preservation committee, only 2 breeds of cattle, 6 breeds of horse, 4 breeds of sheep and 17 breeds of chicken are on the endangered list (Nakatsuji, 2006).

Korea

In Korea, like other countries, ecosystem service has decreased due to the overuse of natural resources. The national efforts to evaluate and integrate the value of ecosystem service have been lacking, which generates the need to foster the industries related to ecosystem with high priority; supporting to make right decisions on investments based on evaluation of the right value of ecosystem service, improving the function of the environment regulating services in the urban areas of high population, and executing ecotourism by making good use of cultural service.

Status of AnGR

Taiwan

Livestock and poultry in Taiwan include pigs, cattle, water buffalo, goats, horses, rabbits, chickens, ducks, geese, and turkeys. Other major poultry raised by local farmers include quails and ostriches. Due to high land prices and rising environmental awareness, most local farmers operate on a small scale in rural areas of central and southern Taiwan. Coupled with import-dependent feeds and expensive labour, the local livestock industry operates with rather high production costs. Fortunately, local livestock farmers are highly diligent, and have advanced feeding and breeding skills.

China

China has a long history of livestock and poultry with rich gene resources. According to archaeological studies, the Chinese people had started animal domestication as early as the neolithic age or, say, ten thousand years ago. As a major source of livelihood, animal-raising was well developed about seven or eight thousand years ago. Since the livestock and poultry were raised under complex ecological conditions, and affected by different social economic situations for a rather long period of time, they had been artificially selected and raised for different purposes, so that different livestock and poultry breeds evolved with their own characteristics. Furthermore, some Chinese livestock and poultry breeds have had great influence on the evolution and development of some livestock and poultry breeds in foreign countries. Much attention has been paid to develop animal husbandry and the utilization of livestock and poultry resources. There are more than 300 domestic livestock and poultry breeds and strains, including 29 horse breeds, 20 ass breeds, 42 cattle breeds, 18 buffalo breeds, 5 yak breeds, 4 camel breeds, 35 sheep breeds, 37 goat breeds, 64 pig breeds, 72 chicken breeds, 30 duck breeds and 21 goose breeds (Number of Livestock, 2017).

The genetic resources of China's domestic animals have certain changes in 20 years. The population of 41.9% of native breeds has decreased by different extent. In1993, The Ministry of Agriculture (MOA) had confirmed 10 extinction breeds. In 1999, MOA had confirmed 7 extinction breeds, 11 critical breeds and 40 endangered breeds. There are many factors that are responsible for the population decline of domestic animal genetic resource. For example, the production performance of some native breeds could not meet the demand of current market as well as an inadequate recognition of the special characters of some native resources, therefore, the people introduced foreign exotic breeds to simply substitute or blind cross with native breeds for improvement. As such, it caused the quantity and homogeneity of the population decline of some native breeds or even caused crisis in some native breeds. Once a breed disappears, the loss would be invaluable. Therefore, it is essential to adopt powerful conservation measures for preservation of them, otherwise, a relatively big risk exists in the conservation of Chinese native animal and poultry breeds.

The domestic animal and poultry breeds of China have varied good performance characteristics such as meat output, milking, wool and cashmere production, egg production, draft, high reproduction, small body size, medicinal purpose and ornamental purpose, etc. Many breeds are well known in the world for producing traditional style products.

Characteristics of China's native domestic animal resources

- **Pig:** Most of the Chinese pig breeds are dual-purpose pigs. They are classified into large-, medium- and small-types. Jinhua Pig has the characteristics of thin skin, fine bone and tender pork. It is the raw material for making Jinhua hams. Gilts can be mated at the age of 3 months (body weight of 20 kg) with a litter size of 14.25 piglets per sow. Wuzhishan Pig has small body weight and good resistance, with a body weight of 35 kg for adult pig, lean meat percentage of 47.3% and litter size of 6-8. It can be used as laboratory materials for life science, nutrition science, birth control and comparative medicine. Tibetan Pig is suitable to be used for all-year-round grazing and has the characteristics of small body size, thin skin and high lean meat percentage with an average body weight of 40 kg for adult pigs. Rongchang Pig has the characteristics of good quality strong white coarse and long bristles with a length of 11-15 cm and a maximum length of 20 cm. The output of bristle is 250-300 g per pig. Taihu Pig has the characteristics of big litter size and quality pork, with a litter size of 14.9 piglets per sow. The pre-slaughter weight is 61.5 kg with a dressing percentage of 66.7%, lean meat percentage of 43.9%. It has good reputation for its high fecundity in the world.

- **Yellow Cattle:** Famous excellent native breeds include Qinchuan cattle, Luxi cattle, Nanyang cattle, Jinnan cattle and Yanbian cattle. Nanyang cattle and Yanbian cattle are located in the hilly regions, and the other three breeds are distributed in the plains. These native cattle breeds are high in confirmation and very strong with good draft capacity and fine meat performance. They are the basis for developing and cultivating China's beef cattle.
- **Water Buffalo:** China has a population of more than 20 million buffaloes. All of them belong to Swamp type, but they are divided into four categories. Some of them are produced in Jiangsu, Zhejiang and coastal regions, and are called Haizi water buffalo. Some of them are beach-lake buffaloes produced in Boyang Lake, Dongting Lake and Honghu Lake regions, with strong constitution, suitable for working in paddy fields in South China. Wenzhou Buffalo has good milking performance and high butter fat percentage.
- **Yak:** Yaks are produced in the high frigid region above the altitude over 3000 m in the Qinghai-Tibetan Plateau and has the characters of dual-purpose of milk and meat, pack transportation and producing hairs. It is very essential animal for herdsmen in Qinghai-Tibetan Plateau frigid pastoral region. It is not only a production means but also living means. The white yak, produced in Tianzhu Prefecture, Gansu Province, is a rare yak breed. According to statistics of 2001, China has a total population of more than 14 million yaks, accounting for 95% of the world yak population.
- **Sheep:** China have sheep breeds of wool purpose (carpet wool), meat purpose (coarse wool and fat tail), fur purpose and lamb skin purpose, of which, the Tibetan Sheep produced in Qinghai-Tibetan Plateau and the Hetian sheep from Xinjiang have the characters of long wool and good elasticity and belong to sheep breeds of quality carpet wool. Aletai sheep from Xinjiang has well-developed fat rump and the Tan sheep from Ningxia produces white fur coat after first shear, which is famous worldwide. In addition, the Black Fur sheep from Qinghai and Gansu, Hu sheep from Jiangsu and Zhejiang are famous breeds producing lambskin. Hu sheep and Small-Tail Han sheep have the characteristics of early maturity, multiple lambs and high fertility.
- **Goat:** The famous goat breeds include Zhongwei goat, Liaoning Cashmere goat, Jining Black goat, Inner Mongolia Cashmere goat, Chengdu Ma sheep. Zhongwei goat produces white fur coat after first shear with beautiful curl and evenly arranged wool. Liaoning Cashmere goat has the characters of high cashmere output with long cashmere. Qingshan goat from Jining has a hair coat of black and white mixture with a color of black, pink black or iron black, with quality black fine long wool and a productivity rate of 270% per lambing and two lambings per year. Chengdu Ma goat has milk production of more than 150 kg per lactation, with milk fat of 6.47%, dense wool, durable and can be divided in layer for use. The lambing percentage is 210% with two lambings per year.

- **Horse:** Chinese horses belong to dual-purpose type. Mongolian horse is high in speed during short distance. Kazak horse has good milking performance. Wuzhumuqin horse is dual-purpose for riding and drafting, adapted to hard conditions among the Mongolian horses. It is good in walking with strong forces and working sustainable. Hequ horse is suitable for working as a draft horse. Its draught force is equivalent to 80% of the body weight and sustainable. Yushu horse is adapted to plateau climate, and can walk freely in swamps, steep slopes, and narrow winding trails In Yunnan, Guizhou and Sichuan provinces as well as Baise Prefecture, Guangxi Zhuang Autonomous Region, most of the adult horses have a height of about 1 meter, and is called short horse. These horses have been used in developing urban tourism.
- **Donkey:** The famous donkey breeds include Guanzhong donkey, Dezhou donkey and Jiami donkey. Guanzhong donkey can be used as draft, ride and pack purposes. Male donkey has a draught force of 93.8% of the body weight while female donkey can be used in pack and riding purposes in mountainous roads.
- **Poultry:** Most of the poultry breeds belong to dual-purpose breeds. Of which, some breeds, such as Beijing You chicken and Huiyang chicken, have the characteristics of thin skin, fine bones, tender meat and good flavor, and can be used as broiler breeds. Beijing Duck is a large-size meat purpose duck famous in the world and can be used as the raw material for making "Beijing Roast Duck." Gaoyou duck can be used to make pressed salted duck, and is famous for its double yolk egg. China has many excellent native breeds of egg layers, Xianju chicken has an annual egg output of 200 with egg weight of 50 g; Shao duck has an annual egg output of 280-300 with egg weight of 60-65 g; and Huo goose has an annual egg output of 100-120 with an egg weight of 128 g. In addition, they also have Taihe Silk fowl, which is a precious breed being used as medicine. The Chinese Fighting fowl is used as ornamentals.

In the aspect of animal and poultry breed characteristic identification, in addition to conventional distribution, population, confirmation and production performance investigations, China has unfolded germplasm study of major native poultry breeds. The study has systematically measured the physiological and biochemical targets: meat quality, fat composition and carcass composition and studies on some other flavor related materials. In recent 10 years, related research institutions have conducted molecular level research on major animal and poultry genetic resources in China, and found some genetic labeling of major economic characters. For example, the genetic labeling includes the high fertility of Taihu pig, quality flavor of native chicken breeds, and high fertility of small-tailed Han s heep and microsatellite DNA genetic diversity on different breeds of animal species. This has provided scientific basis for the conservation, development and utilization of genetic resources.

Japan

Japan has relatively rich and varied livestock and poultry resources among the countries of East Asia. Breeds covered in livestock-related statistics and other native species and populations include 9 beef cattle breeds, 7 dairy cow breeds; 12 pig breeds (including wild boars and counting Kagoshima Black pig and Berkshire separately), 12 horse breeds and populations; 3 goat breeds and populations; 2 sheep breeds; one breed of rabbit, and 6 other mammal species. There are 38 chicken breeds and 6 other bird species, of which quail is the only animal species that has been domesticated in Japan. The exotic breeds and crossbreds play an important role in animal production. Lots of species and breeds of livestock and poultry have been introduced into Japan, but breeds other than major breeds of cattle, pigs and chickens have decreased in number and have not played an important role in animal production.

- **Cattle:** Since the Meiji era, exotic cattle breeds have been introduced and crossbreeding between Japanese cattle and exotic breeds have been promoted in most regions nationwide. As a result, there are only two cattle populations that escaped hybridization with exotic breeds, Mishima cattle, which have survived in Mishima Island off the coast of Hagi city in Yamaguchi Prefecture and Kuchinoshima cattle living on Kuchinoshima of the Tokara Islands in Kagoshima Prefecture. Cattle other than the above-mentioned populations are categorized into 4 breeds depending on the types of exotic cattle introduced into the region: Japanese Black, Japanese Brown, Japanese Shorthorn, and Japanese Polled which were developed through crossbreeding.
- **Pigs:** Before Japanese people began to eat pigs nationwide, a native pig called Shima-buta or Aguh existed in Kagoshima and Okinawa. At present Black pig (it is thought to be of Berkshire origin) has gained popularity as a special brand product in Kagoshima Prefecture. In the case of Aguh, almost all of native Aguh pigs disappeared due to ground fighting in Okinawa at the end of the World War II and the donation and introduction of exotic breeds having high productivity after the war. Given these circumstances, the collection and conservation of a few barely surviving individuals having a shape similar to the native Aguh was carried out. As a result, the population increased to 100, and the F_1 is now being marketed as a brand pig. Ohmini is being preserved by private businesses and the F_1 of Ohmini is being marketed as a laboratory animal.
- **Chickens:** The cutting off of Japan from outside contact in the Edo era (from 17th to the mid-19th century) had a significant impact on the establishment of the Japanese chicken as birds either for pets or cockfighting. The Japanese chicken as a chicken for practical use came about under the influence of exotic breeds introduced in the Meiji period. Since the liberalization of imports for breeding chickens in 1960, native chickens for practical use have fallen into a disastrous condition. Some native chickens are now being used to breed brand chickens. Brand chickens using native chickens are referred to as Jidori Japanese old style native), a name that helps consumers to differentiate this chicken from the others on offer. Chickens permitted to use the Jidori label are limited to chickens containing at least 50% of the blood of 41 native breeds designated by the Japan Chicken Association (38 native breeds according to JAS). The major native chicken breeds including these Japanese old-style natives are Rhode Island Red (44.8%), Nagoya (3.8%), Shamo, Hinaidori, Barred Plymouth Rock, and Satsumadori. These six breeds account for 58% of all native breeds.
- **Horses:** After World War II, farm horses that had been actively raised till then and native horses used for conveyance lost their roles, resulting in a corresponding decline in their numbers. In spite of this, 8 native populations comprising Hokkaido horse, Kiso horse, Noma horse, Tsushima horse, Misaki horse, Tokara horse, Miyako horse, and Yonaguni horse are left and all are protected by conservation groups.
- **Goats:** As native goats, there are Tokara goat and Shiba goat. The Japanese Saanen breed has been produced by successive crossbreeding with a native goat. The Shiba goat is bred as a laboratory animal in universities and research institutes. Its present status is "endangered-maintained." With regard to Tokara goat, 35 purebred individuals exist at Kagoshima University and Hirakawa Zoo. Toshima village, the birthplace of Tokara goat, has opened a goat farm. However, even here, there are only a few purebred individuals. The present status of Tokara goat is "critically-maintained."
- **Quail:** Quails are the only indigenous poultry species that have been domesticated in Japan. There are about 7.71 million quails being bred focusing on the use of eggs.

Korea

There are only a small number of livestock and poultry breeds native to the of Korea. They were low in productivity and have been improved by crossing with imported breeds. As the vulnerability of endangered species in Korea becoming an alarming issue, institutionalized protection and management are necessary. With the potential value of biodiversity in mind, an intensive level of care should be given to endemic species of Korea. According to the Red List of Korea, 27 mammals, 58 birds, 5 reptiles and amphibians, 27 fishes and 224 vascular plants are extinct or critically endangered, and the number of species needed to be protected is 2,177, which is 5.6% of total species in Korea. Since the number of critically endangered species are increasing due to catch, overhunting, poaching and loss of habitats, mid and long-term conservation plan for endangered species and marine organisms are strongly requested to be established at national level. Protection systems for endangered and legally protected species by relevant government agencies: Endangered species (249 species), rare plants (571 species), wildlife protected by local governments (305 species by municipal governments; Seoul 49, Daegu 47, Incheon 24, Gwangju 56, Daejeon 41, Ulsan 49, Gyeonggi 29, Chungbuk 10). The protection and management plan should be established on the basis of the surveys of endangered species periodically and endemic species annually, overcoming the extinction crisis and conserving biodiversity by in situ and ex situ conservation measures for critically endangered and endemic species.

Unique underutilized AnGR

In East Asia, Taiwan, Japan, and China are the countries that have carried out better and earlier the protection and preservation of livestock and poultry resources than other countries.

Taiwan

The existence of threats to AnGRs in developed countries due to globalization is generally accepted, and AnGR conservation is likely to be consistently undervalued. Native breeds generally maintain one or more adaptive characteristics to the living environment, which may provide useful or potentially useful genes or combinations of genes for future needs. Examples of useful genetic traits are prolificacy and early maturity of pigs, heat tolerance of Taiwan yellow cattle, disease-resistance of Formosan buffalo, roughage tolerance of native geese, and the meat flavor of native chickens. Furthermore, most native breeds of animals in Taiwan are still raised in grazing production systems. This was recognized at the 8th Board Meeting of the Advisors for Science and Technology - Agriculture Group in April 1986, which formally recommended that life resources be preserved so that their genes will not be forever lost due to concentration on limited and highly selected strains. Consequently, a large-scale pilot national project, “Germplasm Preservation and Utilization in Domestic Animals”, was initiated in 1987. There are three methods for preserving livestock germplasm: maintaining live populations, cryopreserving germ cells, and establishing DNA stores. Animal resources are bounteous and are preserved for improving exotic breeds in terms of future production performance and efficiency. Conservation and integration of germplasm for new variants were attempts to adequately use the gene pool in Taiwan since then.

Germplasm collection, characterization, evaluation, conservation and documentation

Protocols on conserving livestock germplasm are as follows:

1. Establishment of standards for visible characteristics of conserved breeds;
2. Collection of native animals from small farms;
3. Selection of places for conservation;
4. Propagation using a small population at random; if animals have economic traits for improving production performance of exotic breeds, then intercrossing programs are implemented;
5. Phenotypic measurements and data collection on animal growth, reproduction, living habits, and genetic polymorphism;
6. Preservation of germ cells with emphasis on semen and embryo cryopreservation; Information exchange of utilization and provision for public needs;
7. Typical animals after propagation with benefits of cooperative germplasm research being released to the private sector;
8. Promotion of public extension and education with intellectual property rights for this germplasm relative to arts and culture; and
9. Sharing the world's genetic diversity resources and turning potential into reality.

China

In China, many breeds of Chinese domesticated animals and poultry have various characteristics. For example, Yunnan Zebu cattle is well adapted to the tropical and subtropical climates in the south and resistant to external parasites; Erlunchun horse and Ming pig in the North-east are adapted to cold climate and severe environment in the north; Nanyang cattle and Luxi cattle are good for both meat and draught purposes and can be fed on roughage; Tibet range sheep, Liaoning cashmere goat and Inner Mongolia cashmere goat have good performance in producing cashmere wool; Jinding duck, Shao duck, and Gaoyou duck are excellent in egg production; Jianchang duck and Xupu duck are good for liver production; Chinese fighting cocks are for entertainment purposes.

The genetic resource preservation of domestic animals is a long-term, public welfare and social cause. First of all, the Chinese Government has actively given support by enlisting it into the development plan of national economy and social development, encourages enterprises and individuals to take part in the conservation and scientific development of animal genetic resources. Secondly, it is overall arranged and is responsible by governments at different levels. The central government and local governments should formulate perfect, practical plans for animal and poultry breed resources conservation and development. Thirdly, the conservation work is combined with development and utilization, with preservation as the major objective and combining conservation with utilization and promoting conservation by utilization. Fourthly, combination of traditional means with modern biotechnology, it is essential to bring into full play the roles of the conservation farms and conservation areas while unfold conservation work by making use of embryo, sperm, DNA and other modern conservation technologies and methods.

At present, the "Animal Husbandry Law" has integrated the conservation of animal and poultry genetic resources as an important content in the Law. It has concrete stipulations on the legal responsibility of conservation work, and this has made the conservation work to follow legal procedures. Meanwhile, MOA has formulated the "Plan of Animal and Poultry Genetic Resource Conservation", conscientiously implementing and improving the system and science of our breed conservation work.

The living body conservation is undertaken by the method of constructing conservation farm and conservation areas in the original producing place or other established place of animal and poultry genetic resources, for example, the Poultry Conservation Gene Bank in Jiangsu Province has conserved 21 chicken breeds, with conservation scale of 200-300 chickens for each breed. These places of genetic resources are responsible for formulating corresponding conservation policies, such as forbidding crossing with exotic breeds, formulating scientific and effective breeding programs, avoiding inbreeding and other technical measures, etc. At present, this method is fairly popular and play an active role in resource conservation work. In order to further select and purify the quality of native breeds, the producing areas of various species have established numerous selection breeding farms for horse, cattle, sheep and poultry through special funds allocated by the government Meanwhile, China has also divided some corresponding conservation areas. Through years of breeding and purification work, the quality of native breeds has been improved significantly. These breeds have not only been conserved, but also performance tested, which has enabled China to further understand the characters of these breeds.

Chinese MOA established the Center of Preservation and Utilization of Germplasm Resources of Domestic Animals and Forage in 1996. The center develops conservation technologies very rapidly. At present, it has conserved frozen embryos and frozen semen of 16 breeds of cattle, sheep and other animals. Each breed has conserved 1500 ampoules of frozen semen and 100 frozen embryos. There are two yak breeds in conservation, storing about 1500 ampoules of semen in each breed. In the Center of Preservation and Utilization of Germplasm Resources of Domestic Animals and Forage, they have preserved the blood samples of 58 Chinese native pig breeds, corresponding extracted DNA samples of nearly 3600 individuals, some genetic materials of ear tissues and the blood samples of 56 Chinese native cattle breeds including yellow cattle, yak and water buffalo. Awareness of the value of genetic resources has stimulated the molecular level study of the genetic diversity of indigenous breeds in recent years. In June of 2002, the center finished the project "Measurement of Genetic Distances between Chinese Indigenous Pig Breeds". Its objectives are to confirm the order of conservation among these breeds, to propose effective methods to maintain and utilize them, and to estimate the diversity and genetic relationships local pig breeds by means of twenty-seven microsatellite recommended by the International Society of Animal Genetics (ISAG) and the Food and Agriculture Organization (FAO). Measurement of genetic distances between Chinese indigenous cattle breeds is still going on.

Japan

The number of native livestock animals which have been kept for generations in Japan is decreasing rapidly in pursuit of productivity improvement, etc. For example, there are now only about 2,000 native horses in eight breeds. As for livestock in general, the popularization of superior breeds and strains among livestock farmers has reduced the genetic deviation of livestock. On the other hand, livestock breeding businesses are preserving genetically diverse livestock for the purpose of securing materials for future livestock improvements. Nineteen breeds of livestock and poultry native to Japan have been designated as natural monuments. All of these are chickens except for Mishima cattle and the Misaki horse. Of these, only Onagadori in Tosa has been conserved as a special natural monument. Moreover, financial assistance to support measures for strain conservation was provided targeting the Hokkaido horse and 14 chickens that are kept for research in three universities. A liaison meeting for the project to conserve 8 native horse groups including Misaki horse hosted by the Japan Horse Council has been held every year since 1977. In Japan the major form of animal protection has been to preserve the indigenous livestock breed resources. Three ways of protection are adopted, i.e., protection by the broad mass of people, protection by the local production area of breedsand at the national level, keeping these animals as a heritage of nature. These breed resources represent basically the endangered livestock.

- **Artificial insemination (AI):** According to 2000 statistics, the prevalence rate of AI is 99% and the frozen semen is used in all of the cases of AI for 2.48 million cows in total and the rate of artificial insemination for dairy cows is 99.4%, with frozen semen being used exclusively. For beef cattle the percentage for AI is 97.8%, and again only frozen semen is used in this procedure. Contrast this with pig and horse, where the corresponding figures are less than 10%.
- **Embryo transfer (ET):** the embryo transfer was carried out for 62,000 cows which corresponds to 2.5% of artificial insemination of cattle including Japanese Black in which ET was conducted to the figure corresponding to 6.3% of 740,000 AI.
- **Livestock Clone:** Cattle, fertilized-ovum clone, in 40 organizations, 629 animals, somatic cell clone, 293 in 38; Pig somatic cell clone, in one organization, five animals; goat, somatic clone, in one organization, two animals have been produced.

Korea

Genetic resources such as seeds indigenous to the region and strains of breeding of long history have great potential values to play a vital role to the human survival. Collection of genetic resources is weighted toward some specific crops and the collection of native genetic stocks has been poor. It is also urgent to analyze economically valuable characters even for the collected genetic resources. The foundation for the beneficial use of genetic resources should be established by examining and studying genetic resources preferentially, collecting, conserving and managing genetic resources from native organisms and operating genetic resources banks systematically. According to 'Master Plan for Agriculture and Fisheries Genetic Resources (2009–2018), Korea is targeting to strengthen its position as the 5th country in genetic resources through securing 330,000 collections for 6,000 species of agriculture plant resources and completing examination of characteristics for 77% of genetic resources by 2018. Collecting and expanding integrated management system for livestock genetic resource from 1,000 to 5,000 resources by live and frozen storage method are also pursued.

Processing, value addition and product development

Taiwan

In recent years, food safety incidents have put the issue under the spotlight and have gradually changed Taiwanese people's consumption habit. More and more consumers are willing to purchase agricultural products with label or certificate of origin. Thus, in order to boost local production and consumption of livestock product, the Council of Agriculture (COA) actively promoted the labeling and production traceability system of cattle and goat products, which serve as a reference basis for local consumers when purchasing livestock and dairy products. Moreover, the system helps consumers to differentiate between domestic and imported products. In order to elevate the quality of livestock products and encourage manufacturers to utilize domestic livestock products as raw materials so that the interests of farmers and consumers can be protected, the COA has introduced the production traceability system since November 2007, which provides consumers with relevant information about domestic livestock production, slaughtering, and sales for reference when purchasing products. All these measures aim to prevent the possible confusion created by merchants mixing imported dairy and meat products to fake as domestic livestock products.

China

Domestic animal genetic resources are an important basis for livestock industry development. Over a long period of time, China has always followed the principle of combining development and utilization with conservation in the aspect of development and utilization of domestic animal genetic resources. Chinese MOA is responsible for the administration of genetic resources of domestic livestock and poultry, with corresponding administrative institutions established in different provinces, autonomous regions and municipalities and with the bureaus and stations of animal husbandry established in different prefectures, cities, counties and towns. The National Examining and Approving Committee for Livestock and Poultry Breeds has been established by MOA and the corresponding committees have also been established in some local areas, which are responsible for examining and approving new breeds and new lines.

Japan

The image of high quality livestock products from Japan is established. Livestock animals in Japan have been raised carefully in good faith just like Japanese traditional culture. Both the updated technology and the thorough feeding management in each individual animal are the secret to supply delicious and safe livestock products.

Marketing, commercialization and trade

Taiwan

In order to improve the quality and safety of agricultural and derived processed products, the COA promulgated the Agricultural Production and Certification Act and promoted the Traceable Agricultural Products (TAP) and Certified Agricultural Standards (CAS) systems (Chen, 2008).

For the purpose of elevating the quality of livestock traceability system and its certified products, the COA continues to subsidize municipal and county governments for carrying out administrative inspection and random product quality check on certified livestock farms, slaughterhouses, meat-packing facilities, and sales points. In the future the COA will continue to organize relevant promotional events about livestock product certification as well as administrative inspection on products to ensure domestic livestock product quality and increase consumer's awareness and support on domestic livestock products.

The value of enforcing label, certification, and production traceability system:

1. Effectively achieving market segmentation between domestic and imported products:

   Through the implementation of certification label and mark of origin, consumers are able to effectively identify products. The systems protect the interests of both producers and consumers, and can be favorable for the promotion of local production and consumption.

2. Increasing the safety of livestock product:

   When problems with agricultural products occur, it is possible to quickly track down the cause and product source so that the responsibility of each party involved may be clearly determined. The application of identification label or number on product management could facilitate information relay during the process of production and improve product quality and safety.

3. Improving product production and business management technology:

   In addition to the integration of label, certification, and production traceability system into production, consumers' growing demand on the quality of domestic livestock products would encourage the industry to invest in novel production systems and more sophisticated management methods in order to elevate overall farming management efficiency, and expedite industrial upgrading.

4. Raising profit for the industry and promote mutual trust with the consumers:

   Producers could establish brand image, build up product trustworthiness, meet consumers' demand, and increase product competitiveness. On the other hand, consumers are guaranteed to eat healthy food when they purchase certified and safe livestock products with transparent information.

China

In recent years, there have been many problems in food safety from mad cow disease and foot-and-mouth disease (FMD) in foreign countries to water injected meat, inferior milk powder and Sudan red event in China which has attracted the attention of the world (Guangming et al., 2007). Food safety has been the concerned issues by the consumers and the businessmen together and becomes the important factor that affects the international competitiveness of Chinese agriculture and food industry. As the biggest developing country and WTO membership country, China actively has coped with various food problems, carried out the preliminary study on food safety traceability, made some related standards and guides, preliminarily created some food traceability institutions and issued some regulations in some local governments and enterprises. Article Numbering of China (ANCC) cooperated with China National Food Industry Association (CNFIA) to build the food safety traceability platform by bar code, establish a great deal of traceable foods and enterprises and develop a series of traceability subsystem (Huang et at., 2006). Food safety traceability system (FSTS) refers to an information management system that can connect the production, inspection, supervision and consumption etc., processes to let the consumers know about the sanitary and safe production and circulation process and improve the safety trust of consumers on the food. FSTS provides the traceability mode – from farm to table, selects some common traceable factors concerned by the consumers from production, processing, circulation and consumption etc., supply chains, creates food safety information database. Once there is food safety problem, it can effectively control and call back the food according to the traceability so as to ensure the legal rights and interests of consumers from the food source (Huang et al., 2006).

Japan

The consumption of livestock products in Japan is one-third lower than the USA, and half that of the EU. However, the Japanese people eat a lot of fish and shellfish, so the intake of animal food compares favorably with developed western countries. In terms of the demand for livestock products, dairy products such as cheese are expected to increase, but fresh milk, meat and eggs are unlikely to increase due to a leveling off or downward trend in the population. However, in terms of quality and in response to consumer needs, there are increasing efforts to expand production and consumption through product differentiation. The trend among consumers is to purchase fresh, safe, palpable and healthy livestock products rather than just focusing on the price. Accordingly, livestock producers are endeavoring to meet consumers' needs by developing brand livestock and products. Brand products are being produced from beef, pork, chicken and eggs, with 141, 178, 158, 636 brands known, respectively. There are a few brands that use native breeds as a point of difference. Native breeds such as Mishima cattle, Kagoshima Berkshire, Aguh, Hinaidori, Tosa Jidori, Nagoya, Gifu Jidori and Shamo are being utilized to produce brand products, a situation which is greatly contributing to the conservation of these breeds at the present time.

Japan has high standards and strict market requirements, imports a large volume of food, has a public that is responsive to food safety issues, has a production system based on small farms, and uses a high technology traceability system (Guangming et al., 2007). Japan is the biggest food importer in the world, importing more than 60% of its food, increasingly from developing countries. Compliance with Japan's food safety standards and traceability requirements opens the door to increased business opportunities. To protect consumers, the public sector moved relatively quickly to support food safety systems. Moreover, unlike other developed countries where food production is often done on large-scale farms, Japanese farms are generally small, providing experiences that are more applicable to farms in developing countries. The high rate of IT adoption in Japan provides a wide range of examples of ICT support in traceability systems. Introduction of ICT in Japanese food traceability systems has had to take into consideration the level of IT skills among the small-scale rural producers—a challenge also faced by developing countries. The public and private sectors have collaborated in addressing the food safety issues through food traceability systems using ICT.

- **Beef cattle:** In 1999, the population, excluding cattle for fattening, totaled 669,000, 93% of which are Japanese Black. With regard to other breeds, Japanese Brown constitutes 4.8%, Japanese Shorthorn 1.2%, and other species constitute less than 1% in total cattle being fattened for beef production totaled 1.84 million head. Holstein and its cross are also included in the statistics, accounting for 57.7% of the total and Japanese Black accounts for 39.8%.
- **Dairy cows:** In 1999, Holstein totaled 1.73 million head, accounting for almost 100%, while the second most common breed was Jersey with only 9,202 head, and species other than Holstein totaled 10,287 head, accounting for less than 1%.
- **Pigs:** Although there is the high popularity breed, the Kagoshima Kurobuta in Japan. In addition to this breed, three-way cross hybrids among Large White, Landrace, and Duroc, and partially among Large White, Landrace and Berkshire (in place of Duroc), or commercial pigs, which have been produced utilizing imported parental hybrid stock pigs imported from foreign pig breeding companies.
- **Chickens:** For chicken production, meat production using broilers produced from imported parental hybrid stocks accounts for 89.4%. Adding waste chickens (9.0%) to this figure takes the percentage to 98.4%. For eggs, White Leghorn and other laying chicken breeds account for 7.21 million fowls, while native chickens and other breeds of chickens for meat and eggs account for 340,000 fowls in total (probably used mainly for meat).

Strategies adopted to harness their potential

Taiwan

Domestic animals supply 30% of total human requirements for food and agriculture, and 70% of the world's rural poor depend on livestock as a component of their livelihoods. As an example, there have been tremendous movements of livestock germplasm from the northern hemisphere to Taiwan driven by global production systems as compared to that from the southern hemisphere to Taiwan. Exchanges of genetic materials among the regions have been a very valuable mechanism for breeding and livestock development. Taiwan farm animals such as dairy cattle, pigs, and layers, preserve a high percentage of exotic blood through long-term agriculture trade relationships.

Research and utilization using molecular techniques to verify AnGRs are understood to encompass animal genetic resources that are or have been maintained to contribute to animal protein supplies and farmer livelihoods. Comprehensive assessments of genetic diversity of local breeds using molecular genetic markers are required. Genetic variations within livestock species are partly attributed to differences between breeds and partly to differences among individuals within breeds. A breed or population becoming extinct means the loss of its unique adaptive attributes. The potential of new and emerging technologies, such as DNA libraries of local breeds, is being applied to reveal the genetic bases of disease resistance, adaptation to environmental stresses, and production efficiency. Molecular methods will provide new tools such as new generation sequencing (NGS) technology would certainly facilitate conventional and trans-formative genetic improvements.

China

In order to continuously develop and improve the quality and performance of domestic animals, MOA has established associations, technical organizations and breeding centers of breeding committee for some breeds. These organizations of association and breeding committees have played an important role in improving the quality of domestic animal breeds in China. By using the techniques of computer and Internet and on the basis of the supplementary survey on animal and poultry breed resources, they have established the "China Information System of Domestic Animal Genetic Resources." The software package of the information system can be applied in the administration of animal and poultry genetic resources throughout the country.

Here, the Chinese Government is willing to unfold cooperative research in the domain of domestic animal genetic resources, and spare common efforts in the conservation and utilization of global domestic animal genetic resources and for sustainable development of livestock industry.

In order to strengthen the conservation of native breeds, the Chinese Government has input large quantities of funds and established a big batch of excellent native breed resource farm and bull stations in various parts of the country.

Japan

Animal genetic resources indispensable in agriculture and bioindustries are conserved in collaboration with the sub-banks to facilitate efficient preservation and maintenance appropriate for a specific animal. The conservation methods include the ex situ conservation method that involves collecting fertilized eggs or semen for cryopreservation in liquid nitrogen, and the in- situ conservation method that involves maintenance of live population of animals in their adaptive environment. Livestock and poultry genetic resources are preserved ex- situ using fertilized eggs, semen and somatic cells or in-situ using live populations of animals. In the case of chicken, the primordial germ cells (PGC) which will differentiate into ova or spermatozoa are also used because long term conservation of chicken eggs is difficult.

Korea

To the present, projects on traditional knowledge have been carried out in several research institutes such as the Korean Intellectual Property Office. However, systematic management and streamlined research attempts have so far been insufficient. Korea is moving toward developing a nationally unified approach on the protection and use of traditional knowledge that are fully in line with the Nagoya Protocol. Since the evaluation and the monitoring of biodiversity are the basic tools for the conservation and management of biodiversity, the results of a wide range of biodiversity surveys have been used as evaluation measures for ecological zoning maps and conservation policy making in Korea. Changes in domestic biodiversity should be monitored regularly, which will be used for the establishment of conservation plan.

Several national research projects in place include Survey on Current Inhabitation of Wild Animals (1967), National Natural Environment Survey (1986–), National Distribution Survey of Endangered Wildlife (2001–) and Survey of Native Species (2006–).

Major focus areas

Taiwan

Understanding the diversity and status of AnGRs provides the basis for raising public awareness. However, raising awareness without ensuring capacities to realize actions will not produce the effective management and sustainable utilization of local breeds. Animal conservation activities were further posted on the web site of ANGRIN (www.angrin.tlri.gov.tw) for documentation of pictures and videos of conserved and selective breeding animals. The importance of the conservation and sustainable use of AnGRs was recognized by policy makers and major stakeholders in the livestock sector. Strengthening the breeding capacity and programs for local breeds were established and stimulated in situ conservation. On the other hand, ex situ conservation in cell/tissue banks requires appropriate infrastructure and organization, technical capacity, legal arrangements, and sustained funding. The Taiwan Animal Germplasm Center (TAGC) is a capacity building for managing AnGRs via cell/tissue banks with liquid nitrogen, and it serves as a conservation center of the animal conservation project.

China

In China, to facilitate timely exchange of these livestock and poultry breeds resources at home and abroad, the Chinese Ministry of Agriculture organized almost a hundred renowned professors and experts to compile a book of “Breeds of Domestic Animals and Fowls in China”, which has been published in separate volumes, namely: “Horse and Ass Breeds in China”, “Bovine Breeds in China”, “Pig Breeds in China”, “Sheep and Goat Breeds in China” and “Fowl Breeds in China”. In order to transfer the advantages of rich Chinese animal and poultry breed resources into economic advantages, while strengthening conservation work, China has given focus on the breeding and industrialization of animal and poultry breeds. In recent 20 years, they have used modern breeding techniques and means in developing a huge batch of specialized lines and new breeds. During the period of 1996-2001, the State had examined and approved a total number of 17 new animal and poultry breeds. Meanwhile, the methods of animal and poultry recourse development and utilization move to the orientation of integration of breeding, production and processing. This has enabled China to keep the excellent characters of many local native animal and poultry breeds and improve the production performance by a big margin.

Japan

For livestock and poultry within Japan, data have been accumulated on fundamental and production-related traits from all the studies ever conducted, while NIAS genebank project is also promoting characterization of animal genetic resources held at the genebank.

Genetic relationships among domestic animal breeds and populations have been studied by using molecular information, polymorphism of protein, blood type, mitochondrial DNA, and genomic DNA markers. Individual identification and parentage tests that have conventionally been conducted using blood groups and protein polymorphisms is shifting after a trial period to tests using microsatellite DNA polymorphisms. DNA diagnosis of inherited disease is started on 5 genes of cattle and one gene of the pig. Moreover, genome research, genetic map and QTL analysis on livestock and domestic- fowls are also performed (national Institute of Agrobiological sciences, 2002).

The focus is also included the conservation of livestock, poultry, and insect genetic resources, collection of relevant data such as geographical distribution, maintenance of mutants or lines with useful physiological traits, and implementation of an efficient long-term preservation system to maintain genetic diversity. The animal genetic resources are available for research purposes and have been utilized for genetic analyses, studies on diversity, physiology, ecology, and the development of novel foods and other products.

Korea

Examining phylogenetic relationships of native species was performed by the analyses of genetic information. Elucidating phylogenetic relationships among native species can be accomplished by the analyses of genetic information with the foundation of big data. Establishing convenient identification system using genetic ID is enabled by constructing DNA barcode system. Strengthening examination and research of genetic diversity for important biological resource and establishing improvement by inspecting actual condition of conservation policy and examining the areas of high genetic resources has been welcomed. Protecting the habitats of good genetic diversity could be realized by designating as new protected areas in connection with previously designated areas, thus expanding collection, storage, and ex situ conservation of genetic resources. Collecting genetic resources and natural products by intensive examination of special habitats for collecting diverse genetic resources has been beneficial to the conservation effort. Strengthening management technology such as evaluation, management and preservation of useful genetic resources has been proposed. Developing the discriminating criteria for useful and rare genetic value and revising the related official regulations, promoting developments of management manual for genetic resources of vital importance, and developing the technique of cryogenic frozen storage.

Infrastructure, capacity building and financial investment

Taiwan

Genetic resources are usually conserved in living form or frozen geneticmaterials. Preserving germplasm in living form must conserve a considerable number of mature individuals with reproductive potential, and continued funding and breeding space are necessary. Based on the afore-mentioned restraints and consideration of risk diversification, living germplasms are preserved in LRI branches and breeding stock reproduction sites throughout Taiwan. Genetic materials preserved in frozen form include germ cells (sperm, egg and embryo), tissue, somatic cells, cell lines, DNA and gene pool. Those conserved for less than 5 years are kept in freezers at -20 or -80°C, while those preserved for long term are conserved in liquid nitrogen storage tank at -185 to -196°C.

The livestock Germplasm Center now conserves genetic resources of 77 livestock species and strains, including 19 native and 38 foreign species as well as 20 new species/strains produced by breeding. These species are provided by breeders, preservation sites, importers, local veterinary staff and farmers' association promotion staff. The germplasm bank preserves livestock genetic resources in animal, vegetation and microorganism categories. Livestock are divided into domestic animals and birds, vegetation are mainly feed crops, and microorganism include those in livestock digestive system and fermented compost of manure and urine.

China

In a room of the Animal Husbandry Station of Beijing Municipality, samples of embryos, blood and DNA of livestock and poultry are stored in liquid nitrogen tanks. The purpose of storing these genetic materials is so they can be used by advanced biotechnology to revive the species if they were extinct. Known as a "life bank" for livestock and poultry, this modern "Noah's Ark" is the Livestock and Poultry Germplasm Resources Bank of Beijing Municipality, or the Centre of Livestock and Poultry Germplasm Resources in Northern China of China National Genebank. When genetic resources are needed, they can be taken out of the tanks and released. "The germplasm resources stored here can be used for pure breeding or cross breeding of livestock and poultry through exchanging genetic resources. If necessary, select the best samples to create a high-quality breed. For example, sperm, embryos and gene samples can be used for artificial insemination, transferring embryos and genetic research of biodiversity, respectively. The germplasm bank stores 1,380 blood samples and tissues of Peking chicken and Beijing duck, 600 and 2,628 blood samples of high quality pigs and Holstein cows, respectively, and 700 samples of semen of bulls of Holstein, Limousin, Angus and Simmental; collects 600 DNA samples of Qinghai Fine wool sheep, Karakul sheep, Tibetan sheep and Small-tailed Han (a breed of sheep), and 120 genetic samples of Equus (a genus of mammals in the Equidae family).

Japan

The Ministry of Agriculture, Forestry, and Fisheries (MAFF) genebank project started in 1985 as a nationwide network. From 2001, the National Institute of Agrobiological Sciences has been the main body conducting research and collection of genetic resources both inside and outside Japan, along with implementing characterization and conservation of resources. The conservation of livestock and poultry is practiced at the National Institute of Agrobiological Sciences, the center-bank, and independent administrative institutes such as the National Agricultural Research Organization, the National Institute of Livestock and Grassland Sciences, the National Institute of Animal Health, and the National Livestock Breeding Center, as sub-banks. The center bank is involved with cryo-preservation, mainly focusing on frozen semen. The sub-banks are concentrating more on maintaining live animals, in combination with cryo-preservation. Collection and conservation are being carried out focusing on breeds and strains that have been established in Japan, and approximately 200 accessions have been conserved.

The NIAS Genebank is the main repository of genetic resources of plants, animals and microorganisms of agricultural importance. It also coordinates management of these resources in collaboration with a network of sub-banks throughout Japan. The Genetic Resources Center, NARO (NGRC) is in-charge of collecting and introducing valuable genetic resources from domestic and overseas sources, maintaining passport and evaluation data, and to providing access to these resources for research and development for food and agriculture. The center also carries out diversity studies and develops preservation technology to conserve genetic resources, and creates new genetic and breeding materials using irradiation mutagenesis and other methods. To date, the conserved genetic resources include about 215,000 plant accessions, about 28,000 microorganism accessions, and about 1,000 animal accessions.

Korea

It is necessary to establish adequate financial measures by accurately understanding the current status of biodiversity. Existing state-funded subsidies on agriculture, fishery, transport or energy, etc., could provide short-term economic benefit, but may well be harmful to the health of biodiversity due to environmental damage and resource depletion. OECD countries are still providing environment harmful subsidies of over 400 billion US dollars per year to traditional industries such as agriculture and energy. However, actions to bring reforms on this damaging practice are now in place, imposing ecosystem conservation cooperation charges (CBD, undated). Thorough examination on the state funded subsidies and their impact on environment must be carried out. Also needed is step by step approach to increase government subsidies that are beneficial to biodiversity. Exemplary case of beneficial subsidies: “Biodiversity Management Contract” was developed by local governments and residents. Under this contract, farmers left some crops for migratory birds and then local governments compensated them for the loss (6.66 billion and 3 billion KRW in 2011 and 2012, respectively). Korean government is fully recognizing the importance of developing techniques and training professional manpower to achieve the conservation and sustainable use of biodiversity. By establishing NIBR in 2007 and National Ecology Institute (NEI) in 2013, the information sharing system as well as the workforce training has seen significant improvements. The dependence on some of biological resources such as agriculture, health and medical care, and forest resource is quite high in Korea compared to low level of existence of biological resources.

Case studies/success stories for improvement of health and livelihoods if

Taiwan

The indigenous livestock breeds are proven to be used for more than producing food products, the Lanyu miniature pigs are bred for biomedical and laboratory research. After introducing the black-coated miniature pigs from Lanyu in 1980, the LRI began breeding a selection of the species and has since bred four mini-pig breeds. It’s recognition by the Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) bodes well for the nation’s development of laboratory animals and its efforts to bring the industry in line with international standards (Kuo et al., 2015). The application of the mini-pigs in future medical research will also help boost the international competitiveness and visibility of Taiwan’s medical technology industry. During the breed selection of the spotted mini-pigs in 2001, the first batch of white-coated pigs, which the facility named Lanyu White, appeared. The Lanyu White are particularly suitable for experimental research related to transplant medicine, plastic surgery and cosmetic products and they have become a popular breed of laboratory mini-pigs. Several hundred Lanyu White pigs have been supplied to research centers both in Taiwan and overseas.

China

In China, for producing Chinese traditional animal by-products, the domesticated animal and poultry breeds used are: Jinhua pig for ham; Beijing duck for roast duck; Anhui ma chicken for roasting; Chaohu ma duck for pressed salted duck; Tan sheep and Zhongwei goat for fur; Hu sheep and Jining grey goat for lamb and rich fur. There are also the Taihu pig and the small-tailed Han sheep and big-tailed Han sheep, well-known for their high fertility. And also, there are the silky blackbone chicken of pharmaceutical significance; dwarf and miniature breeds, such as mature horses with body height under one metre; Wuzhishan pig and Xiang pig with body height 35–40 cm and weight around 40 kg. The characteristics of several breeds are rare not only in China, but also in rest of the world.

Japan

Since research into other livestock by veterinarians and zoologists is broadly based, it is important to increase the number of personnel that have an interest in these areas and are involved in genetic resource studies and projects, rather than mere capacity building. The Ministry of the Environment released the New National Strategy of Japan on Biodiversity in March 2000. The Ministry of Education, Culture, Sports, Science and Technology released the "National bio-resource projects" that aim for the improvement of bio-resource systems such as those for laboratory animals and plants. These projects assume the viewpoint of the comprehensive promotion of bio-resources. The NIAS gene bank projects are required to review how effective measures to conserve genetic resources have been, utilizing the characteristics of individual projects and linking these projects and systems effectively to take the entire nation into consideration.

Korea

Korea has established a pan-government measure for the Nagoya Protocol in 2011 and has been pursuing implementation legislation to rectify the Protocol. It is also necessary to provide information and to improve awareness among stakeholders such as government agencies and private sector for the implementation of the access and benefit sharing. Reshaping the national legislation on the access to genetic resources and equitable benefit sharing seems to be a crucial task for the country. Establishing genetic resource information system to promote foreign parties to gain an access to Korean generic resources holds significant importance as well.

Future thrusts

Taiwan

Further losses of local breeds are probably inevitable, even though local breeds are important components of our future food security and cultural heritage. Conservation of local breeds should certainly be a public concern. In the future, a global bio-identification system and exchanges of genetic resources will continuously be carried out to develop a backup system of genetic materials and samples at the regional and global levels (Shao et al., 2007). Therefore, effective and efficient handling and documentation of AnGRs such as DNA samples, cells, and tissues generated from various germplasms in AnGR conservation, cryobanking, bioutilization, and management as follows:

a. To provide a venue to discuss the status of documentation activities of the various cryobanks of animal and forage plant genetic resources in the Asia and Pacific region,

b. To familiarize participants with various documentation systems available, germplasm documentation, data analysis, and information management for AnGRs,

c. To reinforce the capabilities of participants for conservation banking techniques, cell freezing methods, data processing, genetic analysis, and interpretation of results,

d. To provide a venue to discuss and clarify issues concerning international, regional, and national laws and policies of relevance to the conservation and management of AnGRs,

e. To increase the knowledge and understanding of participants on intellectual property rights (IPR) issues, mechanisms of access, and benefits of sharing genetic resources, and

f. To reinforce the capability of participants in dealing with said issues in relation to research and development of AnGR conservation and management.

China

China is an East Asian country with very rich livestock and poultry genetic resources. In Asian and East Asian countries, local breeds have been influenced to some extent by being hybridized with and replaced by foreign breeds. Yet China has a vast area and a rather complicated natural ecological environment. Especially in the south-east and the south-west and the Huang-Huai-Hai regions in China, natural protection regions have formed where a lot of specific animal and poultry breeds have been distributed and protected now, so that many breeds in those regions have been preserved. China is also a developing country. The economic resources used to protect and preserve effectively the genetic resources of livestock and poultry breeds are not sufficient. The Ministry of Agriculture of China has established several protective regions, sperm banks, and embryo banks for some endangered livestock and poultry populations and species that have become almost extinct or greatly reduced in number. This is also required to carry out studies on the development and utilization of these genetic resources in China.

Japan

Many of Japanese native livestock are in a critical situation. As an auxiliary means for in-situ preservation by live animal population, ex-situ preservation by live animal, frozen embryo and frozen semen are being conducted. The conservation of frozen embryos and semen is not necessarily satisfactory because the number of individuals being able to collect is limited and freezing technologies have not been well established in some species. The leading technologies of the next generation applicable for ex-situ and in-vitro preservation should be somatic cell cloning in the mammals and primordial germ cell (PGC) for producing chimeras in the reproductive cell line in avian species. The associations of native livestock and domestic fowls are playing an important role. Policies need to be prepared to provide further incentives to the Conservation Group to continue its efforts. In addition, it is necessary to provide detailed information on livestock location wherever possible, particularly for chickens, by ongoing research on the locations where these breeds can be found and their conservation status.

Appropriately conserve and manage ecosystems and halt the extinction and the population decrease of threatened species. Furthermore, achieve and maintain improvements in the conservation status of species which are experiencing particular declines from among those threatened species. In addition, improve the conditions for biodiversity by conserving the genetic diversity of crops, livestock animals, and wild species that are closely related to them, including those species that are valuable in a socioeconomic or cultural sense. For the genetic resources of livestock animals, move forward with securing and using a diverse array of breeding resources that possess genetic advantages by focusing primarily on varieties that are unique to Japan, such as Wagyu beef, locally raised chicken, and Japanese horse breeds.

Korea

Korea is expanding the establishment of genetic resource management banks. Genetic resource bank of wild animals, Korean Collection for Type Cultures operated by Korea Research Institute of Bioscience and Biotechnology, Agriculture Genetic Resource Bank, Registration

Authority for Marine Biological Resource Deposition, and Pathogen Resource Bank are some examples of such genetic resource banks. Establishing new genetic resource banks for wild plant seeds, natural products, and seed vault for long-term storage is also planned. Also included in the plan are establishing the system for strengthening roles and activating operation of genetic resource banks, resolving problems in overlapping collections and similarities among banks, and establishing "Development Plan for Genetic Resource Banks." Since diverse animal resources inhabit in the Korean Peninsula, the collaboration between South and North Korea holds inevitable significance for the conservation and sustainable use of biodiversity. Especially, DMZ, as one of three core eco-belts in Korea, attracts attention globally as the symbol for the peace and biodiversity. Currently, comprehensive data collection will be useful for biodiversity cooperation between two Koreas.

Conclusions

Biodiversity faces threats from increasing agriculture and livestock production (Butler and Laurance, 2010). Agriculture depends on biodiversity for a variety of reasons, including as a source of present food security and insurance for future outbreaks of pests and diseases and climate change losses. Growing area devoted to agriculture and livestock and increasing reliance on monocultures, high yields and fast growth in turn lowers biodiversity. Key agro-biodiversity functions may be lost that negatively affects long-term sustainability of agricultural systems' food security.

High-output breeds or so-called international trans-boundary breeds have resulted in impressive production increases, and many countries regard them as a means of enhancing their livestock production to replace local breeds (FAO, 2018). The capacity to characterize, sustainably use, and conserve AnGRs in many countries varies due to a lack of inventory and monitoring. The inventories of AnGRs are the basis for planning development programs of local breeds. Collaboration in breeding activities between countries with similar production conditions is an opportunity to share costs and make breeding programs more sustainable. Animal health is the most regulated aspect of livestock management on a global scale. Hence, effective disease control is essential, and trade potentially presents challenges for AnGR risk management and backup systems. This backup concept for global genetic resource management should take the same approach among countries and regions. A global program should be formulated to provide the institutional capacities and resources needed for its implementation at the regional level and to accept the global responsibility.

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Underutilized Animal Genetic Resources in the Pacific

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Introduction

This paper is prepared for presentation at the "Regional Workshop on Underutilized Animal Genetic Resources and their Amelioration", Malaysian Agricultural Research and Development Institute, 4-6 March, 2019. The intent is to present an overview report on the status of animal genetic resources (AnGR) for food and agriculture in the Pacific Region and discuss potentials and some options for future research and development. The focus is on domesticated species of farm animals but some attention is paid to wild species with some potential for exploitation or are already successfully farmed in captivity. The word "amelioration" in the workshop title requires some definition. It means "made better" or "improved" in some defined ways and, therefore, in the present context means made more suited to contributing significantly to food security in the region. The question, therefore, is in what ways or to what extent might the Pacific AnGR be used to improve food security into the future?

The region is the grouping of 18 tropical, insular Pacific Island Countries and Territories (PICTs) ranging from Palau and the Federated States of Micronesia in the North-west to the Cook Island and French Polynesia in the South-east. The PICTs are either collections of atolls or mainly volcanic high islands, single or multiple, but with most of the latter having associated atolls. The exception is the large country of Papua New Guinea (PNG) sharing the island of New Guinea with the two eastern-most provinces of Indonesia. Only eleven of these PICTs had country reports included in the assessments in The State of the World's Animal Genetic Resources for Food and Agriculture (FAO, 2007). These are the Cook Islands, Fiji, Kiribati, Niue, Palau, Samoa, the Solomon Islands, Tonga, Tuvalu, Vanuatu and Papua New Guinea. For these there is, therefore, reasonably current comprehensive information and the eleven reports dated 2003 or 2004 were downloaded from the Internet. For others, reliance is on personal knowledge or contacts plus what the Internet could provide.

The geographic grouping of the PICTs is as follows:

- Exclusively coral atolls – Marshall Islands, Kiribati, Tuvalu, Tokelau.
- High volcanic islands – Palau, Vanuatu, New Caledonia, Wallis and Futuna, Samoa, Tonga, Papua New Guinea (PNG), Solomon Islands, Federated States of Micronesia (FSM), Fiji Islands - most with associated atolls.
- Mixed high islands and atolls – Cook Islands, French Polynesia.
- Raised coral – Niue.
- Rocky with reef – Nauru.

Commonalities and contrasts among PICTs

Table 1 shows estimates of cattle numbers for each PICT while Table 2 contains an attempt to summarize information about all other domesticated species. Note that numbers of animals where given in these tables or elsewhere in the text from a variety of sources are extremely imprecise estimates but are useful as indicators of relevant importance of species among PICTs. Note also, however, that the numbers are affected by the extreme differences in the sizes of the PICTs. PNG alone has about 70% of the total population of the region and two countries have less than 3000 inhabitants each. Land areas show an even larger discrepancy with PNG having 84% and the five Melanesian countries together having 98% of the total land area of the PICTs surveyed. The two largest Polynesian countries have another 1% and leaving only 1% for the other 11 counties combined.

Table 1: Estimates of Cattle Numbers

PICT	Number of cattle, head	Category for development
Fiji	310,000	1
Vanuatu	173,000	1
PNG	92,000	1
New Caledonia	92,000	1
Samoa	30,000	1
Solomon Islands	15,000	1
FSM	14,000	2
Tonga	11,700	2
French Polynesia	7,400	2
Cook Islands	130	3
Niue	115	3
Wallis and Futuna	60	3
Palau	NA <100	3
Atoll PICTS / Nauru	Nil	4

Source: http://beef2live.com/story-world-cattle-inventory-country-fao-164-127640

The following comments come from analysis of the 11 FAO country reports plus several other reports for the other PICTs and the personal knowledge of the author and colleagues. For example, a comprehensive survey of indigenous (Kanak) tribal peoples in New Caledonia (Guyard et al., n.d.; Bouard et al., 2019) covered the agriculture of 12.6% of the total Kanak household population. Animals, mainly pigs, chickens and goats, are kept by 60% of these families with predominance in the Loyalty Islands. However, it should be noted that so much of the available information is dated, mostly 10 years old or more and the present author's on-the-ground experience of all of the PICTs dates back to the FAO/UNDP Regional Livestock Development Project 1988-1990 (UNDP, 1992), except for more recent experience in PNG, New Caledonia, Samoa and Fiji.

The causes of information gaps on AnGR are neatly summed up in the Fiji report and reflected across the reports as lack of priority given to livestock generally, low local skills and knowledge, lack of appropriate resources and facilities, poor funding and absence of an appreciation of the need for any action. A Solomon Islands Policy document (Government of the Solomon Islands, n.d.) states that the need is to develop, conserve and manage important animal genetic resources (*e.g.*, village poultry and feral pigs) which are vulnerable to unplanned interbreeding and hence loss of desirable hardiness and fitness traits. There is a serious lack of research capacity which calls for networking across the region. A document prepared for APAARI (Ghodake and Quartermain, 2003) drew attention to this and drew attention to a gap in livestock improvement. In the Global Conference on Agricultural Research for Development (Singh, 2010) and in a preliminary consultation (APAARI, 2009), livestock activities were not given high priority for the Pacific Region but key issues highlighted were the limited research capacity across the region and sustaining livelihoods on atolls. The regional institutions such as FAO, the Secretariat of the Pacific Community, the Pacific Island Universities Research Network and the Pacific Islands Development Forum are present but limited in their activities.

What comes clearly evident is the strength of traditional custom in attitudes and activities by livestock owners across the region. Livestock are kept for traditional uses. Reports generally refer to three strata of owners, traditional household subsistence, opportunist marketing by subsistence smallholders and fully commercial but small-scale units. The number of large-scale commercial producers is relatively very small. The non-existence of marketing outlets or access to them is a limiting factor especially for islands which are not central administrative centres or are remote.

Animal production in the region is focused on self-sufficiency or import substitution. Rising populations, increasing prosperity and, at least for cattle, declining populations of animals make internal production of meat, eggs or milk unable to meet the demands. Although, Vanuatu has a history of export of beef, 752 tonnes in 1979, some of it to New Caledonia (Quartermain, 1981), internal demand now makes this difficult but it is still policy and new government initiatives include a ban on slaughter of heifers. A recent vision statement suggests 500,000 by 2025 (Government of Vanuatu, 2015). The only other export activity is that of skins of farmed or capture raised crocodiles from PNG.

With the exception of indigenous pigs and chickens, and those species with no recognized breed structure such as Muscovy ducks, Rusa deer, horses and honey bees, most livestock are crossbred. Again, with the exception of sheep in PNG, Fiji and Samoa, and goats in Fiji, there are no systematic crossbreeding and selection programmes to develop stabilized new breeds. The original imported breeds used to produce the present population have not been retained as pure breed populations. For commercial production there are policies or either government or private sector initiatives to replenish breeding stock with regular imports, at least for cattle and pigs using AI or even ET technologies. All PICTs have systems of quarantine, with variable permitted sources for different species. All commercial chicken production relies on systematic importations.

Of course, there are exceptions to everything and these largely depend upon country sizes and degree of urbanization. In most of the PICTs about 80% of the population are rural subsistence farmers with about 80-90% of those keeping pigs and 60% keeping chickens. Fiji has a much higher level of commercialization of production with many small commercial farms producing meat, eggs and milk. In countries such as the Cook Islands, Tuvalu, Tonga and Kiribati, populations of both people and livestock are concentrated on the main island with subsistence production elsewhere. Samoa, Nauru and Palau are highly urbanized while still having the rural or farming population largely engaged in livestock production for household use. While all PICTs are subject to genetic contamination of their indigenous pig and chicken populations by, usually unplanned, crossbreeding with exotic introductions, small island states like Nauru and Tokelau and those with populations concentrated on one island are particularly vulnerable.

General overview of animal genetic resources in the region

Noteworthy is the paucity in the region of indigenous AnGR defined as breeds. This has been determined by pre-history and post-colonial history together with the isolation of the PICTs from Asia and Australasia and from each other. Apart from the introduction of pigs and their subsequent domestication in New Guinea some 5000 years ago and the migrations out of Southeast Asia some 3000 years ago, spreading out into the Pacific with the pigs and chickens, dogs and the Pacific rat (*Rattus exulans*), the colonial development of agriculture meant that all new AnGR were sourced from the colonizing countries or their colonies elsewhere. This has continued to the present day with genetic material mainly from Australia and New Zealand. Hence, the past 150 years or so has seen very little development of new breeds in the PICTs and the few breeds listed in the FAO documentation (World Watch List – Scherf, 2000) are either descendants of the original pigs and chickens or are adapted isolates from early colonial introductions such as the Javanese Zebu and Priangan sheep (PNG) and Fiji goats. For this reason and because of the natural geographical grouping of the 18 PICTs, the focus and arrangement of this discussion is on species and habitats rather than on individual PICTs.

There is also a serious lack of knowledge and, hence, documentation of the current status of the AnGR, not only with respect to the numbers of each species or genotype in each PICT, for which precision is not really needed, but in terms of what unique biological or productive characteristics exist in each population and how these might relate to the needs of the people. There is a very good literature on the animal husbandry and production systems, such as the monograph of Hide (2003) on pigs in New Guinea and the FAO (2007) country reports, with current update in most cases, but this does not extend to research into existing or desirable traits of interest. For example – what is so special about the indigenous genotypes or those of the existing adapted populations that make them worthy of conservation or preservation as such?

With respect to animal genetic resources there needs to be a focus on evaluation and most effective use of indigenous genotypes (pigs and chickens) and of the locally adapted existing genotypes of goats, sheep and cattle. While this does not imply lack of encouragement for commercial producers to source and access the best available genetic material from bio-secure sources, there is untapped potential in available resources without resorting to expensive, potentially unsafe and untried imports of new breeds or species (Quartermain, 2017a).

There are a number of what may be labelled success stories of locally developed or established breeds or domestications and commercial crossbreds. The former includes the Highland Halfbred sheep (PNG), the Fiji Fantastic sheep, Anglo Nubian – Fiji goat crosses, Muscovy ducks, European honey bees, Rusa deer (New Caledonia) and crocodiles (PNG). The commercial ANGRs include all cattle, layer and broiler chickens, and commercial pigs. Formerly listed breeds now apparently lost are the Javanese Zebu and Solomon Islands Red cattle. The ubiquitous native pig and chicken populations have been and remain subject to genetic contamination by released or escaped commercial pigs and chickens but are still extant genotypes. Other ANGR of varying status are discussed under the sections on the separate species or groups of species.

Cattle

It appears that cattle are the priority or prestigious AnGR for governments of PICTs with suitable land for grazing large ruminants, which excludes the four atoll countries and Nauru. An apparent failing in agricultural planning is that proposals for livestock industry development are so often based on demand for meat rather than on assessment of the available resources of land and expertise that can sensibly be mobilized or trained. High demand does not make it feasible to produce something or more of that something. Table 1 gives reasonably up-to-date estimates of cattle numbers in the PICTs. It can be suggested that category one PICTS (author's appraisal) have scope for expansion and have plans to do so. In fact, at least for the first three the numbers have declined over the last 50 years. Numbers of PNG cattle peaked in 1976 at 153,000 but have declined by 40% over the past 40 years. The reasons are thought to be several but need to be better understood if any expansion is to be successful. Numbers of cattle fell dramatically in the Solomon Islands due to the ethnic disturbances (Kemuel Satu, pers. com.) in (2000-2001). Category two PICTs have some scope to retain these herds productively but category three are only wasting resources. One problem with cattle is that they reproduce slowly compared to the other major species and PICTs cannot hope to build herds quickly from small initial numbers. For example, Palau in 1988 was trying to develop cattle production with a government herd of 12 cows. However, the Government of Vanuatu is so anxious to expand cattle numbers that it has placed restrictions on the slaughter of heifers.

Any significant expansion of cattle numbers is restricted to the five large Melanesian PICTs and all have plans to do so. However, care must be taken to ensure adequate land resources of suitable quality are actually available and can be made sustainably available. The better land will vanish quickly as food and cash crops take precedence. In PNG much good former ranch land or potential grazing land has been put into oil palm, including the previous best commercial ranch, and into tree planting for bio-fuel with 1,500 ha of a planned 2,400 ha planted (Post Courier, 2019). The eventual aim is 16,000 ha of customary land in trees (The National, 2019).

All of the cattle AnGR in the region are imported or derived from importations with regular genetic upgrading. Nearly all cattle are Brahman Zebu or crossbred Brahman with genes from Santa Gertrudis or Droughtmaster breeds. The original base imports were European (Shorthorn, Hereford, Angus, Ayrshire, Charolais, Limousin, Simmental, Murray Grey, Red Poll, Piedmontese). Back in 1980 on Santo in Vanuatu there was significant crossbreeding with Charolais and little evidence of crossbreeding with zebu type cattle (Quartermain, 1981). Fiji has a viable dairy industry based on Jersey and mainly Friesian cattle (approximately 8-9% of the national herd) while PNG had two Jersey herds and is now developing a dairy industry again using New Zealand Friesians. A unique aspect of cattle keeping in Fiji is that some 16% of the national herd are work animals, a situation found nowhere else. The firstly exciting and then sorry story of the PNG Javanese Zebu cattle can be found (Quartermain, 2002; 2008). The two government herds accumulated in 1974 from remnants of 1880s introductions were dispersed in the 1980s and there may be only a few if any remaining feral on the Sepik Plains.

Sheep and goats (small ruminants)

Goats are found in most of the PICTs except on atolls, Wallis and Futuna and Nauru. The large and important populations are found in Fiji and PNG but there are significant numbers estimated to be in Vanuatu, New Caledonia, FSM, Tonga, Cook Islands and French Polynesia (Table 2). 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. Documentation of production systems and attributes is good for PNG (Quartermain, 1982; Quartermain, 2002; Yual and Quartermain, 2018) and the Fiji Goat (Payne and Miles, 1953). While Fiji retains high numbers of the original, well documented Fiji goat, a crossbreeding programme started in the 1980s using Anglo-Nubian stock has meant that there are now two apparently separate populations in production. The situation in the other PICTs are not so clear. There is a danger that new crossbreeding initiatives

Table 2: Approximate status of livestock (excluding cattle) in 18 PICTs

PICT	Pigs	Chickens	Goats	Sheep	Others
Cook Islands	15,900	24,300	7,000	nil	70 horses
Fiji	92,000	764,000	265,000	16,000	136,000 ducks 37,000 horses
Kiribati	41,000	51,000	100	nil	
Niue	1,500	10,000	400	nil	
Palau	2,500	14,000	25	nil	700 ducks
PNG	1,800,000 Mainly traditional	1,500,000 Mainly household	25,000	12,000	30,000 rabbits 4,000 bee hives Horses, ducks
Samoa	167,000	431,000	2000	800	1,800 horses
Solomon Islands	50,000	400,000	100	nil	1,000 ducks, 750 bee hives, horses
Tonga	113,000	178,000	2,800	nil	1,200 ducks 3,300 horses
Tuvalu	10,000	14,000			3,000 ducks
Vanuatu	75,000	320,000	7,000	1,200	1,200 horses
FSM	45,000	60,000	4,000	nil	
French Polynesia	Traditional subsistence	Some	16,000	nil	horses
Marshall Islands	Significant	Significant	nil	nil	
Nauru	Some	5,000	nil	nil	ducks
New Caledonia	30,000	382,000	3,500	4,000	9,500 deer, 6,800 bee hives 5,600 horses 6,000 rabbits
Tokelau	1500	Important	nil	nil	
Wallis and Futuna	Village important	Village minor	nil	nil	

Sources: Various (FAO, 2007; personal communications; author estimates)

will occur with interest in all these PICTs in the South African Boer goat, now available in Australia. The genetics of the goats in other PICTs are unknown but probably mixed.

An interesting initiative in PNG has been the testing of the local goats for milk production possibilities with some success (Aguyanto and Ayalew, 2011). In spite of the proven utility of the goat in the Pacific, it appears that sheep are preferred for further development at least by governments. They are not so widespread being found only in PNG, Fiji, Vanuatu, New Caledonia and Samoa (Table 2). In PNG the well documented Priangan sheep (Quartermain, 2002) gave rise in the 1980s to the Highlands Halfbred sheep through crossbreeding with Perendale and Corriedale sheep imported into the highlands from New Zealand for an aborted wool industry (Quartermain, 2002). The Priangan breed can now be regarded as endangered with only two known flocks in the lowlands, those of the University of Technology (35 head) and the National Agricultural Research Institute (NARI) (51 head but not all identified as pure). There may still be other sheep in villages but conservation needs to be taken seriously. The

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 with currently 45 ewes and five rams.

The most important initiative was the development in Fiji of the Fiji Fantastic breed arising from an extended period in quarantine of Barbados Blackberry and Wiltshire Horn sheep during which the new breed was formed by crossbreeding, with some influence also of existing wool sheep animals mainly Corriedale and later Poll Dorset, and then intensive selection for smooth hair coat and meat production capacity (Manueli, 1997). The new breed is fast growing and parasite resistant under the wet tropical conditions. It is now likely that all sheep in Fiji, some 16,000, are Fiji Fantastic. Vanuatu has imported these sheep from Fiji as has Samoa. In Samoa there is now a crossbreeding project using the South African Dorper sheep imported from Australia. However, there are only about 8-900 sheep in the country of unknown heritage. Again, the genetics of the sheep in New Caledonia are unknown but probably of mixed origin.

What is important is that the unique qualities of the small ruminant animals in all these various populations are not well researched and documented.

Pigs

There are pigs on all PICTs which are the descendants of the introductions by the original island settlers over the past several thousand years. However, there are now essentially three genetic types. These are the original Pacific native pigs, introduced commercial pigs of several breeds (Largely Large White, Landrace, Saddleback, Tamworth, Berkshire, Duroc, Poland China and Large Black) and either deliberately or inadvertently produced crossbred pigs from the first two types. Available statistics do not always or cannot distinguish between these types since the native pigs are largely kept in small numbers by villagers. The production characteristics and systems of husbandry of these native pigs are quite well documented, especially in PNG (Hide, 2003; Quartermain, 1996; Quartermain and Kohun, 2002; Ayalew et al., 2011). The boundary between PNG and Indonesia has only existed in colonial times, giving only some 150 years for any differentiation in pig genotypes to have developed. While this boundary is currently tightly sealed it could become more porous in future. However, it is likely that the pigs in the West Papuan Highlands may be closer in genotype to the original immigrants than those on the PNG side and it would be useful to include them in any molecular genetic analyses such as those done or proposed by Allen et al. (2001) and proposed by Ayalew et al. (2011).

What are not well researched and known are the unique qualities that make these native genotypes worthy of conservation as pure breeds and having the possibilities of contributing valuable genes to pigs of the future. Such qualities could revolve around digestive systems or disease/parasite resistance. For example, are these pigs better able to digest plant fibre than the commercial pigs? A comparative evaluation of the qualities of native pigs in PNG and native goats (Small East African type) in Zambia shows how each species is uniquely adapted to its respective ecosystem (Quartermain, 1977). The danger of continued crossbreeding means that it is necessary to take active steps in conservation of the native pigs which may have genotypes and characteristics that vary between PICTs. In New Zealand there are pigs of the unique Kunekune breed of a Chinese type (Trotter and McCulloch, 2010) descended from early introductions by Asian immigrants and these pigs may have left genes in other parts of Polynesia. On Lifou in New Caledonia there are, or were, pigs of a Vietnamese type called Tonkinoise with similar origins (Quartermain, 1981). There are some interesting genetic influences in the presence of hermaphrodites and hairless pigs in Vanuatu and the tradition of growing circle tusks has not disappeared.

Recent initiatives have seen the establishment in Fiji of a herd of native pigs gathered from around the islands for evaluation under the FAO-SPC South West Pacific AnGR Project – Conservation of Indigenous Pig and Chicken Breeds in Fiji, Niue and Cook Islands (SPC, n.d.). Similar herds for the needed research should be established in PNG and Vanuatu, and possibly in FSM (Pohnpei or Chuuk). It may not be necessary precisely to determine the existence of differentiated genetic subgroups among the general population of native pigs in any PICT or even across PICTs. It is doubtful if any differentiation could cause significant variation in traits or abilities that are adaptive because all have been and are subject to the same ecological environments except for climate. However, working within countries is urgent and should use available resources to gather together and evaluate, if necessary, in planned experiments, those characteristics likely to differentiate them from modern commercial genotypes. Obvious crossbreds can be eliminated through phenotypic assessment, *e.g.* coat colour patterns (Lauvergne et al., 1982). However, it is possible that increased variability through having some exotic genes may even be beneficial if selection for adaptive traits is the objective rather than conservation of an ancient lineage per se. While molecular genetic studies of relationships between populations across South East Asia and the Pacific, with estimates of the degree and timing of differentiation, are scientifically and historically interesting they may not take high priority with respect to research resources compared to assessment of existing populations. Hence the FAO-SPC Project 2 could be considered more important than project 1 with replication of the Fijian initiative as suggested.

Poultry - chickens

As with pigs, chickens can be found in all of the PICTs. Again, there are three types pf population comprising native or village birds, commercial layers and broilers, and various crosses. The native chickens are descendants of those introduced by Austronesian settlers and spread across the Pacific some 3000 years ago. The FAO Global Data Bank and World Watch List have entries for the Shaver Brown and Shaver White, local chicken and wild chicken of the Cook Islands, the village chicken of the Solomon Islands and the Vanuatu chicken. However, all PICTs have native, village or local chickens with variable genetic influences from crossbreeding with commercial layer types either deliberately in so-called improvement programmes or inadvertently and unplanned. An account of all the improved chicken distribution schemes in PNG is given by Quartermain (2000). Flocks of the Australorp breed (Kohun et al., 2014) used in these schemes were still extant until recently but purebreeding has now essentially ceased.

These original pre-colonial chickens need evaluation for unique characteristics that might make them valuable sources of genes for future breeding. Such characteristics include the ability to make selective use of the feed resource base under free range conditions as well as disease/parasite resistance, ability to avoid predation, organoleptic qualities and the provision of coloured feathers for traditional uses. High levels of genetic diversity have been found in the PNG population (Sheng-cheng et al., 2010).

An interesting find on the small island of Santa Cruz in the Temotu Province of the Solomon Islands was a population of what were identified as the Red or Wild Jungle Fowl (Parker, 2014; Russell Parker, pers. com.). These birds are a genetic isolate of unknown origin but integrated into the traditional customs of the islanders. DNA sampling in 2007 and 2011 has indicated that they are not pure Red Jungle Fowl but that genetic mixing predated introduction of modern breeds into the Solomons. Plans are underway for conservation and evaluation as to possible utility in breeding programmes.

There has been a recent initiative under the FAO-SPC South West Pacific AnGR Project (SPC, n.d.) in establishing observation flocks of native chickens in the Cook Islands and on Niue for breeding, evaluation and conservation. A DNA characterization pilot project was carried out in Fiji, Niue, Samoa, Solomon Islands, Tonga and Vanuatu under the SPC-FAO South west Pacific ANGR inventory and DNA characterization pilot project (SPC, n.d.). Although results have been hard to find, indications are that, according to DNA analysis Niue has a unique breed of indigenous chickens that is too valuable to be lost and chickens from all six countries show high genetic diversity and have not been contaminated by commercial breeds. NARI in PNG are in the process of establishing a similar observation flock but this needs yet a wider sampling from remote areas not known to have been involved in any distribution schemes.

Poultry – ducks and others

Muscovy ducks have been a successful introduction into many of the PICTS dating back at least in PNG to the 1950-1960s. Numbers are unknown but have been steadily increasing in PNG, there are large numbers in Fiji and there are significant numbers estimated and recorded for the Solomon Islands, Palau, Tonga and Tuvalu. The birds readily incubate their own eggs and are an easy-care scavenging bird for families. Probably there have been no further introductions and the Cook Islands have entered the Muscovy Duck of Rarotonga as endangered in the World Watch List due to decreasing numbers of owners.

Other poultry breeds or species such as layer ducks (Pekin, Campbell, Rouen, Indian Runner), Japanese quail, guinea fowl, pigeons, geese and turkeys have been tried (Quartermain, 2002) and may still be present in a number of PICTs (feral pigeons in PNG) but have never become important anywhere. The Native Pigeon of the Cook Islands has been listed as endangered.

Other species

Rusa deer (*Cervus timorensis russa*) are domesticated in New Caledonia and there are about 9,500 on farms (Severine Bouard, pers. com.). The species is also wild and hunted in the Western Province of PNG as well as in New Caledonia. It is not expected that the New Caledonian deer are a differentiated genotype. It is stated (Wikipedia) that they have also been introduced into Pohnpei, Fiji, Tonga, Samoa, Vanuatu and the Solomon Islands but there is no evidence of establishment.

The live capture and raising of crocodiles of both species (*Crocodylus porosus* and *Crocodylus novaeguineae*) in PNG has been recognised and regulated since the 1970s. Reproduction in captivity is now well established and there is a good export market. *Crocodylus porosus* is also endemic in the Solomon Islands and the government has been promoting farming, but there is no evidence of much progress and the animal may be endangered due to hunting pressure and loss of habitat.

The South East Asian swamp buffalo was introduced into PNG early in colonization, from 1891, for plantation work and at one time were quite numerous with later importations from Australia (Quartermain, 2002). It was thought in the 1970s that they might be more useful for beef production on the Sepik Plains where cattle production was proving difficult. However, this venture failed and there are now few if any feral animals there, and there might be a very few buffalo still kept by villagers for work as a remnant of earlier government initiatives.

Among the equine species, horses are found in all PICTs except the atolls and Nauru. They are used both for sport and for work (in Tonga they are also eaten) but in the context of this paper their usefulness is confined to work on cattle ranches. Numbers are not differentiated but there are large numbers in Fiji, New Caledonia, Tonga, Samoa and Vanuatu with numbers also in PNG. There have been donkeys used as pack animals in the past on plantations in PNG and Samoa and possibly elsewhere but there are none or very few now. Proposals have been made in PNG to re-establish the species as suitable for transport to remote villages in the mountainous terrain, but adequate investments have never been forthcoming. However, they are judged to be more suited for this role than horses, cattle or buffalo.

Domestic rabbits are well established in New Caledonia with some 6000 animals and the introduction into PNG of New Zealand White and Canberra Half-lop breeds in 1993 under very strict quarantine protocols has resulted in disappointing adoption by villagers. However, an estimate of 30,000 animals was made in 2005 (Bourke et al., 2009). Guinea pigs are present in PNG as pets and were considered for exploitation as a meat source for villagers. However, they have proven unsuited to this role and have not been adopted.

The European honey bee (*Apis mellifera*) is well established as a domestic animal in PNG (4,000 hives; Orlegge and Gonapa, 2011), New Caledonia (6,800 hives), the Solomon Islands (750 hives) and probably elsewhere. It is the basis of a thriving and growing honey production industry in the Eastern Highlands Province of PNG.

Other PNG animals considered for wider controlled exploitation or possible domestication include cassowary, wallaby and bandicoot. Cassowary chicks of any one of the three species extant in PNG (*Casuarius casuarius*, *C. bennetti* and *C. unappendiculatus*) are traditionally captured by some PNG highlanders and raised in captivity for eventual gifting and food. Their aggressive nature however makes them unsuitable for further domestication. The agile wallaby (*Macropus agilis*) has been considered and tried without success. A recent paper by Cornelio (2018) described the taxonomy, morphology, habitats and reproductive characteristics of members of the bandicoot (Peroryctidae) family with consideration of controlled harvesting and eventual farming in the Solomon Islands and PNG. This idea has been discussed in PNG for many years but no attempts have been made to investigate this further.

Strategies for amelioration and priorities for conservation and use

Many suggestions or recommendations for interventions have been made or alluded to in the several species-specific sections. These and others are now consolidated as strategies and priorities. The first and essential priority is to get governments, state institutions, research centres, communities and non-government organizations to commit to conservation and, where feasible, utilization and amelioration of the available national AnGR (Hoffman and Scherf, 2010). Dreams of creating new breeds through crossbreeding or introducing new breeds or even species through importation must take second place.

Also, research in molecular genetics is given low priority compared to evaluation of existing AnGR and improvement through conventional selection programmes. However, the former should not be ignored completely since it may be possible that useful genes or gene combinations may be uncovered that might otherwise remain hidden. Also, there are unique populations such as the Santa Cruz chickens of the Solomon Islands that deserve attention and there may be benefit from investigating degrees of genetic mixing in the native pig and chicken populations. Genetic resistance to disease maintained by natural selection has been shown in Red Jungle Fowl and indigenous village chickens (Ommeh et al., 2010).

In a recent paper, Quartermain (2017a) proposed the development of focused policies and plans for livestock sector development in PNG. Emphasis was given to the maximal and effective use of locally available resources, including the AnGR. Earlier, Quartermain (1989) had elaborated on livestock development strategies arising from the 13 country FAO/UNDP Regional Livestock Development Project in the Pacific and covering nine nations with land areas under 1000 km^2 and having less than 100,000 people. While emphasis in the project and report was on smallholder commercial type pig and poultry production, attention was also given to the needs of families which are dependent on native pigs and chickens for subsistence. There is much information and suggestions available as to how the productivity of these herds and flocks can be improved using local resources.

It is now necessary to list the main feasible interventions, prioritize these, uncover any problems and recommend further plans of action.

1. Promotion of cattle production should be confined to the category 1 PICTs of Table 1. The important issue here is to ensure the availability of the necessary geographic and human resources and not think only of import substitution or even export. Importations of breeding stock will continue with the only proviso that the crossbred stock on the ground should always contain zebu (Brahman) genetics. Nevertheless, in category 2 and 3 PICTs, tethering of cattle may be a continuing option, but with cattle the problem is that they reproduce so slowly.
2. Sheep and goat flocks and herds can expand where conditions allow using the now locally available genotypes. Probably the Fiji Fantastic sheep are underutilized and the 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 indigenous 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 into the future. There is also the milk production initiative to consider.
3. For pigs and chickens, the clear need is to expand the research initiated on categorizing adaptive traits and exploring ways to utilize the native genotypes most effectively. Adaptive traits for outdoor production systems are needed for developing commercial production systems as well as enabling the native stocks to continue contributions in household scavenging systems. Research is urgently needed to evaluate native stocks for these adaptive traits and determine how best to use them as they are uncovered. The genetics of these animals is the major underutilized resource for animal production in the region.
4. The two species with the most potential for further production development are deer, at least in New Caledonia and PNG, and honey bees. The former can be regarded as underutilized ANGR as a farmed animal and is deserving of some research and development attention. Little is known in the Pacific about possible genetic differentiation in the honey bee, *Apis mellifera*. Rabbits will probably continue in production where they are established but they cannot be regarded as an underutilized resource.
5. None of the other species mentioned can be regarded as ANGR with potential for amelioration. There have been few successes with these minor species and many failures.

It is suggested that dreams of success with these or new introduced species will not be fruitful. All resources and efforts should be directed at the established species in the PICTs where they are established.

6. What is really important is that before any favoured or costly interventions aimed at expanding production, especially of grazing animals, there must be further research into the available land resources in competition with commercial cropping, tree planting, ensuring retention by communities of adequate garden land in the face of increasing needs for food security, and forest conservation. There should be no clearing of forest land for grazing. The problem seems to be that governments, development agencies and commercial interests put more emphasis on the demand for products than on the feasibility of producing them.

Conclusions

It seems necessary to consider what might be done with respect to amelioration using underutilized AnGR in two different aspects. Firstly, there is a scientific or experimental research aspect and secondly a rural or national development aspect. For the former, there are the following considerations and suggestions bearing in mind that there is very limited capacity in the region for research:

1. Characterization of the existing AnGR as identified with potential for expanded use or potential for contributing genes to crossbred or commercial populations. Some DNA work may be required.
2. On-going research on animal nutrition and health, including the foraging resource base for pigs and chickens.
3. Definition of selection criteria and procedures for genetic improvement
4. Assessment of available resources for expansion of numbers.

For the latter aspect, the following can be done:

1. Prioritize and intensify extension for animal husbandry and management with utilization of AnGR in production systems.
2. Assessment of what genotypes are needed to meet predictable future needs.
3. Special attention directed at the needs of the atolls with limited options.
4. Genetic improvement of prioritized breeds or crossbreds through selection with appropriate use of established bio-technologies.

In conclusion, it must be reiterated that the range of both AnGR and geographic resources are extremely limited, especially for small islands (within as well as between countries) and atolls. It can be noted that underutilized may mean by numbers of animals or by potential to increase production without increase in numbers. Expansion of production cannot be done based on demand for consumption or dreams of export but only what is feasible given the existing AnGR and environmental constraints. Nevertheless, the region has useful and established AnGR and opportunities for amelioration given correct policies and sensible and effective extension programmes.

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Underutilized AnGR for Food and Nutrition - Regional Scenario on their Genomic Adaptation

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Introduction

Livestock contributes to and is also affected by climate change. While the demand for animal-sourced food has been consistently growing, climate change is becoming a major threat to the sustainability of extensive livestock systems where indigenous animal genetic resources still play an important role in Asian and African developing countries. Heat stress from climate change has been leading to the most significant, negative impact on livestock productivity, *e.g.* reduced milk, meat and egg production as well as impaired reproductive efficiency and immunity. Climate change also affects intensified livestock production systems via limited availability of feeds and water resources. However, methane emissions from intensive livestock production systems have shed significantly negative impact on animal agriculture.

New genomic resources to unlock the genetic basis of disease resistance and agro-climatic adaptation in AnGR are nested in association mapping populations for genomic dissection of disease resistant and agro-climatic traits. Genome-wide SNP maps of global livestock diversity for trait-disease/climate-SNP associations and transcriptome analyses of diverse indigenous AnGR under disease/environmental challenges are being explored (Figure 2).

Genomic datasets

Datasets made up of whole-genome sequences from 77 native sheep of 21 native breeds of different genetic and geographic origins in China - at an average effective sequencing depth of c.5× for 75 samples and c. 50× for two samples and whole genomes of three wild species of the subfamily Caprinae, viz *Ovis aries musimon*, *Ovis ammon polii* and *Capra ibex* (one animal from each species) have been created (Figure 1). Grouping of the samples was based on samples from habitats in extreme (or harsh) environments such as Tibetan areas on the Qinghai-Tibetan Plateau (defined as 'plateau', altitude > 4,000 m high), high-altitude region (altitude > 1,500 m high), Taklimakan Desert region (defined as 'desert', average annual precipitation < 10 mm), and arid zone (average annual precipitation < 400 mm, representing arid and semi-arid regions (Photograph 1).

Genomes of 260 modern and eight ancient cattle at 12.72X made up of modern animals representing 22 geographically diverse breeds in China and three indicine cattle representing three Indian breeds were extracted from 146 individuals from 24 breeds retrieved from public databases.

Tibetan Plateau sheep
(Tibetan sheep)

Yunnan-Kweichow Plateau sheep
(Weining sheep)

Taklimakan Desert sheep
(Lop sheep)

Photograph 1. Sheep breeds adapted to different climatic zones

Tremendous achievements on the improved understanding on genomic adaptation of major livestock and poultry species to adverse environmental challenges, *e.g.* heat/cold stress and hypoxia at high-altitudes;

Conclusions

Tremendous achievement on the improved understanding on genomic adaptation of major livestock and poultry species to adverse environmental challenges, *e.g.*, hot and cold stress and hypoxia at high altitude has been achieved. Several large geographic scale and deep genome coverage resequencing data from indigenous animal genetic resources in Asia and Africa were also created through international intensive collaborations. Long term natural selection within a species and historical hybridization or introgression between species towards accumulation of advantageous genotypes or alleles responsible for the enhanced genetic tolerance to heat or cold and hypoxia challenges have been occurring since the beginning of native animal populations.

- Several large geographic scale and deep genome-coverage re-sequencing data from indigenous animal genetic resources in Asia and Africa through international intensive collaborations;

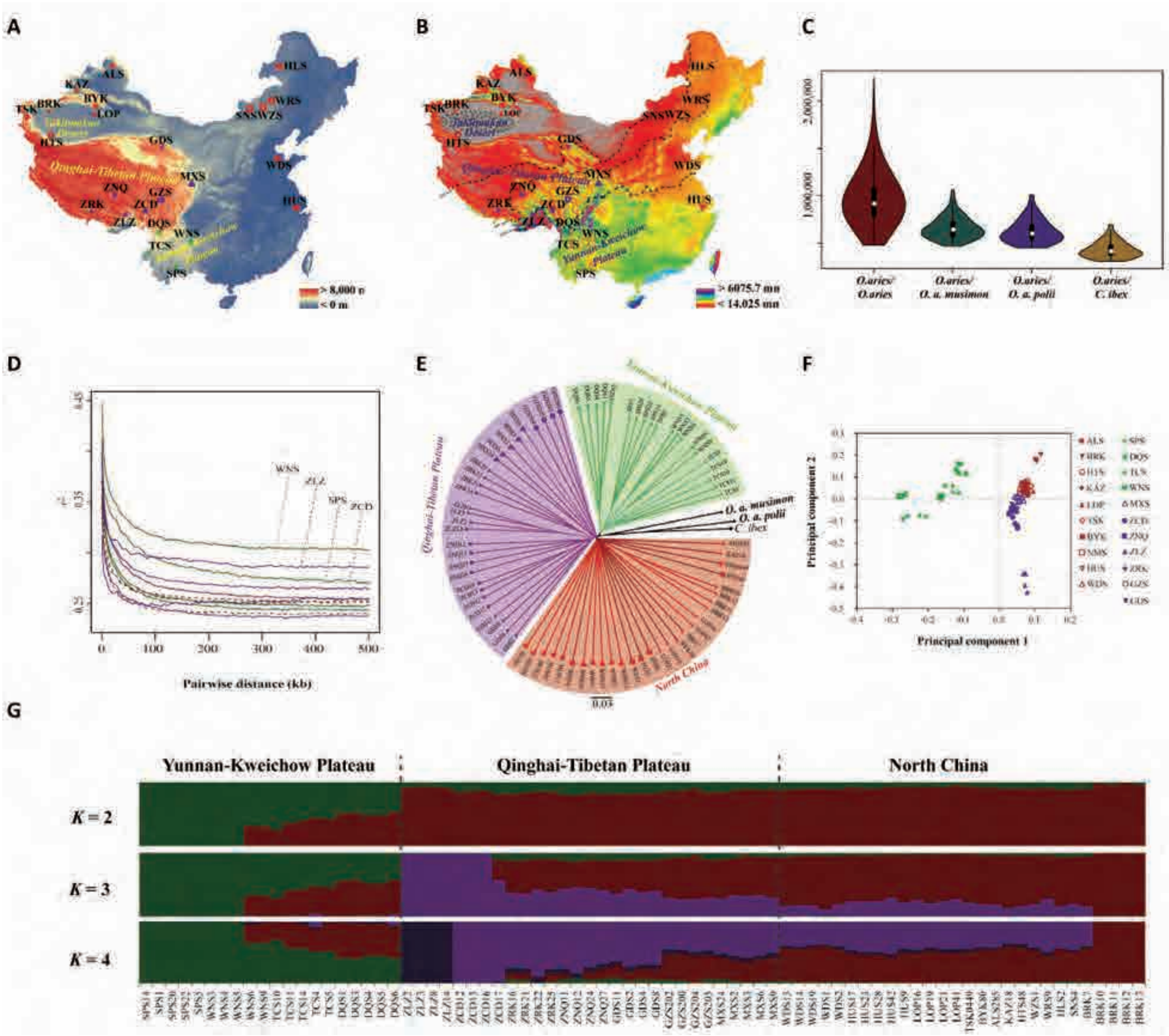

Figure 1. Geographic distribution and population genetic analyses of 21 native sheep breeds

- Long-term natural selection within a species and historical hybridization or introgression between species towards the accumulation of advantageous genotypes or alleles responsible for the enhanced genetic tolerance to heat/cold and hypoxia challenges.
- Tremendous achievements on the improved understanding on genomic adaptation of major livestock and poultry species to adverse environmental challenges, e.g. heat/cold stress and hypoxia at high-altitudes;

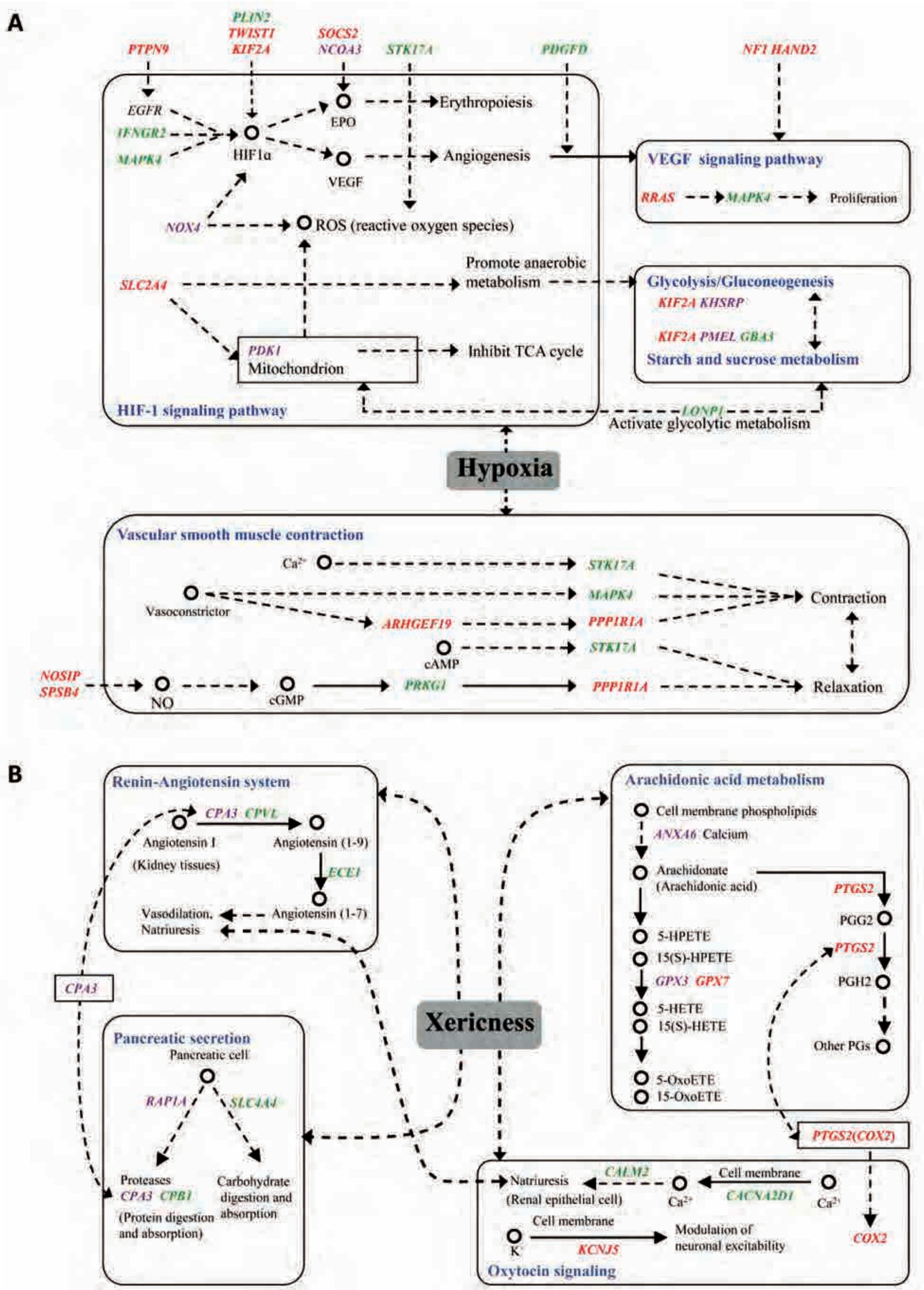

Figure 2. Schematic mechanisms for signaling of pathways for genetic adaptation to extreme environments in sheep.

Inventory, Characterization and Monitoring of Underutilized AnGR

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ABSTRACT

In Asia as it is all over the world, Animal Genetic Resources (AnGR) are under threat. Particularly underutilized breeds of livestock are under threat as they lack utility and are perceived to be lacking in economic potential. Inventory, characterization and monitoring are the first steps in the management of AnGR. However, countries need to have a proper system of administration to manage AnGR effectively. Inventories are undertaken to determine the distribution and composition of breed and breed habitats. An inventory of breeds will mainly include information on their population size, geographic distribution and population trends over time. From the Second State of the World's Report on AnGR, it appears that South East Asia has among the lowest rate of baseline surveys of population size and more emphasis needs to be given to improve inventory in this region. Characterization includes both phenotypic and genetic (molecular) characterization. The term phenotypic characterization of animal genetic resources generally refers to the process of identifying distinct breed population and describing their external and performance characteristics within a given production environment. Molecular or genetic characterization refers to the detection of variation as a result of differences in either DNA sequences or specific genes. Comprehensive national inventories, supported by regular monitoring of trends and associated risks, are a basic prerequisite for the effective management of AnGR. Monitoring is typically used to understand rates of change or the effects of management practices on AnGR populations and their habitat. Updating the Domestic Animal Diversity Information System or DAD-IS needs to be enhanced by all countries. Countries should commit significantly more funding and undertake capacity building to enhance the sustainable development and conservation of underutilized AnGR.

Keywords: Underutilized Animal Genetic Resources, Inventory, Characterization, Monitoring

Introduction

Underutilized Animal Genetic Resources (AnGR) relate to those breeds/strains which appear to have significant potential for use, yet whose potential is scarcely exploited, if not totally neglected, in agricultural production (GTZ, 2005). These AnGR are also referred to in the literature as "minor", "neglected" or "orphan" breeds. More positively these breeds have been referred to as "alternative" or "promising" breeds. Modern agriculture has focused on a few livestock breeds which are usually highly productive, such as the Holstein Friesian for milk production and the Large White, Landrace and Duroc pig breeds for swine production. Other reasons for the underutilization of such breeds are varied, such as, being perceived as of no economic value, promoting these breeds takes too much effort compared to their economic returns, their beneficial traits are not well known, neglected by livestock research and appear to be unmarketable. However, climatic changes and other related developments have led to greater appreciation of underutilized breeds (Evy Thies, 2000). Many underutilized breeds are adapted to low input livestock production and can become breeds of choice. Also, the higher standard of living in developing countries can create demands for more natural food and environmentally-friendly products, a demand which can be met by underutilized breeds. Furthermore, underutilized breeds hold great genetic diversity, and a vast tradition of indigenous knowledge is linked to these breeds.

Photograph 1. A herd of Kedah-Kelantan native beef cattle in an oil palm plantation in Pahang, Malaysia.

According to the FAO, despite their great potential for sustainable development, AnGR are underutilized and under-conserved (FAO, 2013). In 2012, of the 8,262 breeds reported to FAO by its Member Countries, 1,881 (*i.e.*, 23%) are at risk of extinction or are already extinct. As genetic erosion is a problem of national, regional and global concern, the Food and Agricultural Organization (FAO) facilitated the development of the Global Plan of Action for Animal Genetic Resources (AnGR) (FAO, 2007). Under this Global Plan of Action are four Strategic Priority Areas, the very first of these covering Inventory, Characterization and Monitoring of Animal Genetic Resources. Inventory, characterization and monitoring are generally undertaken as a first step in any program for the management of animal genetic resources for food and agriculture. FAO also coordinated the first and second State of the World's Animal Genetic Resources Reports (SOW-AnGR) which provide a global overview of the diversity, status and trends of AnGR and countries' capacity to manage, conserve and develop these resources. These SOW-AnGR reports generally show that national databases and information on AnGR are often poorly developed. Hence there is a

Photograph 2. A Bali cattle native to Indonesia.

Photograph 3. Katjang breed of goats found in many parts of South East Asia

great need to strengthen initiatives at inventory, characterization and monitoring of AnGR to support conservation and breed development programs. This manuscript will cover the more salient aspects of inventory, characterization and monitoring of AnGR as these are particularly important in the conservation and development of underutilized breeds.

Pre-requisites for Undertaking Inventory, Characterization and Monitoring

In order to undertake inventory, characterization and monitoring, countries need to have a National Consultative Council or Committee (NCC) to oversee all aspects of conservation and sustainable development of animal genetic resources. This grouping should meet on a regular basis to administer AnGR projects within the country. Each country should have a government appointed national institution (National Coordinating Institution, NCI) that is responsible for implementing and maintaining an in-country network for national development of the Global Plan of Action for Farm AnGR.

Each country should also have a government appointed National Coordinator (NC) for the country development of the Global Plan of Action for AnGR. The National Coordinator should preferably be a member of the NCC, be technically competent and hold his post on a long-term basis. For continuity, there should also be an alternate NC. The National Coordinator would be responsible for the development of an operational country network and within-country organization of activities concerning the management of AnGR. The National Focal Point for the Management of AnGR (NFP) will include both the NC and NCI.

Inventory

In general terms, *inventories* are conducted to determine the distribution and composition of breed and breed habitats. It is an attempt to document and identify all breeds living in a country or region (trans-boundary breeds). An inventory of breeds will mainly include information on their population sizes and their geographic distribution. Also important are the population trends over time. Inventories are generally undertaken as a first step in any national program for the management of animal genetic resources for food and agriculture. The prime purpose of such an assessment is to document the current state of knowledge in terms of a population's ability to survive, reproduce and produce and provide services to farmers. From the Second State of the Worlds Animal Genetic Resources report, North America has the highest baseline survey of population size at 92 % whereas in South East Asia it's only at 31% (FAO, 2015). From this general information it is apparent that more has to be done on inventory in this region.

Characterization

Characterization is the description of a character or quality of an individual. Some definitions of characterization are "the discernment, description, or attributing of distinguishing traits", "the act of describing the character or qualities of an AnGR" and "a description of the distinctive nature or features of an Animal Genetic Resource". Characterization provides the baseline information as well as the criteria that will be used to establish and update the inventory. Characterization provides data on present and future potential uses of the animal genetic resources under consideration, and establishes their current state as distinct breed populations and their risk status. Characterization includes both phenotypic and genetic (molecular) characterization.

Phenotypic Characterization

The term phenotypic characterization of animal genetic resources generally refers to the process of identifying distinct breed populations and describing their external and performance characteristics within given production environments. A breed is used in phenotypic characterization to identify distinct AnGR populations as a unit of reference and measurement. Phenotypic characterization is used to:

- Identify and document diversity within and between distinct breeds.
- Identify the geographical distributions of the breed.
- Know the status of the breed in terms of characteristics, performance etc. in their production environments.
- Develop a monitoring mechanism for conservation and sustainable use of the genetic resources.
- Create public awareness regarding the importance of AnGR

The process of phenotypic characterization involves literature searches, desk work in gathering existing data, and field recording work. Field work would include getting information on body biometry (observable traits such as height, weight, eye color, hair color and horn type), photos and production parameters (i.e., performance in the production environment) on sampled animals. The term "production environment", in this context, refers not only to the "natural" environment (climatic, terrain, *etc*.), but also to management systems and the uses to which the animals are subjected to. Assessment of the population characteristics of an identified breed is also an important component of livestock characterization. This includes estimates of population sizes, flock/herd structure, and assessment of the level of indiscriminate crossbreeding which are indicators of threat to the survival of the adapted indigenous genetic resources. Recording the geographical distribution of breed populations is considered to be an integral part of phenotypic characterization (FAO, 2015). Guidelines on phenotypic characterization are found in FAO (2012).

Genetic Characterization

In genetic terms, characterization refers to the detection of variation as a result of differences in either DNA sequences or specific genes or modifying factors. Molecular characterization or genetic characterization therefore, can be defined as the complementary procedures used to unravel the genetic basis of phenotypes, their patterns of inheritance from one generation to the next, within-breed genetic structure and levels of variability, and relationships between breeds (FAO, 2015).

Characterization of animal genetic resources is a prerequisite for its management. Advances in molecular genetics have provided us with tools to better understand livestock origin and diversity. There are many technologies capable of determining genetic profiles, including whole genome sequencing, shotgun sequencing, RNA sequencing and DNA microarray analysis. These techniques allow us to map genomes and then analyze their implications through bioinformatics and statistical analysis.

Molecular genetic studies, especially genome-wide association studies and whole-genome sequencing, allow adaptive traits to be linked to genomic regions, genes, or even mutations. From FAO Guidelines on Molecular Genetic Characterization of AnGR (FAO, 2011b), molecular characterization has been able to:

- Identify the wild ancestral species of several livestock species and localize the site(s) of domestication.

- Provide understanding into breed formation and breed uniformity.
- Assess the genetic constitution of breeds.
- Partially reconstruct the phylogenetic relationships of populations, unravelling the evolutionary history of species and populations.
- Allow investigation of algorithms that can be used to prioritize breeds for conservation using molecular data.
- Introduce information into the permanent scientific record.
- Establish an informal international network of organizations and institutions involved in molecular studies of AnGR.

Some of the challenges of the application of molecular characterization of animal genetic resources in developing countries are poor infrastructure, lack of reference genomes, deficient biological background information, unavailable population genotyping data, lack of political will, inadequate funding, poor laboratory services and inadequate technical manpower (Gamaniel and Gwaza, 2017). FAO can assist the global effort in molecular characterization through facilitating networking between international reference laboratories and regional and national molecular laboratories involved in genetic characterization of AnGR.

Monitoring

Monitoring of AnGR is the process of observing and examining the progress of inventory, population trends and characterization activities. It is a systematic review of inventory and characterization actions. Surveying and monitoring are imperative as "*you cannot manage what you don't measure*". Comprehensive national inventories supported by regular monitoring of trends and associated risks, are a basic prerequisite for the effective management of AnGR. Without these, some breeds with distinctive traits may be reduced significantly, or be lost, before their worth is recognized and measures taken to safeguard them. Thus, risk status indicators for use during the monitoring process need to be defined following the inventory and characterization steps. Monitoring is typically used to understand rates of change or the effects of management practices on AnGR populations and their habitat.

Benefits of monitoring include (FAO, 2011a):

- Enhance knowledge of population size and structure and monitor trends.
- Enhance knowledge of breeds' geographical distribution.
- Enhance knowledge of breeds' characteristics.
- Enhance knowledge of cross-border genetic linkages.
- Enhance knowledge of breeds' production environments.
- Document cultural aspects of livestock production and breed utilization.
- Document indigenous knowledge.
- Identify and monitor threats to animal genetic resources.
- Support strategic planning for the sustainable utilization of animal genetic resources.
- Improve livelihoods.
- Improve priority setting for conservation programs.
- Raise public awareness.
- Meet international obligations for reporting on the status of animal genetic resources.

Domestic Animal Diversity Information System

The Domestic Animal Diversity Information System or DAD-IS is an important tool developed and maintained by FAO (FAO, 2014). It provides us with access to searchable databases of breed-related information and photos and links to other online resources on livestock diversity. Furthermore, we can find the contact information of all National Coordinators for the management of animal genetic resources. It allows us to analyze the diversity of livestock breeds on national, regional and global levels including the status of breeds regarding their risk of extinction. National information on DAD-IS is entered by the office of countries' National Coordinators for AnGR. According to the FAO, DAD-IS gives us the ability to monitor national breed populations and with this, to make informed decisions on the management of AnGR. More than 15,000 national breed populations (representing more than 8,800 breeds and about 40 species) from 182 countries are recorded.

Information available on DAD-IS includes:

- Year and population – total, breeding males/females, AI/males in AI, *in situ* conservation.
- Breed data – name, trans-boundary status, uses, images.
- Origin and development, morphology, distinctive traits.
- Performance data – birth weight males/females, age of maturity, age of breeding animals, age at first parturition, parturition interval, length of productive cycle, daily gain, carcass weight, dressing percentage.
- Management conditions.
- *In vivo* and cryo-conservation.

Since the initiation of the Global Plan of Action for Animal Genetic Resources (FAO, 2007), more information has been collected on individual breeds of livestock and information on animal genetic resources within the country are maintained on DAD-IS. However, this is an ongoing process and cannot be considered as complete.

Conclusions

In the Asian region underutilized breeds of livestock are under threat. Inventory, characterization and monitoring are the first steps in the management of AnGR. However countries need to have a proper system of administration to manage AnGR effectively. For countries lacking in organization, they should establish a National Consultative Council to oversee all aspects of conservation and sustainable development of animal genetic resources. The National Coordinating Institution should be selected and a technically competent National Coordinator appointed. Greater efforts should be placed on inventory, characterization and monitoring. Updating DAD-IS with population and breed data needs to be enhanced by all countries. Countries should commit significantly more funding to undertake these AnGR enhancing activities. In addition, there should be capacity building to develop personnel in various AnGR management initiatives. FAO can assist the global effort in improving the development and conservation of AnGR through regional and global cooperation.

Acknowledgements

The authors wish to thank the Director-General of the Department of Veterinary Services, Dato' Dr. Quaza Nizamuddin for his kind patronage. Sincere gratitude is also extended to

the Food and Agriculture Organization of the United Nations for much of the information contained in this manuscript.

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Breeding Strategies for Underutilized Animal Genetic Resources and their Amelioration

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ABSTRACT

The ability to pool and deliberately mix semen from many sires and then use this mixture for instrumental insemination of larger groups of dams is a valuable tool for breeding of poultry populations. In mule duck production with two species crossbreeding via artificial insemination of laying duck sired with mixed semen from Muscovy duck, it is an essential application of multiple-sires instrumental breeding. In free range production, females of native chicken and laying duck can be multiple-sire natural mated to ensure a higher fertility rate of ovulated eggs. Although frozen semen are commercially available in dairy cattle mating system, but there are not for all of dairy breeds, especially in local breeds. Application of frozen semen and embryo may perform sire-daughter mating, brother-sister mating or son-dam mating for increasing genetic homogeneity without inbreeding depression of reproduction performance. Inbreeding quickly brings to the surface any detrimental genes that are in a population. Some excellent inbred lines of chicken, pig and dairy cattle were developed with selection for growth and good reproduction. For maintaining genetic biodiversity and conservation of underutilized and/or endogenous animals, a sound registry mating plan with artificial insemination of mixed semen from two or more breeds could be implemented to enlarge female population for later backcross and inbreeding of genetic identified-sires. With the facility of paternal DNA test, single-sire breeding can be used with extended semen and intra-uterine insemination to test the allele effect of sire genome on their economic traits of beef, goat, deer, rabbit, sheep, pig and poultry breeds in a small-scale farming system.

Keywords: semen, insemination, inbreeding, genome, conservation, biodiversity

Introduction

According to the FAO book of "Breeding Strategies for Sustainable Management of Animal Genetic Resources" (FAO, 2010), highlighted that genetic improvement is an essential component of animal genetic resources management and can make important contributions to food security and rural development. For each nation, the action plan is to develop effective and sustainable genetic improvement programs, taking into account their livestock development objectives and the characteristics of their production systems (FAO, 2011). Mankind started to create breeds of farm animal accompanied with artificial breeding and performance selection 260 years ago. Nowadays, breeding of highly productive farm animals, like cattle, pigs and poultry is in the hands of multinational companies which invest a lot of money in state-of-the art breeding programs. Basically, any population begins from one male and one female with natural or instrumental mating. The reproductive life of each female is affected by certain limited factors, such as the puberty age, seasonal breeding, semen quality and fertility to term. Underutilized animal genetic resources always exist in a small population or lack of animal breeding plan. Animal breeding is aiming at the improvement of animals by changing their genetic abilities for production traits related to social, cultural, food utilization and other purposes of animal keepers.

Animal identification and recording systems

Birth recording of individual animal of underutilized population may not recorded at day basis in a small-scale farm or backyard. To know the birth week and numbers in a litter would help the recording of reproduction ability, family relation and their phenotypic variance. To set the animal identification (coat color pattern can be marked) and recording system with digital photo is essential to consist of all or part of the integrated components of animal identification and registration, animal traceability, animal health information recording and animal performance recording (FAO, 2016). Although the existence of legislation, organization/ administration, technical devices and databases are necessary to perform breeding strategies in association with extension, research and development in applied population, quantitative and molecular genetics.

The following definitions of terms used to ensure clarity and to acknowledge that alternative definitions exist for these terms (FAO, 2016).

- Animal identification means the marking of an animal, individually or collectively, by its group, with a unique individual or group identifier.
- Animal registration is the process by which information on animals is captured manually or electronically, and then entered and securely stored to be made accessible to users as appropriate.
- Animal performance recording refers to the process by which indicators of animal performance are objectively and systematically measured, and related data including parentage, breed characteristics and related test events are collected, recorded, calculated and securely stored and made accessible to users as appropriate.
- Animal keeper is the person responsible for the day-to-day management of animals on the premises.
- Animal owner is a person (physical or moral) who has a legal title or right to the animals regardless of whether he/she owns the premises on which the animals are kept.

For example, the Domestic Animal Diversity Information System (DAD-IS) provides access to searchable databases of breed-related information and photos and links to other online resources on livestock diversity (FAO, 2019). In Taiwan, species of livestock and poultry are majority of pig, cattle, goat, deer, chicken, duck, goose, with some minority of horse, rabbit, turkey, swan, quail and ostrich (Figure 1) (Wu, 2004).

Other major poultry raised by local farmers include quail and ostrich. Due to high land prices and rising environmental awareness, most local farmers operate on a small scale in rural areas of Central and Southern Taiwan. Coupled with import-dependent feeds and expensive labor, the local livestock industry operates at a rather high production cost. Fortunately, local livestock farmers are highly diligent, and have advanced feeding and breeding skills.

Single-sire and multiple-sire mating

Genetic diversity is a measure of genetic and DNA differences between animals in a population (i.e., genetic variation). For maintaining genetic biodiversity and conservation of underutilized and/or endogenous animals, a sound registry mating plan with artificial insemination of mixed semen from two or more breeds could be implemented to enlarge female population for later backcrossing and inbreeding of genetic identified-sire. With the facility of paternal DNA test, single-sire breeding can be used with extended semen and intra-uterine insemination to test the allele effect of sire genome on their economic traits of beef, goat, deer, rabbit, sheep, pig and

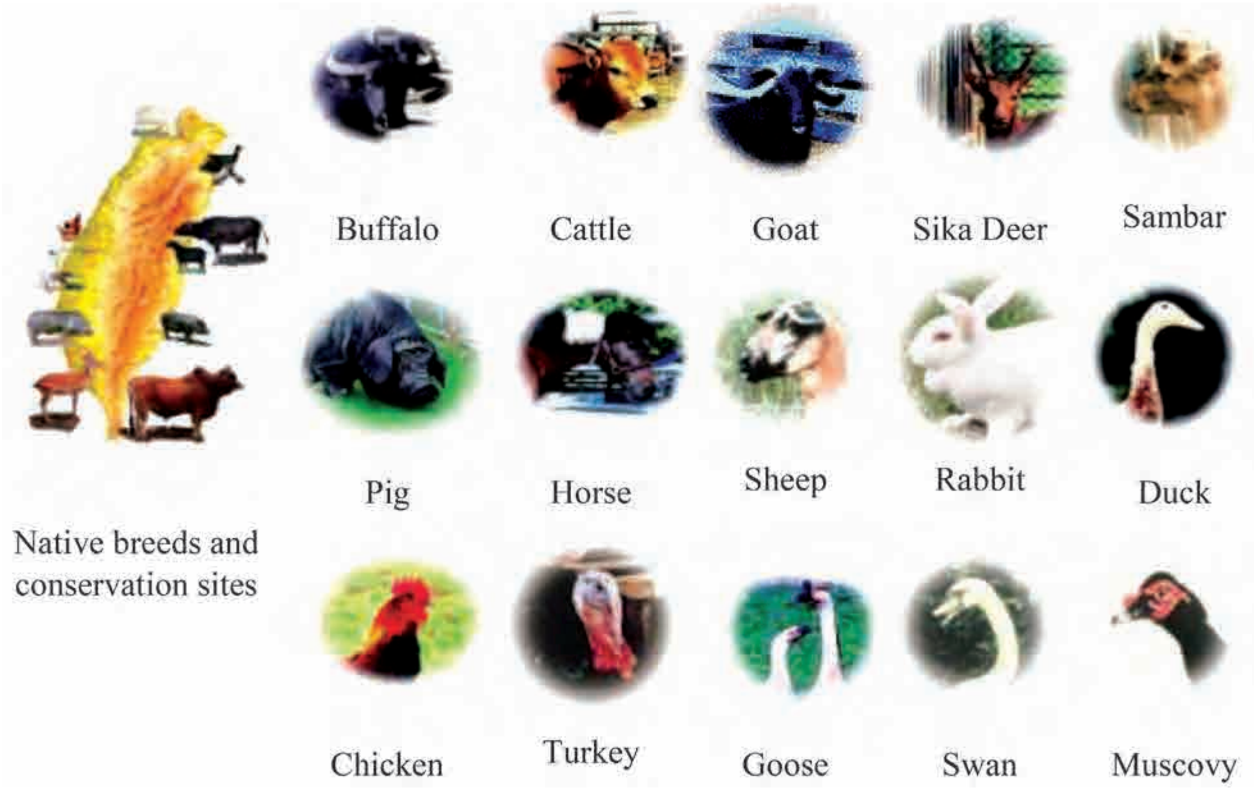

Figure 1. Breed resources for animal industry in Taiwan (Wu, 2004).

poultry breeds in a small scale farming system. A breeding program is illustrated as a circular activity (Figure 2) (Oldenbroek and van der Waaij, 2015). Each generation, the program starts with formulating the breeding goal and ends with a critical review

of the results obtained in the next generation. The evaluation might lead to a reconsideration of the breeding goal for the next round of selection.

- A trait is a distinguishing phenotypic characteristic, typically belonging to an individual. In practice this means anything you can record or measure on an individual.
- A phenotype is that what you observe or measure on the animal for a certain trait. It can depend both on the genetic background of the animal (provided it is heritable) and external circumstances such as level of nutrition.

The developed technique on sperm collection, storage, mixing and artificial insemination allows for a closed population breeding project yearly within a herd, or various populations, and/or various breeds, especially inter-genera crossing. Therefore, maternal and paternal genotypes of every animal could be unambiguously assigned by Mendelian inference. The sires were assigned to ensure fertility in the semen mix with low and high sperm quality measurements or based on the genotypic difference from those of sires. The technique overcomes the single-sire problems resulting from lack of rigorous mating control in breeding season under natural conditions or pen/group mating of multiple males in a large herd. The ability to pool and deliberately mix semen from many sires and then use this mixture for instrumental insemination of larger groups of dams is a valuable tool for breeding of poultry populations. In commercial production of two species cross mule duck via artificial insemination of laying duck sired with mixed semen from Muscovy duck, it is an essential application of multiple-sires instrumental breeding. In free range production, females of native chicken and laying duck can be multiple-sire natural mating to ensure a higher fertility rate of ovulated eggs.

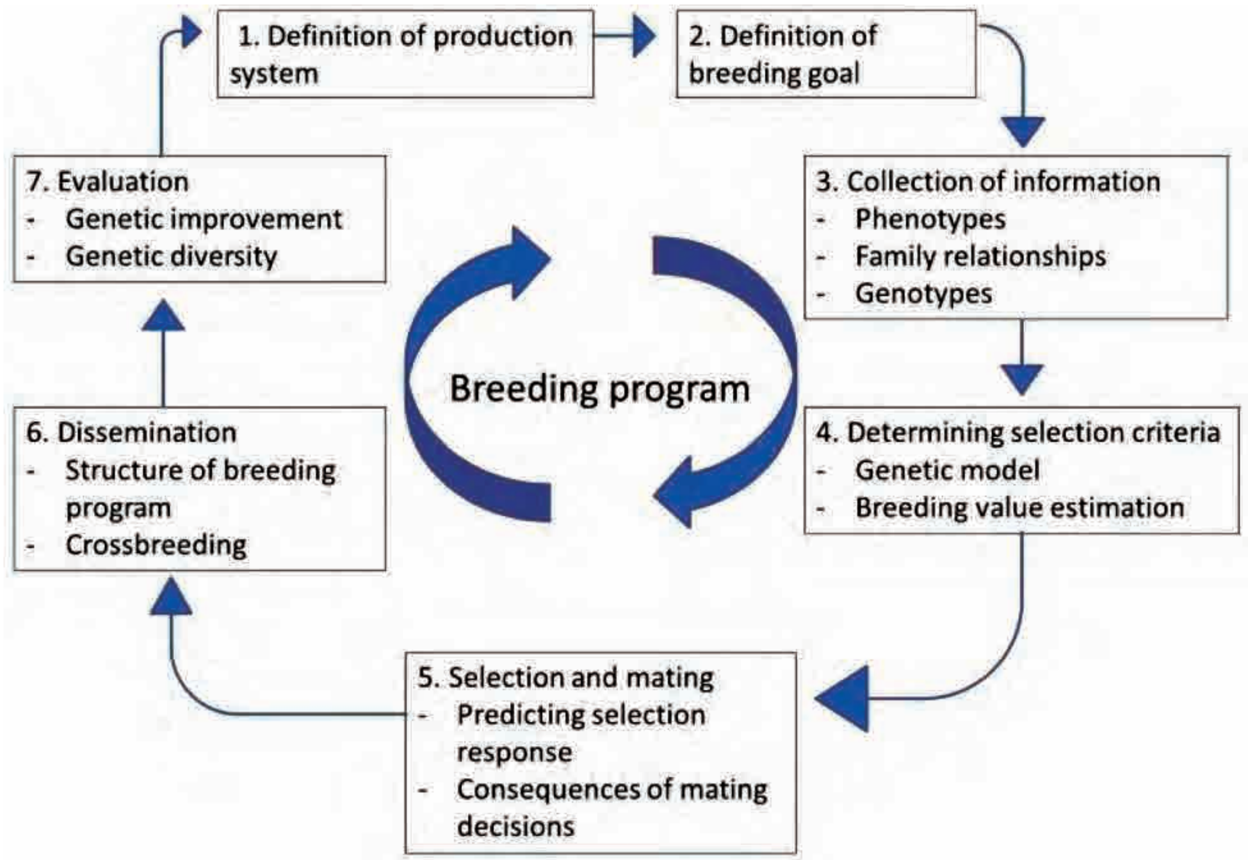

Figure 2. A breeding program is a circular activity (Oldenbroek and van der Waaij, 2015).

Inbreeding and outbreeding

Inbreeding is the result of mating two pedigree related individuals. Related individuals genetically are more alike than non-related individuals because they share alleles. Inbreeding increases homozygosity and decreases genetic diversity. Although frozen semen are commercially available in dairy cattle mating system, but there are not for all dairy breeds, especially in local breeds. Application of frozen semen and embryo may perform sire-daughter mating, brother-sister mating or son-dam mating for increasing genetic homogeneity without inbreeding depression of reproduction performance. Inbreeding quickly brings to the surface any detrimental genes that are in a population. Some excellent inbred lines of chicken, pig and dairy cattle were developed with selection for growth and good reproduction. To illustrate this outcome, due to a male having won an important competition, thereafter many breeders decide to use him as mate for their females. In the next generation it becomes clear that he was a champion for good reason because a number of his sons also perform (much) better than average, so they are also used for breeding relatively often. In the next generation, again some sons of these sons are better than average and are used a lot for breeding. A very large proportion of the inbred animals will have that first champion male as ancestor after a number of generations. Large genetic contributions of genetically superior animals will spread through the population and remain there as excellent inbred lines.

Crossbreeding is mating between animals of different breeds. Outbreeding is mating between animals of different lines within a breed. Phenotypic heterosis or hybrid vigor is the extent to which the performance of a crossbred in one or more traits is better than the average performance of the two parents. Heterosis is often substantial for fertility and health characteristics that cannot be easily improved by selective breeding due to the low heritability. Dominance is the genotypic value of the heterozygote on a trait is not the average of the two homozygotes.

Alleles with a negative effect are often recessive. Two breeds are crossed and the offspring are used only for milk, egg and meat production purposes but not used for selection or breeding.

- Gene introgression is to cross males of breed B with females of breed A to incorporate a characteristic that is present in breed B with a high frequency and that is absent or has a low frequency in breed A. For those underutilized animal resources, they may be absent or has a low frequency of one allele that resulted in higher quality in disease resilience and heat-tolerant reproduction. Application of introgression way is performed from local herd to imported herd for having the characteristics of local herd.
- Grading-up is the method used in the aims to change a population of animals quickly from one breed to another. Imported sires or frozen semen of the newly desired breed are continually backcrossed to the females from the previous generation. After three generations the F_3 animals contain already for 87.5% the genes of the desired breed and after four or five generations the population fully resembles the desired parental breed.
- New breed or synthetic breed is from that two breeds which are crossed and males and females of the F_1 generation are reciprocally mated to create a breed containing equal parts (50%) of the alleles of the two founder breeds. According to this principle also three or four breeds can be used to create a synthetic breed as a new breed.

Challenges and opportunities

In animal species kept for conservation purposes control over the breeding program by the animal keeper and owner is very loose due to limitations of all females in a small scale or lack of frozen semen storage from the breeding sires. The breeding goal, accuracy in collecting phenotypes, genotypes and pedigree registration, selection and mating are all important human factors that should be linked to social activity and marketing potential. The production of regional products with a high additive value and the maintenance of cultural historic activities are not key factors for their amelioration of underutilized animal resources as the developed technique on semen collection and insemination are implemented to the animal keeper. Single-sire breeding is performed to have genetically superior population. Multiple-sire breeding in mixed semen is to increase the fertility rate of female for more female progeny production and to evaluate quickly the favorable gene introgression.

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Utilizing Molecular Approaches for Underutilized Animal Genetic Resources

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ABSTRACT

Molecular biotechnologies are applicable in various fields and for various purposes. In the context of conserving animal genetic resources, application of molecular biotechnologies is in the form of genetic markers. DNA sequences in a genome contain many repetitive elements which are highly variable and mutate frequently. The characteristics of these elements make them suitable to be molecular markers. There are many types of DNA markers and these markers evolve with technologies. From the traditional, hybridization and chromosome-based markers, the common DNA markers now are DNA markers that are either gene based or linked to quantitative trait loci or more advanced genome-based markers such as SNP panels. In term of application, there are three main purposes to use DNA markers which are for genetic characterization, trait-linked purposes and genomic analysis to explore and obtain information. In MARDI, molecular markers are used for all the above purposes. Characterization of breeds has been performed on local cattle, goats, buffaloes and native chickens. Traits linked to production such as high growth, high fertility and resistance to diseases have been studied using various DNA markers.

Keywords: DNA markers, molecular biology, animal genetic resources, SNP panel, gene expression

Introduction

The importance of underutilized animal genetic resources should not be underestimated. At a time where there are too many uncertainties especially in terms of environment and climate change, understanding the diversity, distribution, basic characteristics, comparative performance and the current status of each country's animal genetic resources are essential for their efficient and sustainable use. Structured breeding of Animal Genetic Resources (AnGR) is a necessity to ensure the conservation of these valuable resources is done in an efficient manner utilizing the right animals and pedigree. Hence it is of utmost importance to be able to identify the most desired breeds, pedigrees and animals. Many tools can be utilized for the above purposes. However, molecular biology tools have been identified as one of the more accurate methods given their consistency and accuracy.

DNA marker is an application of molecular biology tool that is based on information at the genomic level. The genome is a powerful source of information in the form of deoxyribonucleic acids (DNA). It holds all information necessary for an organism to survive and is located in the nucleus in every cell. Thus, without it or, even a slight change to it could result in very detrimental consequences. The genome size varies from 580,000 bp for *Escherichia coli*, 3 billion bp for humans to as large as 120 billion bp for wheat. From these sequences only a small percentage are genes which are the DNA sequences that are actually transcribed and translated into proteins. In humans, this is only about 3% of the total DNA or approximately 25,000 genes (Dunham et al., 1999). The other 97% consist of other sequences mostly of unknown function and a major portion of these sequences are highly repeated (Flavell,1980). Generally, repetitive sequences in the genome can be divided into two types: repeats that occur in a tandem fashion and form large blocks (Heslop-Harrison, 2000) and repeats that have a dispersed distribution (Hull, 2002). Some of the repeated sequences do have clear functions such as telomeric, centromeric or ribosomal DNA, but for most of the repeated DNA, the function and role still remain a mystery. They are however, highly variable, mutate frequently and are very abundant. These repeated sequences are therefore useful markers for comparative studies of genomes and for investigation of phylogenetic relationships between species. Studies on markers allow us to establish association or linkages between genes and these markers, thus understanding the genotypes of a certain trait.

The evolution of DNA markers

The development of DNA markers follows the advancement of methods in molecular biology. Most of the DNA markers are based on the concept of hybridization. The initial hybridizations were carried out on membranes, commonly known as Southern Hybridization. When polymerase chain reaction (PCR) was developed in 1985 by Kary B. Mullis, DNA markers were then developed based on this method. PCR is basically an amplification technique for a hybridization process guided by DNA fragments known as primers. Now with emerging fields such as genomics and molecular cytogenetics, hybridization is now carried out on glass chips, and hybridization is done on either DNA clones or on the chromosome.

There are generally two types of PCR based DNA- markers that have emerged over the years. The first type of PCR-based DNA marker uses arbitrarily or semi-arbitrarily primers and the second type is sequence targeted. Markers generated by PCR include Random Amplified Polymorphism (RAPD), Amplified Fragment Length Polymorphism (AFLP) and Sequence-tagged Microsatellite Site (STMS). Random Amplified Polymorphism (RAPD) marker uses a short oligonucleotide as a primer and in low stringency conditions. This will result in multiple amplification products from loci distributed throughout the genome (Williams et al., 1990; Welsh and McCelland,1990). Amplified Fragment Length Polymorphism (AFLP) uses primers that are specific for one restriction site and adapter, the other is specific for unique parts corresponding to the selective bases.

The field of genomics is a field where all the genes in a genome is studied simultaneously. Genomics can be divided into two main areas - physical nature of whole genomes (structural genome) or overall pattern of gene expression at the mRNA level (functional genomics). In both areas, markers can be used for mapping the detailed characterization of any economic trait and for identification of relevant genes controlling traits of interest. Single Nucleotide Polymorphism (SNP) is a DNA based marker that gives a lot of information on polymorphisms detected in a functional candidate gene or within chromosomal region containing quantitative trait loci (QTL) (Eggen and Hocquette, 2003). In SNP, high technology is used to identify single base mutations in the DNA sequence. The association of the existence of SNP with the variability of a phenotype will be useful in identifying genes involved in the determination of certain characteristics (Garcia et al., 2002). It has also becoming a great interest to understand the overall pattern of gene expression at the mRNA level. DNA Microarray is a powerful technique where robotics is used to identify genes of interest by comparing gene expression of two different genomes. This method is useful to identify differential gene expression for a certain phenotype. Thousands of known DNA sequences are placed or synthesized on a glass chip and hybridized with two different pools of labelled DNA. The DNA will hybridize with either or both pools and will be labelled differently. By using software analysis, a gene expression fingerprinting will be produced.

Applications of DNA-based markers in Malaysian animal genetic resources

The amount of data obtained from DNA based analysis is a fundamental attraction as they reveal much more than those obtained using morphological or biochemical methods. Character differences known as DNA polymorphisms identified by DNA based-markers can be used to investigate the organization of genomes and the construction of dense genetic maps. These maps will provide blue-prints for strategies of gene isolation by map-based cloning, marker assisted selection and introgression and the dissection of complex traits.

Genetic relationship and diversity studies for Malaysian AnGR

Diversity can occur at species, population and individual level. At the population level, DNA markers can help in determining the genetic class and the differences among them and how much diversity is present in these classes. This information is important for characterization of breeding lines as it helps in organizing the germplasm including elite lines and provides for a more efficient parental selection. A RAPD marker has been successfully used to identify genetic variation among Malaysian local cattle (Johari et al., 2001), local deer (Ismail et al., 2000) and local sheep (Kumar et al,, 1997). STMS marker has been used in identifying genetic variation among swamp buffaloes in Asia (Tan, 2004). The information gathered is important in breeding programs as different clusters of swamp buffalo populations, namely Southeast Asian buffaloes and Sri Lankan swamp buffaloes have different diploid chromosomes and crossbreeding animals with different chromosome numbers may give rise to fertility problems.

Diversity studies can also be applied to study distribution of natural populations. DNA markers will help in determining the population of a given species or breed, genetically distinct populations and the genetic variation within and between populations. Genetic analysis using DNA markers will also establish whether there is gene flow or migration between populations or breeds. STMS markers were used to study the Katjang goat populations in Indonesia, Malaysia, Thailand, Indonesia, the Philippines, Australia and Sri Lanka (Tan, 2004).These populations showed low genetic differentiation indicating that there are more exchanges of the animals in the region (Barker et al., 2001) For effective conservation and sustainable utilization practices, information on genetic variation is needed to define appropriate geographical scales for monitoring and management, to establish gene flow mechanisms and to identify the origin of individuals (Karp and Edwards,1998). Within populations, DNA markers can help in identifying individuals, identifying breeding patterns on degree of relatedness and how genetic variation is distributed within a population. Parentage and paternal analysis can also be done using DNA markers. PCR-based microsatellite markers were used to determine the genetic variability in four goat breeds found in Malaysia, namely the indigenous Katjang goat and the exotic Jamnapari, Boer and Savanna goats. Thirty microsatellite markers were used and low levels of allelic variations were found in all four goat breeds. Katjang goats showed the lowest observed heterozygosity with a value of 0.36. The results showed that the Katjang goat population had a high level of inbreeding compared to the other goat breeds.

Marker assisted selection

Upon understanding genetic distances of different breeds by gathering information from the genetic maps, genetic improvement programs can now be planned via marker assisted selection (MAS). The first step in MAS is to identify the most distantly related breeds with desirable characteristics for breeding programs. After breeding, QTL mapping can be used to test that the offspring carry the different genes controlling the desirable traits (Gibson, 2003). Although MAS can increase the genetic gain by 8 to 35% where the higher figure applies to traits that are difficult to address by conventional breeding (Meuwissen, 2003) and it is not to be applied to all kinds of genetic improvement programs. Since conventional selection schemes are already designed for high accuracy of selection, MAS is more useful for selection of traits where the accuracy of conventional selection is low such as traits with low heritability, traits with few recordings, traits that are measured late in life, slaughter quality traits and disease resistance traits (Meuwissen, 2003). The response to MAS is reduced as the time period of the selection program becomes longer as the genetic gain decreases very quickly with the number of generations of selection for the same QTL, so unless new QTLs are continuously identified, MAS is more of a way to increase short term gains.

Genome wide analysis of indigenous Katjang goats

The commercial whole genome markers panel was utilized to the determine the mixture of breed composition in the current Malaysian indigenous Katjang goat population. Analysis of 398 DNA samples comprising of Katjang and its parental lines with STRUCTURE and MEGA softwares showed that Katjang goats in the state of Kelantan has highest Katjang breed composition with 70% of Katjang blood, 25% of Jamnapari blood, and 2, 2.4 and 0.6% of Boer, Kalahari and Savannah blood, respectively. A smaller, cheaper and more precise SNP panel has been developed to allow more accessible method to study local Malaysian breed composition or similar breeds.

Elucidating weaning induced expression changes in postpartum cows

Weaning influences the hypothalamic control of reproduction. To understand how weaning affects hypothalamic gene expression patterns in beef cows, RNA samples from the anterior and ventral posterior hypothalamic regions of suckled and weaned primiparous cows were hybridized to Agilent bovine microarray to reveal possible interactions. In total, 199 differentially expressed genes were observed between suckled and weaned cows. Among these genes, gene ontology-molecular function terms *hormone activity* and *signal transducer activity* and KEGG pathway *neuroactive–ligand receptor interaction* were significantly over-represented as a response to weaning. Ten genes associated with physiological processes, characteristic of lactation, namely osmolarity and stress, energy balance and suckling were revealed to be differentially expressed. These genes include angiotensin receptor 1 (*AGTR1*), arginine vasopressin (*AVP*), calcitonin-related polypeptide beta *(CALCB)*, corticotrophin releasing hormone binding protein *(CRHBP)*, neuropeptide Y *(NPY)*, growth hormone *(GH)*, growth hormone releasing hormone *(GHRH)*, agouti related protein homolog (*AGRP)*, oxytocin receptor (*OXTR),* prolactin (*PRL).* In addition, 37 genes encode transcription factors, hormones and proteins that are either modulated by oestrogen or involved in oestrogen signalling in various tissues. *ESR1* and 9 of these genes had the same regional expression where eight of these genes code for either a hormone or receptor. The significant differential expression of *AGRP, NPY, ESR1* and *PRL* that was observed with microarray showed the same trend when verified by qRT-PCR.

In summary, the altered expression of genes associated with lactation and oestrogen signalling in the hypothalamus upon weaning could be important in the control of postpartum reproduction.

Conclusions

The strength and versatility of DNA information pose endless options of its applications as DNA-based markers. However, it is not without challenges. One major challenge of understanding and application of DNA markers is due to the fact that not all genomes have been sequenced and thus the effects of QTL must be estimated empirically on the basis of statistics. Statistical analyses although necessary can sometimes overestimate results and give false positive results. Furthermore, for more complex traits, statistical analysis is impossible.

Another challenge for the application of DNA-based marker is the difficulty to apply the methods at the field as it requires expensive equipment and the persons involved should have minimal skills in handling molecular biology experiments.

Nevertheless, understanding the blueprint of life existence gives so much advantage that DNA based markers will remain an important tool in animal breeding. With advancements of technology, it is hoped that the limitations mentioned above will be overcame. In the end, when genome maps of most major livestock breeds are more developed, and more information will be known, DNA test kits for various traits based on any of the methods mentioned can hopefully be available to the animal breeders for them to fully utilize genome information for the production of superior animals in time to come.

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Animal Genetic Resources in the ASEAN and the Three Objectives of the Convention on Biological Diversity

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ABSTRACT

The Convention on Biological Diversity encompasses animal genetic resources thus when Parties to the Convention implement their obligations on conservation and sustainable use, animal breeders and researchers will also find it as a useful instrument that will assist them in their work. The interface between the Convention as well as the work needed for biodiversity for food and agriculture has been highlighted by the recent 2019 assessment made by the FAO Commission on Genetic Resources for Food and Agriculture. The work of the intergovernmental organization, ASEAN Centre for Biodiversity, likewise speaks to these various objectives of the Convention, from the ASEAN Heritage Parks, the ASEAN Clearinghouse Mechanism and the ABS Practice Manual, which animal breeders and researchers may also find useful in their work.

Introduction

To those who have long worked in the area of animal breeding, the Convention on Biological Diversity or CBD, one of the key multilateral environmental agreements that came out of the Rio Summit back in 1992, is one unfamiliar instrument that may either be outrightly irrelevant in their work or in cases when they seek to gather breeds from the wild, appear to be the cause of various problems and tensions in their fieldwork, especially on matters relating to securing permits and licenses to do these collection or taxonomic activities. After all, the implementing agencies at the national level for this Convention, the Ministries of Environment and/or Natural Resources usually do not have as part of their mandates the achievement of goals that have anything to do with agriculture and rural development or animal breeding.

Nonetheless, this paper will show that the Convention on Biological Diversity is one international legally-binding instrument that can help the work of animal breeders, though it is imperative that they will have to work with other groups of people for them to be able to maximize the benefits of this Convention.

In the course of illustrating the value of certain key commitments by the Contracting Parties to the Convention that are relevant to animal genetic resources, some aspects of the work of the ASEAN Centre for Biodiversity in some of these areas will also be highlighted.

First things first, let's start with our use of terminologies. Animal genetic resources (AnGR) have not been defined specifically in the Convention on Biological Diversity but it is deemed encompassed by the term "biological resources" which is defined in Article 2 of the Convention on Biological Diversity as "includes genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity." This definition does not appear to be that specific that may include considerations on what usually happens to animal genetic resources these days, but for the purposes of the Convention on Biological Diversity, that contains specific obligations and commitments on what Contracting Parties have to do as regards "biological resources", which are in turn encompassed in the term "biological diversity". The terminology "biological resources" is sufficiently broad such that Contracting Parties may implement the commitments in the Convention and include already animal genetic resources in the scope of action and intervention carrying out such obligation.

Conservation of biological resources: What's happening in the ASEAN Region

Conservation commitments in the Convention on Biological Diversity are two-fold: they may either be through *in-situ* or by *ex-situ* conservation. *In-situ* conservation commitments by Parties are enumerated under Article 8 of the Convention, while Article 9 of the Convention sets out similar commitments but on *ex-situ* conservation. These measures which are broad enough to encompass animal genetic resources, are actions that may be taken by animal breeders for their purposes and animal breeders may invoke these provisions such that they may be assisted by their countries, which are most likely to be also signatories to the CBD.

Methods and strategies for *in situ* (including on-farm and in other production systems) and *ex situ* conservation of biodiversity for food and agriculture (BFA), in particular of associated biodiversity, need to be improved and information on them made more widely available (FAO, 2019). These various methods and strategies may be integrated in the **National Biodiversity Strategies and Action Plans (NBSAPs)** of CBD Contracting Parties in order that they may be prioritized and given secure funding at country level. Components of BFA should not be considered in isolation from each other or from wider ecosystems, landscapes and seascapes; this requires the restoration of degraded habitats and maintaining or recreating wildlife corridors linking patches of habitat (FA0, 2019).

In-situ conservation

In-situ conservation could be implemented through an established system of protected areas which allows for the regulation and management of biological resources, protection of ecosystems and habitats and maintenance of viable populations of species in natural surroundings, promotion of environmentally-sound and sustainable development in areas adjacent to protected areas. Included in-situ conservation are rehabilitation and restoration of degraded ecosystems and prevention and control of introduction of invasive alien species. Such an effort would also include the need to respect, preserve, maintain knowledge, innovations and practices of indigenous peoples and local communities.

Ex-situ conservation

Ex-situ conservation would establish and maintain facilities for the upkeep of AnGR. It will adopt measures for recovery and rehabilitation of threatened species and for their reintroduction into their natural habitats, regulate and manage collection of biological resources from natural habitat. It will also cooperate in providing financial and other support for *ex-situ* conservation facilities in developing countries.

ACB activities relating to conservation

The ASEAN Centre for Biodiversity has a flagship program on biodiversity conservation in the ASEAN, dubbed as the *ASEAN Heritage Parks Programme (AHP)*. The AHP Programme manages a regional network of representative protected areas created to generate greater collaboration between ASEAN Member States (AMS) in preserving their shared natural heritage. ASEAN Heritage Parks are defined as protected areas of high conservation importance, preserving a complete spectrum of representative ecosystems of the ASEAN region (ASEAN Centre for Biodiversity, 2017). At present, there are 44 AHPs spread out in all member-states of the ASEAN.

Another activity that the ACB is doing relative to conservation which may be useful to work relating to underutilized animal genetic resources is ACB's work on the ASEAN Clearinghouse Mechanism (ASEAN CHM). The ASEAN CHM provides a cohesive and integrated perspective of the region's biological resources. It is a single-entry point to the national CHMs of the AMS and offers a range of services, such as providing biodiversity-related information and capacity building guides and tools, to aid conservation planning, monitoring, and decision making.

Looking closely at the entries in the ASEAN CHM relative to each country, one does not find there any information or data entry relating to animal breeds. There is however a potential for animal genetic resources to be included in the ASEAN CHM. These items of information can be easily established, for as long as AMS provide the necessary guidance and approval for such kinds of information, to be shared and ACB can very well integrate the same in the current ASEAN CHM. What needs to happen are the followings: 1) the AMS to provide data on status of breeds and their utilization, 2) prior clearance at the national level and 3) collaboration with all other stakeholders including the private sector.

Potential role of CHM

CHM provides a sound understanding of the range of species involved, their distribution, characteristics, uses and risk status, including information on associated biodiversity, wild foods and wild relatives of domesticated species. It also serves as a reference and a tool (maps and apps) for designing awareness-raising campaigns, and also may be used to identify further gaps in R&D involving the status, inventory and characterization of AnGR in the region. The ASEAN CHM seeks to improve access to and sharing of biodiversity information, generate knowledge products, promote scientific and technical cooperation and serve as a tool to show progress in biodiversity conservation.

ASEAN member states are to provide data on status of breeds and their utilization or share information found in other portals upon obtaining prior clearance at the national level. It is encouraged that collaboration with all other stakeholders including private sector be intensified.

Sustainable use

As regards to sustainable use, the CBD commits Parties to, among others, integrate consideration of the conservation and sustainable use of biological resources into national decision-making, protect and adopt measures relating to the use of biological resources to avoid adverse impacts and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements. Involved parties also support local populations to develop remedial actions in degraded areas and encourage cooperation between government and private sector.

Interface with CBD

Recently, the FAO Commission on Genetic Resources for Food and Agriculture came up with its assessment of biodiversity for food and agriculture, which necessarily includes animal genetic resources. One of its conclusions relating to conservation is that methods and strategies for i*n situ* (including on-farm and in other production systems) and *ex-situ* conservation of biodiversity for food and agriculture (BFA), in particular of associated biodiversity, need to be improved and information on them made more widely available (FAO, 2019).

This finding provides an opportunity for these methods and strategies for conservation to be aligned with that of the Convention on Biological Diversity and this can be done through the integration of these various methods and strategies of animal genetic resources conservation through the National Biodiversity Strategies and Action Plans (NBSAPs) of CBD Contracting Parties which is part of what each Party to the Convention will have to establish.

Once part of the deliverables of the NBSAP, these methods and strategies for the *in-situ* and *ex-situ* conservation of animal breeds will have a stronger chance that it will be prioritized, along with the other priorities for general biodiversity conservation of the country, aside from eventually being given secure funding at country level. The need for more information dissemination about these methods and strategies can also be made part of the NBSAPs, through the CBD's communication, education and public awareness (CEPA) tools and strategies.

Another finding of the FAO CGRFA 2019 assessment includes components of BFA should not be considered in isolation from each other or from wider ecosystems, landscapes and seascapes, this requires the restoration of degraded habitats and maintaining or recreating wildlife corridors linking patches of habitat (FA0, 2019). What the CGRFA assessment underlines as important is the need to ensure the connectivity between various fragmented habitats which enables animals and plant species maintain their population and live out their life cycles. The restoration of some habitats also contributes towards this goal.

Under the Convention, the pursuit of ensuring connectivity between protected areas is also called for by CBD Aichi Target 11. This Target is recently reinforced by the CBD COP 14 decision on OECMs (other effective area-based conservation measures) - a step towards this direction.

The ASEAN Centre for Biodiversity on the other hand has a project called the *Biodiversity-based Products (BBP) as an Economic Source for the Improvement of Livelihoods and Biodiversity Protection* or the BBP Project, a technical cooperation module under the program Protection of Biological Diversity in the AMS in Cooperation with the ACB (CARE4Biodiv) and implemented by the GFA Consulting Group (on behalf of GIZ) together with ACB from March 2015 to February 2019, but now extended until 06/2019. With a budget of 4 million Euros, it is implementing pilots in Cambodia, Lao PDR, and Viet Nam (CLV). The biodiversity value chain approach may be something that will be useful to enhancing the underutilization of animal genetic resources.

Fair and equitable sharing of benefits from the utilization of animal genetic resources

The third objective of the CBD, on the need for the fair and equitable sharing of benefits from the utilization of genetic resources, is a work in progress in many AMS. This is confirmed by the FAO CGRFA 2019 assessment which state that ABS policy frameworks are in a process of transformation, evolution and adjustment and there is consensus among Parties to the Nagoya

Protocol on the need for capacity-building and other support measures critical to the development and implementation of ABS measures (FAO, 2019).

What these capacity-building activities need to focus on according to the said FAO assessment is article 8 of the Nagoya Protocol which commits all Parties to consider the importance of genetic resources for food and agriculture and their special role for food security (FAO, 2019). These provisions have gone largely unimplemented and what is at issue is the matter of granting permits and licenses so researchers may be able to proceed with their researches.

As a response, ACB had recently developed the **ABS Practice Manual.** This Manual is being developed by the ASEAN Centre for Biodiversity and the National Biodiversity Authority of India with inputs from ASEAN Member States and advice from UNCTAD on the bio-trade activities as part of a common effort to enhance the capacity of ASEAN Member States in implementing their respective ABS regulations and for those ASEAN Member States who are still in the process of developing their ABS regulations. The aim of the Manual is to serve as a guide in how the ASEAN Member States who have already established their ABS regulations have dealt with the various issues in ABS implementation, the most basic of which is, which activities that are being applied for permits will be covered or excluded by a country's ABS regulations.

It is hoped that by demonstrating to the newcomers to ABS regulations how common situations in the ABS regulatory field were dealt with, they may also have an idea how they may deal with a similar or analogous situation that they may be currently faced with and act on them accordingly, along the lines of what their ABS policy or regulation may be on the particular item.

This Manual is based on the existing laws, rules and regulations and administrative practices of identified ASEAN Member States. It does not serve to be the sole authority on which to guide how the various activities and actions relating to the grant of ABS permits and all other related matters to the administrative decision on how the fair and equitable sharing of benefits from the utilization of genetic resources are achieved. It does not also serve to supplant or be a substitute for those regulations. Those who may have detailed queries on how a particular situation was dealt with and how the entire activity or application turned out, they are advised to consult the appropriate competent national authority in question.

Ways forward

There are a lot of ways the CBD may assist animal breeders in their breeding and conservation work but what needs to be done further by animal breeders are the followings: consider further the interface between AnGR and CBD objectives and its corresponding measures biodiversity mainstreaming in AnGR may be pursued to carry out these various areas of interface and ASEAN CHM a good option for information sharing on under-utilized AnGR, provided AMS supports the effort.

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Market-driven Approaches to Conservation and Utilization of AnGR

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Models of livestock production

Principally there are two models of livestock production: Smallholders and Large producers. The Smallholders or the "household model" of production has multiple objectives besides income, including risk reduction, diversification, insurance, and social capital. It features up to 40% additional "returns" to livestock in other benefits and maximum use of low cost resources and farm synergies, minimum use of purchased inputs. The Large producers or the "enterprise model" of production has only one objective of profit (which has its own risks) and is characterized by its capital intensive, mechanization and economies of scale.

Table 1. Comparison of alternative models of livestock production and market

Attribute	Large producers	Smallholders
Production profile	• Few outputs/objectives, enterprise model • Often subsidized • Capital intensive • Strong economies of scale	• Multiple outputs/objectives, farmer household model • Few subsidies, may be taxed indirectly • Labour intensive • Weak economies of scale
Nutrient and nutrition profile	• Human over-nutrition, threat to human health • System nutrient surpluses, threat to environment	• Human undernutrition, sustaining human health • System nutrient deficits, sustaining natural resources
Demand and product profile	• Value-added products, highly processed • High relative demand for food safety/ quality	• Low cost products, traditional processing • Low relative demand for food safety/ quality
Policy profile	• Highly regulated and monitored • Over represented, loud voice in domestic and international policy	• Largely unregulated, unrecorded • Invincible, little voice in domestic and international policy
Sustainability and livelihoods	• Livelihood through wages	• Livelihoods through asset accumulation
Production of indigenous breeds	• Not able to easily commercialize production of indigenous breeds economically	• Can use farm resources to economically raise indigenous breeds
Market	• Industrial products in consumer perception	• Can market attributes of local branding, traditional products

The key point is in many cases indigenous breeds offer opportunities particularly for smallholders

A smallholder raising indigenous chickens

Issues and challenges

Securing poor farmers' livelihoods vs. keeping local breeds

- Farmers are changing the genotype of their livestock assets, largely due to need for greater productivity
- Farmers invest in livestock for private benefits
- Society wants to maintain AnGR for long term public benefits
- Is it fair to ask farmers to maintain public goods embedded in AnGR and to forego productivity gains and income?
- How do we reconcile these two seemingly contradictory objectives?

Demand for improved productivity frequently is in conflict with diversity conservation. Loss of diversity caused by stakeholders' choices primarily for economic reasons.

The animal genetic requirements of industrial systems are thus characterized by:

- ability to manage environment means less demand for breeds adapted to local environments or disease resistance
- more demand for efficiency, and especially FCR to maximize benefit
- more demand for quality traits due to consumer demand and technical requirements related to standardization, size, fat content, color, flavor, etc.

Private benefits to support sustainable conservation

It is recognized that there two possible means of capturing benefits, through production side and demand side. From production side it is pertinent that maximizing benefits of adaptation be shown. Traits such as heat tolerance, hardiness, diet suitability and disease resistance are among the breeds' attributes worth to be maintained. Social status due to traditional practices and preferences is given priority. On the other hand, demand side offer traits that the market is willing to pay for and products which have unique taste, novelty and traditional consumption. Efforts are encouraged in converting public into private benefits through branding and certification. Animals grown locally in sustainable and animal welfare friendly conditions are preferred by consumers. Structured cross-breeding systems would then provide an opportunity for in-situ conservation of indigenous breeds. The key point is as consumer disposable income grow they don't discard traditional taste preferences.

Market demand growing for indigenous breed products

A number of examples could be cited in identifying market for products from indigenous breeds of livestock.

- Indonesia kampong chicken: markets more sophisticated, commercializing, specialized DOC producer
- Native/black pigs:
- EcoPig franchise-based market development in Philippines, for high end lechon roasted pork in Philippines.
- Local "black pig" branding in NW Vietnam – specialty restaurants.

Prices are often double the value of industrial breed product equivalents. It is estimated in Thailand that 20% of poultry production will remain local and independent of large operators. While in Africa, there is growing demand for specialized feed for native chickens with local eggs fetching double the retail price.

Reproductive Biotechnology for Underutilized Animal Genetic Resources

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Introduction

Animal reproductive biotechnology has been used quite successfully in the propagation and genetic improvement of domestic livestock in cattle, sheep and goat (Velazquez, 2008; Tibany, 2017). The advancement made in the ability to manipulate the oestrus cycle and gamete production, has made application of assisted reproductive biotechnologies (ART) such as artificial insemination (AI), embryo transfer (ET), gamete collection and sexing more feasible to be used in increasing the production and ensuring sustainability of the various livestock breeds. Advancement has also been made in in vitro production technologies such as in vitro fertilization (IVF), cloning encompassing embryo splitting and Somatic Cell Nuclear Transfer (SCNT). The various ART have the potential to be applied in the diversified and underutilized animal genetic resources for their conservation and propagation. This article will highlight the *in vivo* and *in vitro* reproductive biotechnologies available as tools for sustaining the underutilized AnGR as potential alternative sources for food production.

In vivo reproductive biotechnologies

Artificial Insemination (AI)

AI is the oldest assisted reproductive technology applied for the genetic improvement among domesticated animals (Kubkomawa, 2018; Van Doormaal and Kistemaker, 2003). The discovery of glycerol as cryoprotectant for semen freezing has made AI an accepted breeding tool globally for genetic improvement and conservation. The genetic improvement within a country or across countries has been made through the ease of genetic dissemination through frozen semen. Due to strict health protocol, the application of AI has indirectly reduced drastically sexually transmitted diseases among livestock. Semen is commonly collected by using artificial vagina or electro ejaculator in ruminant livestock and back massage or stroking in poultry. The main constraint in the application of AI is the accuracy of oestrous detection which influences the conception rate. The use of hormone for oestrous control has made possible the use of pre-determined or fixed time AI. The deposition of semen varies among various species of animals depending on the accessibility to the uterus. In large ruminants, the common technique is inserting an insemination gun into the vagina and through the cervix into the body or uterine horn. In sheep, the common practice is depositing the semen into the vagina or mid cervix using an insemination gun due to the difficulty of passing the insemination gun through the highly convoluted cervix. In order to obtain reasonable conception, relatively high dose of fresh semen is commonly used. An alternative method is the use of laparoscopic intra uterine insemination which needs specialized equipment and higher skill (Rashid and Jamsuri, 2005; Candappa and Bartlewski, 2011). Recently the application of AI among dairy or beef cattle has been enhanced by using sexed semen. The commercially available sexed semen gives the dairy or beef farmers greater choice of increasing the female or male calves in the farm for milk and beef production. Other than ruminant livestock, currently AI is also been accessed for its application in genetic improvement in the local native/kampong chicken.

Multiple Ovulation Embryo Transfer (MOET)

The second generation of reproductive biotechnology is the application of MOET in genetic improvement of large and to a lesser extent small ruminant production. The objective is to enhance the genetic potential of the females as AI is used to enhance the utilisation of the male for genetic improvement. The application of embryo collection and transfer have increased since 1972 (Perry, 2016). The number of in vivo derived (IVD) dairy and beef cattle embryos from live donors and in vitro produced (IVP) embryos have increased from 294 890 in 1972 to 1 604 294 in 2016 with corresponding number of embryo transfers at 391 225 and 964 895, respectively. The main contributors are from North and South America and Europe. Initially livestock embryos were produced in vivo from selected genetically superior live donors through MOET. Currently, the number of IVP embryos derived from IVF technology has increased significantly. In 2016, 448 113 IVP cattle embryos were transferred (Perry, 2016). The increase in IVP application is the result of advancement in the IVF technique resulting in improved in in vitro maturation and fertilization and subsequent embryo culture development. The availability of ultrasound oocyte pickup (OPU) technique makes it possible to extract oocytes from selected genetically superior donor cows. In the small ruminant sector, the numbers of embryo collection and transfer are relatively much lower as compared to the cattle sector. In 2016, the number of in vivo collected and transferable embryos was 27 394 and the number of embryo transfers was 6 756.

The constraints in MOET are the variable responses to superovulation resulting in unpredictable embryo production. The cost of the procedure has confined the application to an elite group of breeder animals. In Malaysia, a unique problem is the ban in the use of porcine follicle stimulating hormone (pFSH) due to religious reason. The other alternative superovulation hormone is equine choriono gonadotrophin (eCG) which is relatively less effective (Mapletoft et al., 2002).

Ovum Pick Up (OPU)/ Laparoscopic Ovum Pick UP (LOPU)

Although the majority of embryos in MOET programme are obtained from in vivo embryo recovery, there is increasingly more in vitro derived embryos through IVF been used for genetic improvement in cattle, sheep and goats. The main source of oocytes for IVF is either from live donors or abattoir collection (Perry, 2016). Comparatively more cattle oocytes are collected via OPU from selected live donors versus sourcing from abattoirs. In transvaginal OPU, an ultrasound probe is used to visualise the follicles on the ovary and large follicles are aspirated using an attached aspiration needle using a vacuum pump. In sheep and goats an alternative method using laparoscopy (LOPU) to visualise internally the ovary and with the aid of aspiration needle attached to a vacuum pump the follicular aspiration is performed (Rashid et al., 1993). Some practitioners may use superovulation hormone to stimulate the ovaries for greater follicle development.

Gamete/cell cryopreservation

The acceptance and application of AI among the farmers were enhanced after the discovery of the method for cryo-preserving the sperm using glycerol by Polge (Polge et al., 1949). The ability to freeze gamete makes it possible for long term storage and transportation of sperms and embryos within a country and between countries. It opens the gate for the wider dissemination of genetic materials globally. The freezing process may result in changes in membrane integrity and damage due to the ice crystal formation. Glycerol, dimethyl sulfoxide (DMSO), dimethyl acetaldehyde, propylene glycol and ethylene glycol are commonly used as permeable cryoprotectants in the preservation of sperms and embryos (Maryam et al., 2018). Slow freezing method at about -0.5^{O}C/min is commonly used for semen freezing in a programmable bio freezer before storing in a liquid nitrogen tank for long term storage. For oocytes and embryos other than the slow freezing using programmable bio freezer and seeding, an alternative approach is ultra-rapid freezing or vitrification. Vitrification is a viable option as it is cheap and without the need of expensive bio freezer. The use of high concentration of cryoprotectant prevents the ice crystallization during freezing and replaces with glass like formation. The main advantage of vitrification can be used in the field without the need of expensive equipment.

Sexed sperm and embryo

The main difference in the sperm and embryo sexing is for the sperm it is a pre-selection process whereas for sexed sperm it determines the outcome of the sex of the offspring. Whereas for the embryos it is to determine the sex of the embryo after it is formed. Therefore, sperm sexing in combination with ET and IVF are a more useful tool for increasing the farm production. The most effective method is sperm sorting through the flow cytometer based on the small DNA difference of about 4% between X and Y bearing sperms (Maxwell et al., 2004). Sexed sperm is available commercially and is being used in AI, MOET and IVF. In embryo sexing the only reliable technique requires biopsy of a few embryo cells, the DNA is amplified by PCR and sexing is done by using Y specific probe for male which is visualised using UV light (Sharma et al., 2017). Commercial embryo sexing kit is available.

In vitro reproductive biotechnologies

Production of embryos by in vitro fertilization (IVF), Intracytoplasmic Sperm Injection (ICSI) and embryo manipulation could be some of the biotechniques that offer immediate practical application in increasing the population of quality livestock.

In vitro fertilization (IVF)

In vitro embryo production or IVEP is an important technology to mass produce embryos at low cost and could be used to develop the cattle industry. However, the success of IVEP programme depends on the development of improved in vitro techniques and better understanding of the composition of culture medium required for embryo development. Knowledge of maturation and fertilization of bovine oocytes under in vitro conditions has expanded rapidly since their initiation in 1960s. These techniques are today employed worldwide. However, only approximately 30 – 40% of the bovine oocytes matured and fertilized under in vitro conditions would develop to the transferable stages of morula and blastocyst (Rodriquez and Farin, 2004; Habsah et al., 2010). Although proper culture conditions after initial cleavage are essential, the process of in vitro oocyte maturation requires special attention for successful formation of a zygote. Proper in vitro conditions for oocyte maturation and the need to develop chemically defined media for IVC should be emphasized. The use of CR1 with the addition of amino acids helps the further improvement of cleavage and blastocyst rates. It is well established that the culture conditions employed for IVM of mammalian oocytes can significantly influence IVF success rates and subsequently embryonic development (Rose and Bavister, 1992). It has been reported that oestradiol-17B alone enhanced blastocyst development (Saeki et al., 1991), and the addition of oestradiol-17B to the maturation medium improved the maturation rates of poorer quality oocytes, namely Groups B and B', but not the higher quality oocytes categorised as Group A (Habsah, 1997).

Glutathione (GSH) is a major non-protein sulphydryl compound in mammalian cells and is known to have an important role in protecting cells from damage to oxidative stress. The increase in cytoplasmic GSH content provides oocytes with large stores of GSH available for protection during subsequent embryo development until the blastocyst stage. Low molecular weight of thiol compounds such as cysteamine and B-mercaptoethanol added during in vitro maturation (IVM), was reported to increase intracellular glutathione synthesis and consequently improving embryo development and quality (de Matos and Fumus, 2000). In Malaysia, there are limited number of sources and oocytes available. Thus, slaughterhouse ovaries are used to salvage available oocytes for in vitro embryo production. Most of the cows slaughtered in Malaysia are quite old and the oocytes are mostly of poor quality. If we can modify the current IVF protocol to enhance the maturation of these poor quality oocytes, then the IVF technology in Malaysia could be utilized extensively as routine propagation of local cattle.

Somatic cell nuclear transfer (SCNT)

Bovine cloning by Somatic Cell Nuclear Transfer (SCNT) is an advanced reproductive biotechnology with many potential applications in livestock production. The birth of Dolly set in motion a new wave of interest in livestock cloning. Although cloning of bovine embryos has never resulted in large scale commercial application, interest in nuclear transfer and cloning livestock continues. However, the low efficiency of SCNT in producing animal clones is one of the major constraints of this technology. In Malaysia, MARDI has attempted to develop a nuclear transfer protocol with regards to activation and development of enucleated-reconstructed oocytes subsequent to SCNT as well as parthenogenetic development of non-enucleated oocytes (Habsah et al., 2016). Adult skin fibroblast cells were chosen as the donor karyoplasts as the source of DNA because these cells were easy to obtain and easy to culture and propagate. The proliferation rate of skin fibroblast cells derived from different locations on the animal also has been studied. Most adult somatic cells cloning used skin-derived fibroblast cells (Hill et al., 2000; Hwang et al., 2013) compared to tail (Wakayama and Yanagimachi, 1999) and leg (Powel et al., 2004) as donor karyoplast. However, leg skin fibroblast cells had higher proliferation rates compared to those from tail and ear (Habsah et al., 2015). These cells reached the plateau phase at 120 hours of in vitro culture. This showed that initially the cells proliferated rapidly but declined after 129 hours of culture due to contact inhibition. The PDTs were 54, 43 and 40 hours for leg, tail and ear skin fibroblast cells, respectively. These indicated that most of the skin fibroblast cells derived from the leg, tail and ear were G0/G1 stage, the preferable stage of donor cells for cloning. This study demonstrates that ear, tail and leg skin fibroblast cells are potential donor karyoplast in bovine cloning. However, future studies are required to determine the production efficiency of cloned bovine embryos using skin fibroblast cells as donor karyoplast.

In one study, 36.4% of SCNT-reconstructed embryos using bovine ear skin fibroblast cells as donor karyoplasts cleaved to the two-cell stage compared to 23.5% oocytes which cleaved partenogenetically in the absence of sperm and fertilization. Furthermore, the SCNT-embryos produced from the procedures developed in MARDI, advanced to the 16-cell stage. In comparison, the parthenogenotes were arrested at the 8-cell stage. The pregnancy rates of eight recipient dams based on the transfer of cloned and in vivo-derived embryos were both

25%. However, only in vivo-derived embryos developed to term but the cloned embryos were aborted naturally at 5 months of gestation. This shows that the developed SCNT protocol using ear skin fibroblast cells could be used to produce cloned bovine embryos. However, further studies are needed to improve this technology for the production of viable cloned bovine embryos and offspring.

Intracytoplasmic sperm injection (ICSI)

Intracytoplasmic sperm injection (ICSI) is an important assisted reproductive technology with vast application in the treatment of human infertility (Merchant et al., 2011) and the conservation of endangered animal species (Parmar et al., 2013). It involves the injection of a spermatozoon into a matured oocyte using micromanipulator equipment. ICSI is advantageous when only very few spermatozoa are available for insemination. In livestock, this technique offers great opportunity for the studies of oocyte activation and fertilization, development of transgenic animals, and generation of preselected sexed offspring. Generally, the success of ICSI procedure is related to the quality of spermatozoon and oocyte, effective activation of oocytes, and ability of oocytes to cleave subsequent to sperm injections (Effekhar et al., 2012). ICSI remains a low efficiency technology and has less widespread application in comparison to IVF. The efficiency of ICSI technique in cattle reproduction is limited by the necessity for additional oocyte activation before or after the ICSI procedure. Induced activation is required for oocyte to progress beyond the pronuclear stage and for embryos to continue further development (Habsah et al, 2016).

The available reproductive technologies will be useful in the conservation and enhancing the utilisation of underutilized animal genetic resources such as the ayam kampong or village chicken, swamp buffalo and Katjang native goats.

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Avian Genetic Resources: Conservation and Improvement

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ABSTRACT

Avian species are important for their utility as they are a good source of protein and minerals. About 10,000 avian species are available around the world, among them are fast-growing chickens and many other industrialized species. The genetic diversity of different avian species between and within breeds is increasing due to breeders' effort, subsistence production, and commercialization. Genetic diversity of avian species is becoming threatened. However, there are still some avian species, breeds and strains that are underutilized. To protect the erosion of diversity it needs to conserve these valuable genetic materials in both in-situ and ex-situ. Nonetheless, due to urbanization, rapid disease outbreak in ex-situ conservation environment that cryopreservation is the best option to conserve the underutilized avian genetic resources than in-situ conservation. To improve the genetic potentialities of these underutilized genetic resources both line-breeding and crossbreeding can be introduced in consideration of effective population size and inbreeding level, however it requires consistent and objective breeding decisions.

Key words: Avian species, diversity, cryopreservation, breeding objective, improvement.

Introduction

There are more than 9,000 to 10,000 avian species throughout the world - out of them 11 species are common and their utilities are for meat, egg and feather production, ornamentation and use as experimental animals. The most popular and common species, chicken and duck, are playing the main roles for supply of protein and minerals to humans. Among them, the chicken is the fast-growing, most specialized and industrialized species. Some multinational poultry companies have dominated the poultry meat and egg industries. However, the small scale family chicken farms do exist in many rural areas of the Asia-Pacific region.

The climatic factors (temperature, humidity, rainfall and light) have an impact on both global and local scales with subsistence livestock production. The changing climate scenarios have decreased production and increased disease and mortality rates, which could threaten the viability of avian species. Heat stress is one of the most important environmental factors. The effects of heat stress on broiler and layer chickens are reduced growth and egg production with concomitant decrease in meat and egg quality (Lucas et al., 2013; Khan et al., 2017). Furthermore, genetic diversity is threatened (erosion and breeds disappearance) without notice and globally the variation within breed decreases due to inbreeding. There are some underutilized avian germplasms available which can mitigate the climatic change factors and assist to maintain genetic diversity. Therefore, the objective of this paper is to utilize unrevealed avian genetic resources in sustainable production through conservation and their genetic improvement.

Avian genetic resources

Many avian genetic resources are available throughout the world. For example, an overview of some avian genetic resources that are common in South East Asia is listed in Table 1. Among the listed species, chickens dominate than ducks and other species.

Table 1. The underutilized or less utilized avian genetic resources

Species	Name of birds
Chicken	Red Jungle Fowl, Assel (golden red; black & red; white; black; black & white spotted; black; white and golden or black with yellow or silver; brown and light red), Naked Neck, Hilly (Reddish brown and Spotted Black and White), Kadaknath, Tellichery. Non-descriptive Deshi
Duck	Nageshari, Sylhet Mete, Deshi Black and Deshi White, Non-descriptive Deshi
Guinea Fowl	Indigenous and Mixed
Turkey	Indigenous population
Pigeon	Jalali, Gola, Lotan, Giribaz, Non descriptive deshi

Chicken genetic resources

Non-descript indigenous chickens are more acceptable by the village people in the developing countries due to lower nutritional demand, higher resistance to diseases and adaptable to heat stress (Khan et al., 2017). They are good brooders and efficient foragers. The morphometric characteristics of some underutilized chickens are presented in Table 2. They vary greatly in their plumage pattern, comb type, body conformation and other physiological attributes. The heavy (Aseel, Tellichary, Hilly *etc*.) and light chicken (Kadaknath, Naked neck *etc*.) exist in natural habitats, along with non-descriptive chickens (white, brown, black and yellow mixed plumage). However, these potential genetic resources are undergoing genetic erosion due to the continuous introduction of exotic stock and their unsystematic crossing and lack of conservation programme. No attempts have been made to improve and conserve these valuable genetic resources.

Performance of chicken

The production performance and survivability of different genotypes of chicken are presented in Table 3. Among the indigenous population, egg production is higher in Hilly than other chickens. In general, the eggs of indigenous chicken are smaller and they are late maturing than the other genotypes. The livability of Deshi chickens is also lower than other improved types of chickens.

Performance of duck

The wild Mallard duck (*Anas boschas*) is the progenitor of all domestic duck except the Muscovy, which has been derived from the South American tree duck (*Cairin amoschata*). Performance of unutilized duck is presented in Figure 1 (data source: Khatun et al., 2012; Bhuyian et al.,

Table 2. Morphological characteristics of different underutilized chickens

Traits	Non-descriptive	Naked Neck	Assel	Hilly	RJF	Kadaknath[5]
Origin	Local	Hot humid coastal region	Andhra Pradesh in India; Sarail, Brahmanbaria in Bangladesh; Punjab in Pakistan	Hilly region of Bangladesh, Myanmar, Assam and Meghalaya of India	South East Asia	Madhya Pradesh in India
Plumage colour	Blackish, White, Grey and Reddish[1,2,3]	Blackish and Reddish[2]	Deep purple[2], Black	Reddish or Spotted black and white[3,5]	Reddish[4]	Black, Black with white and golden
Skin colour	Whitish or yellowish[4]	Yellow[2]	Whitish or Yellow[4]	Yellow[1,3,4]	Blackish	Grayish Black
Shank colour	Black, yellow and whitish[4]	Grey, Yellowish	Yellowish	Yellowish[1,2] Blackish Yellow[1,3]	Grey	Black
Comb type	Single, Rose and Pea[5]	Single and Pea[4]	Single[4]	Single[5]	Single	Single
Earlobe	Red, Whitish[4]	Red	Red	Red[5]	Red	Red
Shank	Featherless	Featherless[4]	Featherless[4]	Featherless[1,3,4]	Featherless	Featherless
Body type	All types	Medium[4]	Large [4]	Medium[4]	Small	Medium
Body shape	Round, Oval and cylindrical[1]	Round[4]	Triangular, upright[4]	Cylindrical[2]	Oval	Round
Egg shell colour	Brown or white[2,4]	Brownish[4]	Brownish[4]	Brown, white and light brown[1,2,4]	Brown	Black

[1]Faruque *et al.* (2017), [2]Khan *et al.* (2017), [3]Faruque *et al.* (2010), [4]Bhauiyan *et al.* (2005), [5]Mishra (2013).

2017; Muraduzzaman et al., 2015). Figure 1 indicated that except egg production (EP) and mature live weight (LW) and all other traits were not significant between the genotypes. The Nageswari produces more egg than indigenous duck.

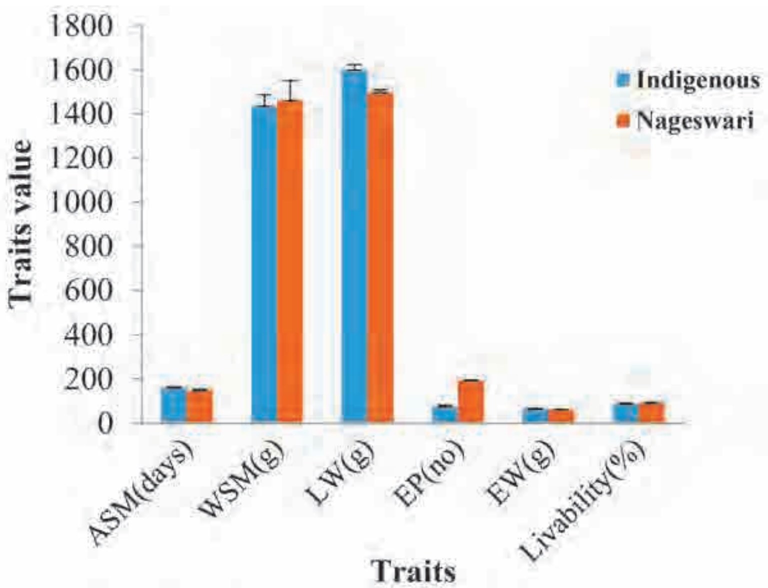

Figure 1. Performance of underutilized ducks under semi-intensive farming systems

Genetic diversity

Genetic diversity refers to the total number of genetic characteristics in the genetic make-up of a species. Globally, the genetic diversity within avian species results due to (1) the activities of avian fanciers and breeders; (2) the remarkable numbers of small semi-scavenging flocks kept by subsistence farmers

Table 3. Performance and survivability of different genotypes of chicken

Traits	Genotypes				
	Assel	Naked Neck	Hilly	Non descriptive Deshi	Red Jungle Fowl
Age at sexual maturity (d)	270±30.25[3]	195.0±43.8[3]	173.18±3.05[4]	204±1.53[6]	-
Weight at sexual maturity (g)	1500±22.8[3]	969±132[3]	1023.09±26.83[4]	925.15[7]	-
Mature live Weight (g)	2288.39±27.20[1]	1117.0±150[3]	1562.47[b]±42.21[4]	1358.37±1.84[7]	1000-1200
Hen house egg production (%)	31.43±0.66[1]	13.63[3]	17.24[4]	29.1[7]	-
Hen day egg production (%)	43.28±2.5[2]	18.75[5]	19.54[4]	17.54[4]	-
Yearly egg production (No)	33.0[1*]- 159[2]	50-60[3]	94.44[4]	45[3],76.80[4] 60±0.51[7]	8-10[8]
Egg weight (g)	48.27±0.52[2] 44.04±0.39[1]	42[3,] 40.55[5]	41.45[4]	37[3], 41.66[4,] 44.41±0.88[6]	39
Livability (%)	94.29±0.5[2]	91.67[3]	80.45[4]	78.5[4]	-

[1]Rheman et al. (2016), [2]Valavan et al. (2016), [3]Bhuyan et al. (2005), [4]Khan et al (2017), [5]Uddin et al (2007), [6]Khawaja et al. (2012),[7]Khatun et al (2005),[8]Francisco et al. (2015).

in developing countries, and (3) commercial breeders' effort to produce high-performing meat and egg production lines. Diversity is demonstrated by the huge numbers of avian breeds and ecotypes found globally. Diversity occurs between and with the breed of ecotypes. The principal features of poultry permit rapid increases in the numbers for their high reproductive rates and short generation intervals. Paradoxically, it is this capacity that now threatens the survival of many breeds. The need of high production efficiency, combined with the complexity and cost of running effective breeding programmes has resulted in commercially selected lines of broilers and layers those replacing several of the breeds. The genetic diversity can be measured by genetic progress which results in the magnitude of selection intensity, accuracy, generation interval and genetic variation. Genetic diversity of poultry can be estimated by estimation and makers for a specific trait and kinships.

Breeding strategy

Genetic improvement can be done by selecting animals based on high genetic merit and planned mating between selected individuals to achieve the target of breeding objective for a particular production system. The available genetic resources are avian species, semen, oocytes, embryos and somatic cells. Village chicken can be improved through breeding by introducing exotic breed(s) to the indigenous stock. The breeding strategy is described as a nucleus breeding station and production units under village/farmers control. The breeding flock consists of 300 improved indigenous hens and 30 exotic cockerels from which crossing and hatching can be performed, preferentially in small pens and this shed can be used to rear a flock of 300 pullets/ chickens. In this flock, selection takes place based on a selection index and the female progeny are placed at the smallholder farmers' households. The flow of information is shown in Figure 2. The standard feeding and management condition should be maintained.

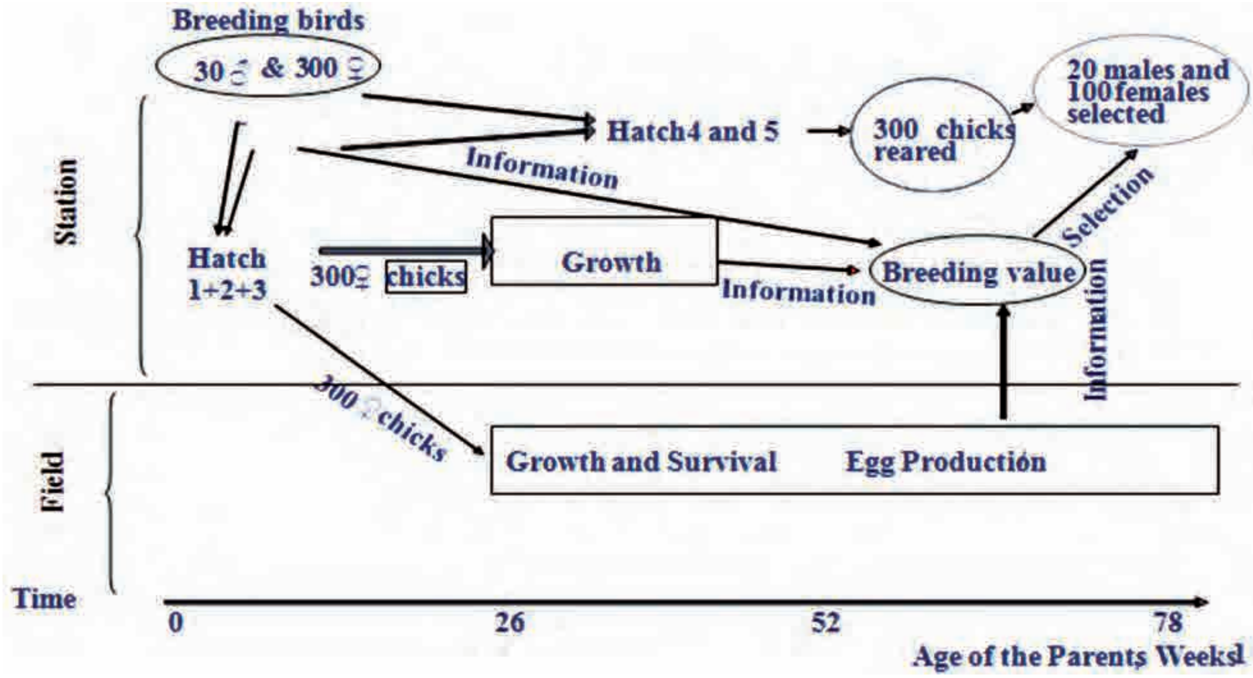

Figure 2. Village chicken improvement scheme (adapted from Sørensen 2012, unpublished)

At the breeding nucleus, chickens reproduced in 5 hatches, hatch no 1, 2 and 3 are expected at the parent's age of 35 weeks in a number of 300 pedigreed females and 150 males at least. Females will be transferred to smallholder farmers at the age of 10-12 weeks and data are recorded for daily gain up to start of lay. The laying intensity, mortality and number of chickens raised to 8 weeks are recorded and best-selected males are transferred to the farmers. The information is used for calculating the breeding value (BVs) for the cockerels combined with the field test of their sisters and for the base dams regarding egg yield at the station. Hatch 4 and 5 are produced when the daughters in the field test have started lying egg. The elite birds are, at an age of 78 weeks, expected to produce 300 chicks per hatch to be selected based on the BVs of the cockerels and they will be the elite in the next generation. The EBVs of different traits (survival, daily gain, age and weight at sexual maturity, number of chicks raised to 35 weeks, and egg yield in terms of rate of lay during egg production could be estimated from the animal model using ASREML or AIREML.

A selection procedure is conducted in two/three non-overlapping generations. The improvement of any trait can be measured by genetic progress. After making the genetic progress for a particular trait then it should be disseminated. The minimum effective size for a population to be "safe" from genetic disaster (inbreeding vortex), Frankham *et al*. (2014) recommended N_e > 100 to limit total fitness loss to <10% over 5 years and N_e > 1000 to minimize it permanently. Nonetheless, specific line for meat and egg can also be developed using linebreeding.

Conservation

Avian genetic resources can be conserved in (i) In-situ or (ii) Ex-situ. The objectives of both systems are: In-situ is conservation and utilization; economic function in rural communities and maintenance of agro/ecosystems; and maintenance of diversity and for Ex-situ conservation is insurance (market/ environmental changes); and safeguard (diseases, wars, disasters). Avian genetic resources are presently maintained as live animals - a costly and vulnerable praxis, with major risks related to disease outbreaks, environmental or man-made disasters. Genetic diversity, sex selection traits and reproduction-related traits can be maintained more accurately by cryopreservation of germplasm (Blesbois et al., 2008), providing genetic banking for future needs in biological research and avian production. However, we need to work on an efficient standard freezing procedure assuring a steady and suitable level of fertility in avian species which, consequently, impairs the systematic use of frozen semen in the intensive breeding of the poultry industry. Alternative types of germplasm for gene banking are ovaries and testis can be for wider application.

Conclusions

A good number of avian genetic make-ups are still underutilized. Utilization of avian genetic resources is facing challenges due to stakeholders use and indiscriminate breeding. Thus, the genetic diversity of avian species is becoming threatened. To protect the erosion of diversity it needs to conserve these valuable genetic materials, both in-situ and ex-situ environments and introduce structured genetic improvement programmes. The genetic potentialities of these underutilized genetic resources can be done through selection of potential germplasm and use of both linebreeding and crossbreeding in consideration of effective population size and inbreeding.

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Modern Methods of *Ex-situ* and *In-situ* Conservation of Underutilized AnGR: Bacterial Isolation from False Gharial (*Tomistoma schlegelii*)

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Introduction

The False Gharial (*Tomistoma scheligellii*) or also known as Malayan gharial is one of the species in the family, Gavialidae, a family of reptiles within the order Crocodilia. Gavialidae has conventionally consisted of only one surviving species, the gharial *(Gavialis gangeticus*), which is native and endemic to the river in India (Singh, 1991). Previously the status of False Gharial cannot be ascertained between the family Crocodyloidea and Gavialoidea. Several studies have been conducted to focus on morphological aspects (Norell 1989; Brochu, 2001, 2004) and biochemical or molecular profiles (Gatesy et al, 2003; Harshman et al, 2003). The False Gharial (*Tomistoma schlegelii*) has usually been thought to be a member of the family Crocodylidae based on several characteristics including skull morphology, but has sometimes been viewed as a member of Gavialidae due to general similarities in morphology and habit. However, numerous molecular studies have consistently showed the two species to be very closely related, supporting the view that they are in the same family (Brochu, 2004; Harshman, 2003; Willis et al., 2007) belonging to the subfamily Tomistominae and Genus Tomistoma.

Currently there is no conclusive estimate of population size of the False Gharial, and their distribution is limited to Indonesia (East Sumatra, West Java and Kalimantan), Malaysia (Peninsular Malaysia, Sarawak) and Brunei. The species appears to be extinct in Thailand (Steubing et al., 2006). The current number of captive False Gharial held at various facilities around Malaysia is approximately 9 animals at the National Zoo, 9 animals with the Wildlife Conservation Center Sungai, Dusun, 6 animals at the Malacca Zoo, 2 animals at the Malacca Crocodile farm and only 1 animal in the Taiping Zoo. Natural breeding of captive *Tomistoma schlegelii* in Malaysia has only been documented in the National Zoo with four hatchlings in 2003 and the Jong Crocodile Farm with 19 hatchlings produced from 1996-2001 (Mathew et al., 2011; Steubing et al., 2006).

In order to prevent this species from extinction, assisted captive breeding is being carried out on the animals in Sungai Dusun, as well as a population study is being conducted in the wild. A deficient intestinal flora is likely to be one of the factors predisposing farmed or captive crocodiles to enteritis and usually associated with septicemia (Lovely and Leslie, 2008).

Although normal intestinal flora studies of family Crocodylidae have been done, all the published works were conducted in the African and Western region and not for the False Gharial. The intestinal tract flora isolated from wild-caught African dwarf crocodiles (*Osteolaemus tetraspis*) and from wild Nile crocodiles (*Crocodylus niloticus*) have been reported (Huchzermeyer et al. 2000; Lovely and Leslie 2008). There is lack of information on the intestinal tract normal flora of *Tomistoma schlegelii* especially those are in captivity in Malaysia due to the difficulty in obtaining meaningful sample for this species.

The study

Work on the false gharials was done in the dry areas at the side of the pond. After safely restrained the animals in dorsal recumbency, several pieces of cloth or jute bags were used to blindfold their eyes. A cloacal swab was taken by inserting and rotating a sterile cotton swab into the cloaca to a depth of 50-100 mm (Misra et al., 1993). Aseptic measures were undertaken during collection of samples.

There were 42 isolations with 13 different species of aerobic and facultative anaerobic bacteria which were cultured from ten samples. The number of species cultured per sample varied from 3 to 5, with no animals yielding a single species. One False Gharial (10.0%) had 3 isolates, six False Gharials (60.0%) obtained 4 and three False Gharials (30.0%) yielded 5 isolates. The mean number of isolations per False Gharial was 4.2. All bacteria which were isolated from each specimen are presented in Table 1. The bacteria are given in the order of frequency in which they were isolated from each cloaca swab, with the first-named being the most frequent isolate.

Table 2 shows the gram and type of bacteria, number of isolates for each bacterium and the percentage of False Gharials carrying each species of bacteria. All the bacterial isolates were gram negative with aerobic and facultative anaerobic type. Most of the genera present were members of the family Enterobacteriaceae and only one bacteriaum from family Moraxellaceae that was *Acinetobacter lwoffii*. The most commonly isolated species was *Salmonella spp* (8 isolates), found in eight of the False Gharials (80.0%), and followed by *Proteus vulgaris* (6 isolates).

Table 3 shows comparison of bacterial isolates between this study and the previous ones on captive Gharial[8]. Not all bacteria found in this study were discovered on the captive Gharials. Table 4 shows the comparative result between samples from captive pond with concrete flooring and captive pond with mud flooring. Samples number 1 - 5 were collected from captive pond with concrete flooring at the Taiping Zoo and National Zoo while sample

Table 1: Bacterial isolates from each cloacal swab from 10 captive False Gharials

Sample	Bacterial isolates
1	*Aeromonas spp, Citrobacter freundii, Edwarsiella tarda, Klebsiella oxytoca, Plesiomonas shigelloides,*
2	*Edwarsiella tarda, Pantoea agglomerans, Proteus vulgaris,Salmonella sp*
3	*Citrobacter freundii, Pantoea agglomerans, Proteus vulgaris,Salmonella sp.*
4	*Escherichia coli, Morganella morganii, Proteus vulgaris*
5	*Escherichia coli, Klebsiella oxytoca, Proteus vulgaris, Salmonella sp.*
6	*Citrobacter freundii, Enterobacter cloaca, Escherichia coli, Salmonella sp.*
7	*Acinetobacter lwoffii, Edwarsiella tarda, Escherichia coli, Klebsiella oxytoca, Salmonella sp.*
8	*Proteus vulgaris, Providencia rettgeri, Morganella morganii, Salmonella sp.*
9	*Edwarsiella tarda, Escherichia coli, Providencia rettgeri, Salmonella sp.*
10	*Enterobacter cloaca, Edwarsiella tarda, Morganella morganii, Proteus vulgaris, Salmonella sp.*

Table 2: Number of isolates of each bacterium, and percentage of captive crocodiles carrying each species.

Bacterium	Gram/Type	No. of isolates	Percentage of crocodiles (%)
Acinetobacter lwoffii	- / A	1	10
Aeromonas spp	- / FA	1	10
Citrobacter freundii	- / FA	3	30
Edwardsiella tarda	- / FA	5	50
Enterobacter cloacae	- / FA	2	20
Escherichia coli	- / FA	5	50
Klebsiella oxytoca	- / FA	3	30
Morganella morganii	- / FA	3	30
Pantoea agglomerans	- / A	2	20
Plesiomonas shigelloides	- / A	1	10
Proteus vulgaris	- / A	6	60
Providencia rettgeri	- / A	2	20
Salmonella spp	- / FA	8	70

Table 3: Comparison of bacteria isolated between captive False Gharial and Captive Gharial

Organism	Captive False Gharial, N=10 (% of bacteria isolates)	Captive Gharial[1], N= 23 (% of bacteria isolates)
Acinetobacter lwoffii	10	0.0
Aeromonas spp.	10	30.43
Citrobacter freundii	30	26.08
Edwarsiella tarda	50	13.04
Enterobacter cloacae	20	0.0
Escherichia coli	50	39.13
Klebsiella oxytaca	30	0.0
Morganella morganii	30	0.0
Pantoea agglomerans	20	0.0
Plesiomonas shigelloides	10	0.0
Proteus vulgaris	60	0.0
Providensia rettgeri	20	0.0
Salmonella spp.	70	0.00

number 6 - 10 were collected from captive pond with mud flooring at the Wildlife Conservation Center, Sungai Dusun. The results showed, which the samples taken from captive pond with mud flooring had a higher number of bacteria than samples from those from captive pond with concrete flooring.

Several studies on normal flora of the crocodilians were carried out before either on those kept in captivity or from the wild. The intestinal tract flora isolated from wild-caught African dwarf crocodiles (*Osteolaemus tetraspis*) and from wild Nile crocodiles (*Crocodylus niloticus*) have been reported. The other four crocodilian species that were examined in the wild conditions included *Alligator mississippiensis* (Flandry et al., 1989; Johnston et al., 2010), *Crocodylus acutus* and *Crocodylus moreletii* (Charruau et al., 2012), *Crocodylus porosus* (Anderson, 1999) and *Crocodylus johnstoni* (Anderson, 1999). The present finding is the first record for the identification of normal flora in cloaca of the False Gharial.

The bacteria isolated were similar to the normal intestinal flora of other animal species. Most of the genera usually present in high abundance were members of the family Enterobacteriaceae. In this study, the number of bacteria found did not prove that the bacteria isolated were a part of normal intestinal flora of this species of crocodiles due to limited samples. Bacteria isolated from the cloacal swabbing were not really meaningful as an indicator of normal intestinal compared to swabbing directly from the intestine. This is due to the anatomical structure of genital and reproductive organs that shared the same cloaca with the gastrointestinal tract. The bacteria isolated from the cloaca could also originate from the genital and reproductive area.

However, from other studies about normal flora, *Aeromonas spp*. is not considered as normal intestinal flora of crocodile. *Aeromonas spp*. is a part of the micro flora found on the freshwater, estuarine, brackish and saltwater and also fish. *Citrobacter spp, Edwarsiella tarda, Escherichia coli, Klebsiella oxytoca, Morganella morganii, Pantoea agglomerans, Plesiomonas shigelloides, Proteus vulgaris,* and *Providensia rettgeri* are members of the normal intestinal flora in other species of crocodiles (Ladds et al., 1996; Mahajan et al., 2003). The same

Table 4: Comparison between bacteria isolated between sample from captive pond with concrete floor and captive pond with mud floor

Organism	Captive pond with concrete floor, (Sample 1-5) (No of bacteria isolates)	Captive pond with mud floor, (Sample 6-10) (No of bacteria isolates)
Acinetobacter lwofii	-	1
Aeromonas spp	1	-
Citrobacter freundii	2	1
Edwardsiella tarda	2	3
Enterobacter cloaca	-	2
Escherichia coli	2	3
Klebsiella oxytaca	2	1
Morganella morganii	1	2
Pantoea agglomerans	2	-
Plesiomonas shigelloides	1	-
Proteus vulgaris	4	2
Providensia rettgeri	-	2
Salmonella sp	3	5
No. of isolations	20	22
Mean	4.0	4.4

goes to *Salmonella spp*. Crocodiles, like other reptiles, were reported to harbor salmonella in their intestine as part of their normal intestinal flora (Obwolo and Zwart, 1993).

Several factors may have caused for the apparent occurrence and absence of bacteria in this study. The composition of intestinal flora is dependent on ingested food and condition of captive pond. The type of food provided at both captive ponds are the same and a possible equality of bacteria found in both the ponds is higher due to the same diet. Furthermore, cloacal swabbing may underestimate the prevalence of bacteria compared with faecal swabbing. Natural habitat of salmonella is the intestinal tract. The prevalence of salmonella in faeces is higher than in cloaca because faeces itself originated directly from the intestine.

Other than that, the prevalence of microorganisms in the aquatic environment also could be influenced by the water temperature, salinity and type of floor (Sedas, 2007). Different environments provide different bacteria results. Table 4 shows the comparative result between samples taken from the captive pond with concrete floor and captive pond with mud floor. Even though they are considered as normal flora, these bacteria can act as opportunist microorganisms and cause severe problem to the captive crocodiles. It is supported by other studies that mentioned that the gram-negative bacteria are common cause of septicemia and death in captive reptiles, including young crocodiles.

Escherichia coli, Aeromonasspp, and *Salmonellae* had been reported to be found associated with mortality caused by enteritis and septicaemia in farmed crocodiles. Besides that, other genera (*Citrobacter spp, Edwarsiella tarda* and *Proteus vulgaris*) are also known causes of septicaemia in crocodiles (Foggin, 1992; Huchzermeyer et al., 2000; Lovely and Leslie, 2008). This supports the view that many bacterial septicaemias are caused by normal intestinal tract inhabitants which act as opportunistic pathogens in an immune-suppressed host.

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Access and Benefit-sharing of Underutilized Livestock Breeds under the Nagoya Protocol Framework

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ABSTRACT

Access and Benefit-Sharing (ABS) of animal genetic resources has had a low profile and even the mandatory Nagoya Protocol has not changed this, as country representatives struggle with understanding the implications of ABS for the livestock sector. In the course of the discussions around this topic the original rationale of ABS as a tool for conserving genetic resources has been lost. The core argument of this paper is that the ABS concept – which was originally developed with wild biodiversity in mind – needs to be adapted to address the specific characteristics and requirements of the sector. If tweaked in the right way, ABS for AnGR could support the conservation of those animal genetic resources that matter most in the context of climate change and for achieving food security within planetary boundaries. The promotion of Community Protocols, a key element of the Nagoya Protocol, could be the starting point for conserving climate resilient livestock breeds *in situ* to ensure access to them in the future. Developing countries should push for an enabling mechanism in the relevant international fora, such as the Commission on Genetic Resources for Food and Agriculture (CGRFA).

Key words: Access & Benefit-Sharing, Food security, Pastoralists, Nagoya Protocol, Community Protocols, Conservation

Introduction

Access and Benefit-Sharing of genetic resources is a key principle of the UN Convention on Biological Diversity (CBD) which places genetic resources under state sovereignty and in its Art. 15 states that access to genetic resources is subject to national legislation. The CBD mandates that its contracting parties shall create measures to share in a fair and equitable way the results of research and development and the benefits arising from the commercial and other utilization of genetic resources.

Enacting these principles into practice has been fraught with difficulties, especially with respect to genetic resources for food and agriculture. The CBD was created with wild biodiversity in mind, especially medicinal plants where the source of a particular genetic resource and associated traditional knowledge can often be established easily. The situation is different with respect to domestic biodiversity such as crops and livestock, as humans have modified these in an incremental manner and in many different geographical locations far from where they were originally domesticated. To address this situation, a special instrument has been developed for access to crop genetic resources, the International Treaty on Plant Genetic Resources for Food and Agriculture. Nothing similar exists with respect to animal genetic resources.

The Nagoya Protocol

In order to address the problems associated with implementing ABS, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (Nagoya Protocol) was agreed upon during the tenth meeting of the Conference of the Parties (COP 10) to the Convention on Biological Diversity, held in Nagoya in 2010. This legally binding instrument seeks to regulate the access and benefit-sharing of genetic resources and associated traditional knowledge at national, regional and international level. It requires its Contracting Parties to consider, in the development and implementation ABS measures the importance of GRFA and their special role for food security.

It also explicitly recognizes that the special nature of agricultural biodiversity and its distinctive features require distinctive solutions, and to bear in mind that all countries are interdependent with regard to the exchange of genetic resources for food and agriculture. Furthermore, it places emphasis on prior informed consent, mutually agreed terms, involvement of indigenous and local communities and the development of community protocols in which they articulate under which conditions they would provide access and share benefits.

The current status of the implementation of the Nagoya Protocol with respect to animal genetic resources

Within the animal genetic resource sector, Access and Benefit-Sharing has had a low profile (CGRFA and FAO, 2015). Prior to the development of the Nagoya Protocol, most stakeholders, including governments and industry, did not engage with this concept, because the scenario in the sector is different from other subsets of biodiversity. Many/most animal genetic resources are privately owned and there has not been much interest in the North in the animal genetic resources from the South, because the differences in production parameters are considered to be too vast. (Flows of AnGR have been mostly North-North or North-South, even South-South, but only rarely South-North, although new needs in the North caused by climate change may alter this scenario). The emerging technology of gene-editing, possibly eliminating the need for genetic material from the South, further complicates the situation. Most pertinently, the livestock industry is concerned that ABS regulations would interfere with the routine exchange of farm animals as a commodity or for multiplication, although such transactions are not subject of the Nagoya Protocol.

The discussions at the concerned international body, the Intergovernmental Working Group on Animal Genetic Resources for Food and Agriculture (ITWG-AnGR) have been proceeding at a snail pace, and at this point in time still concern themselves with identifying the distinctive features of animal genetic resources for food and agriculture in the context of the ABS elements, as the implications of ABS measures on the sector are not well understood. There is a call for an impact assessment of ABS on the livestock sector.

The perspective of small-scale livestock keepers

Contrary to the situation at the government level, small-scale livestock keepers, as represented by the LIFE Network, have welcomed and eagerly supported the Nagoya Protocol because of its emphasis on prior informed consent, mutually agreed terms, and the involvement of indigenous and local communities. Under the Nagoya Protocol, prior informed consent and mutually agreed terms would need to be established if AnGR sourced from indigenous and local communities are utilized for research, even within the country. The hope of small-scale

Photograph 1. Camels as means of transport in South and West Asia

livestock keepers, including pastoralists, is that the implementation of the protocol would motivate countries to closer collaborate with the communities that are stewarding their AnGR and that this would lead to recognition of their role as guardians of livestock biodiversity and providers of eco-system services (LPP, 2018).

Communities and NGOs have therefore embraced the establishment of community protocols to highlight their role as local and indigenous communities stewarding AnGR and traditional knowledge under paragraph 8j of the CBD which had previously remained largely invisible. They have developed community protocols to claim their connection with specific breeds and argue that these provide an opportunity for countries to better understand their animal genetic resources, the social contexts in which they exist, and the threats that they are

Photograph 2. Modern facility for camel dairying in West Asia

exposed to. This in turn lays the foundation for the long-term participatory conservation of a country's animal genetic resources.

A crucial point they make is that "Access" to AnGR is not just about contracts between specific providers and commercial users (MTAs), but about ensuring their survival long into the future (Köhler-Rollefson and Meyer, 2015).

Table 1. List of Biocultural Community Protocols

Community	Breeds	Country	Status
Raika	Camel, Nari cattle, Boti sheep, Sirohi goat	India	Finalized
Banni Maldhari	Banni buffalo	India	Finalized
Rebari and Jatt	Kutchi and Kharai camels	India	Finalized
Bargur Hill cattle	Bargur Hill Cattle	India	Finalized
Attappady goat breeders	Attapatty goat	India	Finalized
Pullikulum cattle breeders	Pullikulum cattle	India	Finalized
Pashtoon	Various breeds	Pakistan	Finalized
Samburu	Red Maasai sheep	Kenya	Finalized
Golla	Ganjam goat	India	In prep
Kuruba	Kuruba shepherding system, incl. Deccani breed	India	In prep
Kangayam cattle breeders	Kangayam cattle	India	In prep
Malgaddi	Brela camel	Pakistan	In prep

The response of countries to Community Protocols has been muted. They have been ignored by India's National Biodiversity Authority which refers to "biodiversity registers" being the appropriate tools in the national legal context. Thankfully the African Union is undertaking a major project to establish Biocultural Community Protocols in a number of countries.

The FAO/CGRFA position is as follows: "*Indigenous people and local communities (IPLC) should be involved in decisions that concern their TK associated with AnGR, and the domestic ABS regulatory measures should respect Bio-cultural Community Protocols and specific institutional arrangements developed by these communities. In cases where several communities share TK associated with AnGR, and only one has granted PIC, a mechanism for benefit-sharing involving all relevant IPLCs might be considered. Bio-cultural Community Protocols are also useful to support in situ conservation of locally adapted breeds, which in some cases may be necessary to maintain endangered breeds and ensure their future availability*." (CGRFA, 2018).

The larger context: Need to conserve climate resilient breeds

There is widespread agreement among experts about the rising importance of livestock breeds adapted to climatic extremes (Hoffmann, 2010). In a scenario defined by global warming on one hand and a human population of close to 10 billion by 2050, it will be inevitable that livestock breeds with the ability to live and produce in environmentally challenging conditions and less dependent on cultivated feed will rise to the fore. According to a recent study by a team of reputed researchers led by a scientist from Wageningen University food security will be possible in 2050 if we reduce livestock product consumption in developed countries and use only "low-cost" livestock that can be fed on crop by-products or on natural vegetation in non-arable areas (Van Zanten et al., 2018).

A major threat to the conservation and sustainable use of such AnGR with fitness traits is posed by the continuing importation of exotic breeds into developing countries, diluting these gene pools. At the same time, pastoralists who steward the breeds that will be most valuable in the future are undergoing developments that undermine their ability to conserve, use sustainably and share the benefits of their genetic resources and traditional knowledge. This is mostly due to neglect and disinterest of governments, as well as due to general trends (scramble for land and resources, disregard for customary practices, changes in values, monetarization of the economy, etc.).

There is also an equity issue. While the industry has developed a number of mechanisms to safeguard the investments that they have made in the development of AnGR (patents, trade secret, hybrid breeding, contracts prohibiting use for breeding), the indigenous and local communities that currently act as stewards of livestock genetic diversity have no such protection. This situation poses a threat not only for them, but for humanity at large, as it will depend on such breeds for food security in the future.

Conclusions

Implementation of the Nagoya Protocol in the spirit in which it was intended – to ensure that benefits are made available to the indigenous people and local communities and thereby provide incentives for the conservation of biodiversity – could make a huge difference to the conservation of the breeds that will matter most in the future. The Nagoya Protocol contains important elements that could create a more supportive scenario for the "keepers of genes" by sharing with them monetary and non-monetary benefits, as listed in the annex of the Nagoya Protocol. Non-monetary benefits should include the participation of livestock keepers in policy formulation and implementation processes on AnGR for food and agriculture, training and capacity building, access to services, marketing support, identification of research needs, and access to information, corresponding to the demands made in the widely supported Declaration of Livestock Keepers' Rights.

In order to ensure benefit-sharing and to create incentives for the conservation and sustainable sue of AnGR, the option of 'decoupling' the sharing of benefits from specific cases of access should be examined. One option suggested would be to grant "Livestock Keepers' Rights" to communities that have claimed status as indigenous or local community stewarding genetic resources under Article 8j of the CBD by means of a (biocultural) community protocol. "Livestock Keepers' Rights" could be an avenue for ensuring in-situ conservation for access in the FUTURE, independent of demand for providing access NOW. Such arrangements would need to be embedded in national legislations, but an international instrument could do much to encourage and support such an approach by emphasizing that this would be the benefit implementing countries and help them adapt to climate change and increase their autonomy from feed imports; i.e. represent an important means towards achieving food security. Developing countries should press for such an approach – and an associated funding mechanism – in the appropriate international fora, especially the Commission on Genetic Resources for Food and Agriculture and its Inter-governmental Working Group on Animal Genetic Resources.

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Technical Program

DAY 1: Monday, March 4, 2019

08.30	**Hotel pick-up for MARDI** *Venue: Tan Sri Yusuf Hashim Hall, MARDI Serdang*
08:30-09:00	**Registration**
09:00-10.30	**Opening Ceremony** ***Arrival of*** **YB Dr. Zunika Mohamed** Deputy Secretary General (Policy) Ministry of Agriculture & Agro-based Industry (MOA), Malaysia ***Doa' recital*** **Welcome remarks by** **Datuk Dr. Mohamad Roff Bin Mohd Noor** Director General Malaysian Agricultural Research and Development Institute (MARDI), Malaysia **Dr Ravi Khetarpal** Executive Secretary Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok **Dr Chung-Hsiu Hung** Director General Council of Agriculture (COA), Taiwan **Opening remarks by** **YB Dr. Zunika Mohamed** Deputy Secretary General (Policy) Ministry of Agriculture & Agro-based Industry (MOA), Malaysia ***Gift exchange*** **Group photo session**
10.30-11:00	***Tea/Coffee break***

TECHNICAL SESSION I

Status of Underutilized Animal Genetic Resources for Food and Agriculture at Sub-Regional Level

Co-chairs: **Abdul Rashid Baba & Jialin Han**

11:00-11:20	***South and West Asia*** **Arjava Sharma** Former Director ICAR-National Bureau of Animal Genetic Resources (NBAGR), India
11:20-11:40	***South-East Asia*** **Synan Bagio** PCAARRD, Philippines Officer-in-Charge Livestock Research Division, DOST-PCAARRD, Philippines
11:40-12:00	***East Asia*** **Tu, Po An** Associate Researcher Livestock Research Institute, Council of Agriculture (COA), Taiwan
12:00-12:20	***The Pacific*** **Alan Quartermain** Professor of Agriculture University of Goroka (UOG), Papua New Guinea
12:20-12:35	**Discussion**
12:35-13:45	***Lunch***

TECHNICAL SESSION II

Thematic Presentations on Underutilized Animal Genetic Resources

Co-chairs: **Ilse Köhler-Rollefson & Mohd Noor Hisham Mohd Haron**

14:00-14:20	**Underutilized animal genetic resources for food and nutrition-regional scenario** **Jialin Han** Senior Scientist ILRI-CAAS Joint Lab, International Livestock Research Institute (ILRI), China
14:20-14:40	**Characterization, inventory and monitoring of underutilized AnGR** **Adrien Kumar Raymond** Former Senior Research Officer Department of Veterinary Service (DVS), Malaysia
14:40-15:00	**Breeding strategies for underutilized AnGR** **Ming Che Wu** Chief, Animal Breeding and Genetics Division Taiwan Livestock Research Institute (TLRI), Taiwan
15:00-15:20	**Discussion**

15:20-15:50	***Tea/Coffee Break***
15:50-16:10	**Molecular biotechnologies for underutilized AnGR** **Ainu Husna MS Suhaimi** Deputy Director Livestock Science Research Centre, Malaysian Agricultural Research & Development Institute (MARDI), Malaysia
16:10-16:30	**Animal genetic resources in the ASEAN and the three objectives of the Convention on Biological Diversity** **Elpidio V. Peria** Programme Specialist Development & Implementation Unit, ASEAN Centre for Biodiversity (ACB), Philippines
16:30-16:50	**Market-driven approaches to conservation and utilization of AnGR** **Steve Staal** Program Leader Policies, International Livestock Research Institute (ILRI), Kenya
16:50-17:10	**Discussion**
17:10-19:00	*Visit to MAEPS Agro Tourism Park*
20:00-22:00	***Workshop Dinner***

DAY 2: Tuesday, March 5 2019

TECHNICAL SESSION III

Strategies for Conservation and Utilization of Underutilized Animal Genetic Resources

Co-chairs: **Alan Quartermain & Redzuan Ibrahim**

09:00-09:20	**Reproductive biotechnologies for underutilized AnGR** **Abdul Rashid Baba** Former Principal Senior Research Officer MARDI, Malaysia
09:20-09:40	**Avian genetic resources** **Khabirul Islam Khan** Professor, Dept. of Genetics and Animal Breeding Chottagram Veterinary & Animal Sciences University (CVASU), Bangladesh
09:40-10:00	**Modern methods of in situ and *ex situ* conservation of underutilized AnGR** **Tengku Rinalfi Putra Tengku Azizan** Senior Lecturer, Faculty of Veterinary Medicine Universiti Putra Malaysia (UPM), Malaysia
10:00-10:30	**Discussion**
10:30-11:00	***Tea/Coffee Break***

11:00-11:20	**Conservation and improvement of small ruminant genetic resources for sustainable food production** **Satendra K. Singh** Scientific Advisor Ministry of Agriculture and Farmers Welfare (MoAFW), India
11:20-11:40	**Access and benefit-sharing of underutilized livestock breeds under the Nagoya Protocol Framework** **Ilse Köhler-Rollefson** Head and Coordinator League for Pastoral Peoples and Endogenous Livestock Development (LPPELD), Germany
11:40-12:00	**Discussion**
12:00-13:30	***Lunch***

TECHNICAL SESSION IV

World Café Discussion – Regional Priorities for Underutilized AnGR

Moderator: **Mohamed Ariff Omar, MARDI, Malaysia**

	Table 1. Conservation, improvement and use *Facilitator*: **Sivananthan Elagupillay**, WILDLIFE, Malaysia
	Table 2. Value addition, marketing and export *Facilitator*: **Saifullizam Abdul Kadir**, DVS, Malaysia
	Table 3. Partnership and capacity development *Facilitator*: **Shahril Faizal Abdul Jani**, MOA, Malaysia
	Table 4. Biotechnology for enhancing utilization *Facilitator*: **Ainu Husna MS Suhaimi**, MARDI, Malaysia
	Table 5. Regional information sharing system and focal points *Facilitator*: **Jianlin Han**, ILRI, China
16:30-17:30	**Compilation of Recommendations**

DAY 3: Wednesday, March 6, 2019

TECHNICAL SESSION V

Panel Discussion on Legal and Policy Framework Support to Promote Utilization of Underutilized AnGR

Co-chairs: **Steven Staal & Wan Mohd Kamil Dato' Wan Nik**

09:00-10:30	***Perception of Panellists*** **Ilse Köhler-Rollefson**, LPPELD, Germany **Ravi Khetarpal**, APAARI, Thailand **Allen Quartermain**, UOG, Papua New Guinea **Steven Staal**, ILRI, Kenya **Khabirul Islam Khan**, CVASU, Bangladesh
10:30-11:00	***Tea/Coffee Break***

PLENARY SESSION

Co-chairs: **Ravi Khetarpal & Sadi Sujang**

11:00-11:30	**Presentation of Technical Session** **Noraini Samat**, MARDI, Malaysia
11:30-12:00	**Presentation of World Café Discussion** **Mohamed Ariff Omar**, MARDI, Malaysia
12:00-12:30	***Brief Remarks by the Co-Organizers*** **Closing Remarks** **Ravi Khetarpal** Executive Secretary Asia-Pacific Association of Agricultural Research Institutions (APAARI), Thailand **Mohamad Roff Bin Mohd Noor** Director General Malaysian Agricultural Research and Development Institute (MARDI), Malaysia **Vote of Thanks** **Rishi Tyagi** APCoAB Coordinator Asia-Pacific Association of Agricultural Research Institutions (APAARI), Thailand
12:30-13:30	***Lunch***
14:00-16:00	Visit MARDI facilities
14:00-14.30	Introduction to Centre of Marker Development & Validation (CMDV)
14.30-14.45	Depart to CMDV
14.45-15.45	Technical visit - CMDV
15.45-16.00	Depart to MyGeneBank
16.00-17.00	Technical visit - MyGeneBank
17.00	Visit to Putrajaya

Appendix 3

Organizing Committee 2019

Regional Workshop on Underutilized Animal Genetic Resources and their Amelioration (AnGR)

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		Mr. Zul Hazwan Abd Aziz (MARDI)

Appendix 4

Photo Gallery

Registration of Participants

Invited guests, organizing committee members and participants

International participants

International participants

Gift Presentation Ceremony

Dr. Ravi K. Khetarpal, APAARI to Dr. Mohamad Roff Mohd Noor, MARDI

Dr. Ravi K. Khetarpal, APAARI to Dr. Chung Hsiu Hung, COA

Dr. Mohamad Roff Mohd Noor, MARDI to Dr. Chung Hsiu Hung, COA

Dr. Mohamad Roff Mohd Noor, MARDI to Dr. Zunika Mohamed, MOA, Malaysia

Participants Corner

Technical Session IV: World Café Discussion

Table I - Conservation, improvement and use

Table II - Value addition, marketing and export

Table III - Partnership and capacity development

Table IV - Biotechnology for enhancing utilization

Table V - Regional information sharing system and local points

Technical Session V: Panel Discussion

Ilse Köhler-Rollefson, Alan Quartermain, Khabirul Islam Khan, Ravi K. Khetarpal and Steven Staal

Plenary Session

Mohamed Ariff Omar, Malaysia

Noraini Samat, Malaysia

Closing Ceremony

Ravi K. Khetarpal, APAARI

Mohamad Roff Mohd Nor, MARDI

Rishi K. Tyagi, APAARI

Book Launching

Books title :

Agricultural Biotechnology - Scoping Partnerships to Improve Livelihoods of Farmers in Asia and The Pacific. APAARI

Appendix 5

Visit to MARDI Facilities

Centre for Marker Discovery & Validation (CMDV)

Centre for Marker Discovery & Validation (CMDV) is a part of Biotechnology Research Centre of MARDI. CMDV was officially operational in 2011. The major research thrusts are discovery and validation of molecular markers, establishing molecular breeding, and analyzing DNA fingerprinting in crops, livestock and fisheries for varietal identification, genetic traceability and quality control. CMDV is currently working on different crops such as coconut, mango, pineapple, rice and also durian, our king of fruits. As for livestock commodities, research is being conducted on tilapia fish, goat and cattle. CMDV is a one stop center well equipped with high throughput equipment in molecular techniques and bioinformatic platform for research and services.

MyGeneBank™

MyGeneBank™ is a program under Agro-biodiversity Resources Utilization and Conservation of Agrobiodiversity & Environment Research Centre MARDI. The mission of MyGeneBank™ is to conserve, manage and utilize agrobiodiversity resources as national heritage for food security and future generation. The facilities in MyGeneBank™ complex include seed gene bank, botanical and phytochemical laboratories, herbarium, insect museum, and histological and microbial culture collections. MyGeneBank™ has several field gene banks for different crops in different locations: Seberang Perai (rice, wild rice), Jerangau (vegetables, fruits, herbs), Jelebu (fruits), Kemaman (fruits), Kuala Kangsar (fruits), Serdang (vegetables) and Bintulu (fruits), with a total area of more than 200 hectares. Research activities include collection of genetic resources, identification of species, genetic diversity analysis, bio-prospection, conservation and cryopreservation.

MAEPS Agro Tourism Park

MAEPS Agro Tourism Park, Serdang was established to serve as an Agro -Tourism Center & Showground The agricultural park or garden or Laman Agro MAEPS consists of 8 agricultural showgrounds to showcase Malaysia agriculture industries which include herbs, vegetables, flowers and livestock. It is a worthwhile agricultural experience that will stimulate our five senses while exploring the beautiful landscapes and fantastic attractions. The tram ride for a short tour brings participants to experience various interactive activities such as honey harvesting, food and drinks sampling at the herbs showground, and agricultural demonstration.


Herbal Garden


Stingless Bee Honey

Workshop Dinner for Participants and Speakers

Steamboat and grill style dining


Appreciation Dinner for the Organizing Committee

Women Power

Members of the various local committees of the workshop

ISBN 978-616-7101-20-0
9 786167 101200

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