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Editorial

The Sixth Session of the Intergovernmental Technical Working Group on Animal Genetic Resources for Food and Agriculture[1] took place in Rome in November 2010. The agenda items included the status of implementation of the Funding Strategy[2] of the *Global Plan of Action for Animal Genetic Resources*. The Working Group stressed the need for adequate funding to support developing-country implementation of the *Global Plan of Action.* It recommended that the Commission on Genetic Resources for Food and Agriculture request FAO to announce the first call for proposals for use of the FAO Trust Account established under the Funding Strategy when it has reached a threshold of around US$500 000. It further recommended that the Commission agree to a maximum of one concept note from each developing country and country with economy in transition in the first call, with an initial maximum of up to US$50 000 per project. It stressed that bilateral or multilateral project proposals should be encouraged. Project proposals will be submitted by governments, but other stakeholders may wish to take the opportunity to draw attention to relevant opportunities for projects in their respective countries and collaborate in the development of proposals.

The Working Group reviewed draft guidelines prepared by FAO on phenotypic characterization[3], molecular genetic characterization[4], cryoconservation[5], surveying and monitoring[6], and development of the institutional framework for the management of animal genetic resources[7]. It recommended that the Commission endorse the draft guidelines and request FAO to finalize and publish them and encourage countries to make full use of them.

In reviewing the status of FAO's work on the implementation of the *Global Plan of Action*, the Working Group noted the importance of the forthcoming reports on the progress made by countries and international organizations in implementing the *Global Plan of Action*. A survey of international organizations' activities was undertaken by FAO early in 2011 via an internet-based questionnaire. Later in the year, countries will be asked to complete questionnaires on their activities. This will be a key opportunity to obtain an overview of how implementation of the *Global Plan of Action* is progressing. Stakeholders should help ensure that implementation activities in their countries are fully reflected in the questionnaire responses submitted by their respective governments.

Also on the agenda of the Working Group was the *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization*[8] adopted by the Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity (COP 10). The Working Group was provided with information on the implications of the protocol for the management of animal genetic resources. It recommended that the Commission consider the outcomes of COP 10 at its next regular session. In its review of FAO activities on *Global Plan of Action* implementation, the Working Group recommended that the Commission invite FAO and countries to initiate the development of policies and protocols for exchange of animal genetic resources for the purpose of multicountry conservation activities, including gene banking, especially in light of changes in disease epidemiology, climate change and natural disasters.

Access and benefit sharing was also the subject of an expert meeting held in Wageningen, The Netherlands, in December 2010. Among the issues highlighted in the report of the meeting were the limited opportunity for generating funds for conservation via South–North exchange of animal genetic resources; the importance of the *Global Plan of Action* and its Funding Strategy as a framework for addressing the use and conservation of animal genetic resources; the pros and cons of a legally binding international instrument for the exchange of animal genetic resources; the potential value of voluntary instruments for access and benefit sharing in the animal genetic resources sector; and the need for measures to facilitate more North–South collaboration in capacity building.

In conclusion, if the FAO Trust Account for *Global Plan of Action* implementation is sufficiently plenished, the call for project proposals will be issued later this year. Given the limit of one proposal per country, research communities in individual developing countries and countries with economies in transition should collaborate in identifying priority projects for their respective countries' submissions. Another priority for this year is the reporting process on national *Global Plan of Action* implementation. Researchers should be involved in ensuring that reporting is as comprehensive as possible. Information on relevant activities should be provided to National Coordinators for the Management of Animal Genetic Resources[9].

[1] http://www.fao.org/ag/againfo/programmes/en/genetics/angrvent2010.html
[2] http://www.fao.org/docrep/012/i1674e/i1674e00.htm
[3] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_inf_6.pdf
[4] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_Inf_7.pdf
[5] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_Inf_8.pdf
[6] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_Inf_5.pdf
[7] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_inf_9.pdf
[8] http://www.cbd.int/abs/doc/protocol/nagoya-protocol-en.pdf
[9] http://dad.fao.org/cgi-bin/EfabisWeb.cgi?sid=-1,contacts

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Editorial

La sixième session du Groupe de travail technique intergouvernemental sur les ressources zoogénétiques pour l'alimentation et l'agriculture[1] s'est tenue à Rome, au mois de novembre 2010. L'état de la mise en œuvre de la Stratégie de financement[2] du *Plan d'action mondial pour les ressources zoogénétiques* était à l'ordre du jour. Le Groupe de travail a souligné le besoin de financements appropriés pour le soutien de la mise en œuvre du *Plan d'action mondial* dans les pays en développement. Il a recommandé à la Commission sur les ressources génétiques pour l'alimentation et l'agriculture de demander à la FAO de publier le premier appel à propositions pour l'utilisation du Compte fiduciaire de la FAO ouvert au titre de la Stratégie de financement, une fois qu'il aura atteint un seuil d'environ 500 000 USD. Il a en outre recommandé à la Commission d'accepter au maximum une note conceptuelle par pays en développement et par pays en transition dans le cadre du premier appel à propositions, avec une allocation initiale de 50 000 USD au maximum par projet. Il a souligné que les propositions de projets bilatéraux ou multilatéraux devront être encouragées. Ces propositions de projet seront soumises par les gouvernements, mais d'autres parties prenantes pourront profiter de cette occasion pour attirer l'attention sur des possibilités pertinentes de mise en place de projets dans leurs pays respectifs et collaborer à l'élaboration des propositions.

Le Groupe de travail a examiné les projets de directives préparés par la FAO sur la caractérisation phénotypique[3], sur la caractérisation génétique moléculaire[4], sur la cryoconservation[5], sur la prospection et le suivi[6], et sur la mise en place de cadres institutionnels pour la gestion des ressources zoogénétiques[7]. Il a recommandé à la Commission d'approuver les projets de directives et de demander à la FAO de les finaliser et de les publier, et d'encourager les pays à en tirer le meilleur parti.

En analysant l'état du travail de la FAO sur la mise en œuvre du *Plan d'action mondial*, le Groupe de travail a noté l'importance des prochains rapports sur les progrès accomplis par les pays et par les organisations internationales dans la mise en œuvre du *Plan d'action mondial.* Une enquête sur les activités des organisations internationales a été réalisée par la FAO au début de 2011, par le biais d'un questionnaire en ligne. Plus tard dans l'année, les pays devront compléter les questionnaires sur leurs activités, ce qui représentera une occasion importante de visionner les progrès accomplis dans la mise en œuvre du *Plan d'action mondial*. Les parties prenantes devraient s'assurer que les activités de mise en œuvre seront pleinement reflétées dans les réponses du questionnaire soumis par leurs gouvernements respectifs.

A l'ordre du jour du Groupe de travail était également le *Protocole de Nagoya sur l'accès aux ressources génétiques et le partage juste et équitable des avantages découlant de leur utilisation*[8], adopté à la dixième réunion de la Conférence des Parties à la Convention sur la diversité biologique. Le Groupe de travail a reçu les informations sur les implications du protocole pour la gestion des ressources zoogénétiques. Il a recommandé à la Commission d'examiner, à sa prochaine session ordinaire, les conclusions de la dixième Conférence des Parties à la Convention sur la diversité biologique. Dans son examen des activités de la FAO pour la mise en œuvre du *Plan d'action mondial*, le Groupe de travail a recommandé à la Commission d'inviter la FAO et les pays à commencer à élaborer des politiques et protocoles d'échange de ressources zoogénétiques aux fins des activités plurinationales de conservation, y compris les banques de gènes, à la lumière notamment des modifications intervenues en matière de propagation des maladies, de changement climatique et de catastrophes naturelles.

L'accès et le partage des avantages était également le sujet d'une réunion d'experts qui s'est tenue à Wageningen, Pays-Bas, au mois de décembre 2010. Parmi les questions mises en exergue dans le rapport de la réunion paraissaient: les possibilités limitées de génération de fonds en faveur de la conservation par l'échange Sud-Nord des ressources zoogénétiques; l'importance du *Plan d'action mondial* et de sa Stratégie de financement en tant que cadre permettant d'aborder l'utilisation et la conservation des ressources zoogénétiques; les avantages et les inconvénients d'un instrument international juridiquement contraignant en matière d'échange des ressources zoogénétiques; la valeur potentielle d'instruments à caractère facultatif pour l'accès et le partage des avantages dans le secteur des ressources zoogénétiques; et le besoin de mettre en place des mesures qui favorisent la collaboration Nord-Sud en matière de renforcement des capacités.

En conclusion, si le Compte fiduciaire de la FAO pour la mise en œuvre du *Plan d'action mondial* est suffisamment assorti, l'appel à soumission de propositions de projet sera

[1] http://www.fao.org/ag/againfo/programmes/fr/genetics/angrvent2010.html
[2] http://www.fao.org/docrep/012/i1674f/i1674f00.htm
[3] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_inf_6.pdf
[4] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_Inf_7.pdf
[5] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_Inf_8.pdf
[6] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_Inf_5.pdf
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[8] http://www.cbd.int/abs/doc/protocol/certified-text-protocol.pdf

annoncé plus tard cette année. Compte tenu de la limite d'une proposition par pays, les communautés de la recherche des pays en développement et des pays en transition devraient collaborer pour identifier les projets prioritaires pour les présentations de leurs pays respectifs. Une autre priorité de cette année est le processus d'établissement des rapports sur la mise en œuvre du *Plan d'action mondial* au niveau national. Les chercheurs devraient s'engager à assurer que les rapports seront les plus complets possible. L'information sur les activités pertinentes devrait être adressée aux Coordonnateurs nationaux pour la gestion des ressources zoogénétiques[9].

[9] http://dad.fao.org/cgi-bin/EfabisWeb.cgi?sid=-1,contacts

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Editorial

Ha tenido lugar en Roma, en noviembre de 2001, la Sexta Sesión del Grupo de Trabajo Técnico Intergubernamental sobre los Recursos Zoogenéticos para la Alimentación y la Agricultura[1]. Los puntos del orden del día incluían el estado de la implementación de la Estrategia de Financiación[2] del *Plan de Acción Mundial sobre los Recursos Zoogenéticos.* El Grupo de trabajo hizo hincapié en la necesidad de una financiación adecuada para apoyar la implementación del *Plan de Acción Mundial* en los países en desarrollo. Asimismo, recomendó que la Comisión de Recursos Genéticos para la Alimentación y la Agricultura solicitara a la FAO el anuncio de la primera convocatoria de propuestas para la utilización de la Cuenta fiduciaria de la FAO, establecida en virtud de la Estrategia de Financiación, cuando se ha alcanzado un umbral de alrededor de 500.000 dólares estadounidenses. Además, recomendó que la Comisión acordara hasta un máximo de un documento de síntesis de cada país en desarrollo y países con economías en transición en la primera convocatoria, con un máximo inicial de hasta 50.000 dólares estadounidenses por proyecto. Se hizo hincapié en que debían ser fomentadas las propuestas de proyectos bilaterales o multilaterales. Las propuestas de proyectos serán presentadas por los gobiernos; sin embargo, otras partes interesadas pueden aprovechar la oportunidad para llamar la atención en sus respectivos países y colaborar en el desarrollo de dichas propuestas.

El Grupo de Trabajo examinó los borradores de las líneas directrices elaboradas por la FAO sobre caracterización fenotípica[3], caracterización molecular[4], crioconservación[5], seguimiento y control[6], y el desarrollo del marco institucional para la gestión de los recursos zoogenéticos[7]. Se recomendó que la Comisión aprobara los borradores de las líneas directrices y solicitó a la FAO que las finalizara y publicara, y, al mismo tiempo, fomentara que los países hicieran un uso pleno de las mismas.

Al examinar la situación de trabajo de la FAO sobre la implementación del *Plan de Acción Mundial*, el Grupo de Trabajo tomó nota de la importancia de los próximos informes acerca del avance llevado a cabo por los países y organizaciones internacionales en la implementación del *Plan de Acción Mundial*. A principios de 2011, la FAO ha llevado a cabo un estudio de las actividades de las organizaciones internacionales, a través de un cuestionario establecido por medio de Internet. Más adelante, a lo largo del año, se solicitará a los países que completen cuestionarios acerca de sus actividades. Ésta será una oportunidad clave para obtener una visión general de cómo está evolucionando la implementación del *Plan de Acción Mundial*. Las partes interesadas deben ayudar a asegurar que las actividades relacionadas con la implementación en sus países quedan plenamente reflejadas en las respuestas del cuestionario presentado por sus respectivos gobiernos.

Asimismo, en el orden del día del Grupo de Trabajo estaba el *Protocolo de Nagoya sobre acceso a los recursos genéticos y* participación *justa y equitativa en los beneficios que se deriven de su utilización*[8] aprobados por la Décima Reunión de la Conferencia de las Partes en el Convenio sobre la Diversidad Biológica (COP 10). El Grupo de Trabajo recibió información acerca de las consecuencias del protocolo para la gestión de los recursos zoogenéticos. Se recomienda que la Comisión considere los resultados de la COP 10 en su próxima sesión ordinaria. En el estudio de las actividades de la FAO sobre la implementación del *Plan de Acción Mundial*, el Grupo de Trabajo recomendó que la Comisión invitara a la FAO y a los países a iniciar el desarrollo de políticas y de protocolos para intercambiar recursos zoogenéticos, con el fin de poner en marcha actividades de conservación entre varios países, incluyendo los bancos de germoplasma, especialmente a la luz de los cambios epidemiológicos de las enfermedades, del cambio climático y de los desastres naturales.

En diciembre de 2010, el acceso y la participación en los beneficios fue también objeto de una reunión de expertos, celebrada en Wageningen, Países Bajos. Entre las cuestiones destacadas en el informe de la reunión estuvieron la limitada oportunidad para generar fondos para la conservación de los recursos zoogenéticos a través del intercambio Sur-Norte, la importancia del *Plan de Acción Mundial* y su Estrategia de Financiación como marco de trabajo para abordar la utilización y conservación de los recursos zoogenéticos, los pros y los contras de un instrumento internacional jurídicamente vinculante para el intercambio de recursos zoogenéticos, el valor potencial de los instrumentos voluntarios para el acceso y la participación en los beneficios en el sector de los recursos genéticos, y la necesidad de medidas para facilitar la creación de capacidad Norte-Sur.

[1] http://www.fao.org/ag/againfo/programmes/es/genetics/angrvent2010.html
[2] http://www.fao.org/docrep/012/i1674s/i1674s00.htm
[3] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_inf_6.pdf
[4] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_Inf_7.pdf
[5] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_Inf_8.pdf
[6] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_Inf_5.pdf
[7] http://www.fao.org/ag/againfo/programmes/en/genetics/documents/ITWG_AnGR_6/CGRFA_WG_AnGR_6_10_inf_9.pdf
[8] http://www.cbd.int/abs/doc/protocol/nagoya-protocol-es.pdf

En conclusión, si la Cuenta fiduciaria de la FAO para la aplicación del *Plan de Acción Mundial* está lo suficientemente grande, la convocatoria de propuestas de proyectos se publicará a finales de este año. Teniendo en cuenta el límite de una propuesta por país, las comunidades de investigadores en los distintos países en desarrollo y países con economías en transición deben colaborar en la identificación de proyectos prioritarios para la presentación por parte sus respectivos países. Otra de las prioridades para este año, es el proceso de presentación de informes nacionales sobre la implementación del *Plan de Acción Mundial*. Los investigadores deben estar implicados con objeto de garantizar que la información sea lo más completa posible. La información sobre las actividades pertinentes debe ser proporcionada por los Coordinadores Nacionales para la Gestión de los recursos zoogenéticos[9].

[9] http://dad.fao.org/cgi-bin/EfabisWeb.cgi?sid=-1,contacts

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Institutional and organizational frameworks for dairy and beef cattle recording in Kenya: a review and opportunities for improvement

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Summary
To facilitate livestock improvement in developing countries, records on animal populations and their various productivity levels are important. However, in these countries, livestock recording presents a huge challenge. This paper presents an outline of the historical developments and the current scenario in dairy and beef recording in Kenya, where a recording scheme has been in place since 1963, yet the productive potential of most animals in the country remains unknown. The paper brings into context the state of recording in relation to the potential for future developments in dairy and beef production within the country. Despite the enormous existing potential, low numbers of livestock records are captured due to multiple challenges, which include limited funding, lack of incentives to record, limited feedback on records, a fragmented organizational structure, poor infrastructure, limited numbers of skilled personnel and lack of supporting policies. Strategies to overcome the challenges and achieve more sustainable utilization of the existing livestock populations are discussed. Linking recording to key service providers within the livestock production sector could enhance data collection, processing and feedback to livestock producers. The quality of extension services provided must be improved in order to holistically support livestock production. Recent international regulations on the traceability of livestock products sold within different countries mean that unless Kenya implements a robust animal recording programme, the country will be locked out of markets for its livestock products.

Keywords: *livestock recording, organizations, opportunities, Kenya*

Résumé
Pour favoriser l'amélioration des animaux d'élevage dans les pays en développement, les registres relatifs aux populations et à leurs différents niveaux de productivité sont importants. Cependant, dans ces pays, le contrôle des performances des animaux d'élevage est un défi de taille. Le document présente les grandes lignes des évolutions historiques et le scénario actuel du contrôle des performances des bovins à viande et laitiers au Kenya. Dans ce pays, un programme d'enregistrement est en place depuis 1963, mais les potentialités productives de la plupart des animaux sont encore inconnues. Le document place dans son contexte l'état des enregistrements par rapport aux potentialités de futurs développements dans la production laitière et de viande du pays. Malgré les énormes potentialités existantes, les enregistrements saisis sur les animaux d'élevage sont limités en raison de plusieurs difficultés comme la faiblesse des financements, le manque de mesures incitatives en leur faveur, l'insuffisance de la remontée d'information relative aux enregistrements, la fragmentation de la structure organisationnelle, la faible qualité des infrastructures, le nombre limité de personnel qualifié et l'absence de politiques de soutien. Les stratégies visant à surmonter ces défis et à atteindre une utilisation durable des populations existantes d'animaux d'élevage font l'objet de débats. Relier le contrôle des performances aux principaux prestataires de services dans le secteur de la production des animaux d'élevage pourrait améliorer la collecte, le traitement et la remontée d'information des données aux éleveurs. La qualité des services de vulgarisation doit être améliorée afin de soutenir la production animale de façon holistique. La récente mise en place de règlements internationaux concernant la traçabilité des produits animaux vendus dans les différents pays aura pour conséquence que les produits animaux du Kenya, 'à moins que le pays ne mette en œuvre un programme solide de contrôle des performances en élevage, seront exclus des marchés.

Mots-clés: *contrôle des performances des animaux d'élevage, organisations, possibilités, Kenya*

Resumen
Para facilitar la mejora del ganado en los países en desarrollo, son importantes tanto los registros de las poblaciones animales como de sus diferentes niveles de productividad. Sin embargo, en estos países, el registro del ganado presenta un enorme desafío. Este trabajo presenta un resumen de la evolución histórica y el escenario actual en los registros relativos al ganado bovino de producción cárnica y

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lechera en Kenia, donde un sistema de registro está en marcha desde 1963, a pesar de que el potencial productivo de la mayoría de los animales de dicho país sigue siendo desconocido. El trabajo pone en contexto la situación del registro animal relacionado con el potencial para su desarrollo futuro, tanto en producción lechera como cárnica dentro del país. A pesar del enorme potencial existente, tan sólo un bajo número de registros animales han sido tomados, debido a la enorme cantidad de desafíos existentes, los cuales incluyen los limitados fondos, la falta de incentivos para registrar, escasa retroalimentación de los registros, una fragmentada estructura organizativa, una deficiente infraestructura, poco personal calificado, y la falta de políticas de apoyo. Se están debatiendo estrategias para superar todas las dificultades existentes y lograr una utilización sostenible de las poblaciones de ganado existentes. El hecho de vincular los registros con las personas que proporcionan una serie de servicios básicos podría mejorar la recopilación de datos, su procesamiento y que, a su vez, existiera una retroalimentación de información hacia los productores de ganado. La calidad de los servicios de extensión proporcionados se debe mejorar con objeto de apoyar de forma integral la producción animal. Las recientes regulaciones internacionales sobre la trazabilidad de productos de origen animal vendidos en diferentes países hacen pensar que, a menos que Kenia ponga en marcha un sólido programa de registro animal, el país será excluido de los mercados en lo relativo a sus productos de origen animal.

Palabras clave: *registro animal, organizaciones, oportunidades, Kenia*

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Introduction

In developing countries, the trends of increased urbanization, higher income and the ever-increasing population have generated a greater demand for animal products as a major source of protein (Seré *et al.*, 2008). Currently, Africa has a deficit in animal products and the situation is projected to worsen because of the increasing gap between supply and demand (World Bank, 2008). To reduce this gap, there needs to be a change in both the manner in which livestock are reared and the productivity of individual animals raised on the African continent.

Kenya, in its Vision 2030, aims at reducing poverty and hunger, and making the country globally competitive and prosperous by the year 2030 (GOK, 2008). Part of this envisioned prosperity is ensuring national food security. Consequently, the government intends to boost growth in agriculture and livestock production by 6–8 percent per year through various measures. This implies the future of the country's economic progress, and stability would significantly depend on livestock production. Pragmatic efforts and approaches should therefore be made to improve performance in livestock production. Areas to constantly focus on are animal health care and welfare, nutrition, sustained genetic improvement, appropriate policies, and value addition of animal products and services (Kosgey and Okeyo, 2007).

The growth in agriculture and livestock production has a significant and direct impact on reducing overall poverty in developing countries (Delgado *et al.*, 1999; Costales, Gerber and Steinfeld, 2006). While genetic improvement might seem relatively slow (range about 0.5–3 percent per year for within-breed selection), it is steady, cumulative and permanent (Smith, 1984). Consequently, substantial improvements can be achieved during a 10–20-year period. To facilitate progress, adequate performance data and consistently kept pedigree records for use in the estimation of breeding values of the animals to be selected for improvement are required. Individual records also support routine farm management decisions, notably for improved animal productivity and profitability (ICAR, 2002, 2004). However, livestock pedigree and performance recording presents a huge challenge for developing countries where low-input and low-output production systems are practised, and where few poorly funded and inconsistent government support services are provided (Holst, 1999; Kosgey and Okeyo, 2007).

To facilitate improvements in livestock recording practices in developing countries, documentation and analysis of past efforts and current status of livestock recording are required. While overviews on various aspects of livestock production in Kenya have been presented by various authors (Mukisira, 2002; Okeyo *et al.*, in press), this paper presents a detailed analysis of the historical developments, and the current scenario of dairy and beef recording in the country. The paper also contextualizes the state of recording in relation to the potential for future development plans for genetic improvement of dairy and beef cattle in the country.

Dairy and beef production systems in Kenya

Dairy and beef cattle in Kenya are raised in different production systems that vary according to the agro-ecological potential of the area, breeds kept and sociocultural values of the livestock keepers.

Dairy cattle production

Dairy cattle production in Kenya is the second largest contributor to the agricultural gross domestic product (GDP) (Muriuki, 2009). Dairying in the country started at the beginning of the twentieth century when European settlers introduced exotic high milk-producing cattle breeds and

other exotic forms of agriculture from their native countries in Europe. However, improved cattle production was not undertaken by the indigenous people until after 1955 when the Swynnerton Plan of 1954 allowed them to take on commercial agriculture (Connelly, 1998). At Kenya's independence from the British rule in 1963, the dairy herd had grown to 400 000 head of exotic cattle largely owned by the settlers (Muriuki, 2009). The government subsequently introduced highly subsidized input services for animal health care, production, artificial insemination (AI) and bull schemes, dipping to control ticks and other ecto-parasites, and training of livestock specialists. However, Structural Adjustment Programmes (SAP) (GOK, 1986) instituted in 1992 led to an abrupt withdrawal of all government subsidies in these areas. The impact of this on the livestock improvement programmes is covered later in this paper.

Kenya's dairy production is largely undertaken in the highlands (high-potential areas) because of the favourable agroclimate, infrastructure and market access. These areas experience an annual rainfall of more than 750 mm, and spread from central Kenya through the Rift Valley to the western part of the country and the coastal strip (Muriuki, 2009). The animals are raised in a variety of production systems, namely intensive smallholder systems with 1–2 pure-bred exotic or mixed-bred animals and less than 1 acre of land (animals are often zero-grazed, i.e. stall-feeding with fodder cut and carried to them); semi-intensive systems comprising medium- and smallholder farms with 5–20 pure exotic or mixed-bred cows; and large-scale commercial systems with more than 20 pure exotic cows and more than 20 acres of land (Ojango, 2000). The medium- and small-scale producers own over 70 percent of the existing 3.5 million dairy cows and produce about 56 percent of the total milk; this comprises approximately 80 percent of the marketed milk in the country (Muriuki, 2009).

The dairy herd is mainly composed of Holstein–Friesian, Ayrshire, Guernsey and Jersey animals and their crosses. Crosses constitute over 50 percent of the total herd while the Holstein–Friesian and Ayrshire dominate the pure breeds (Muriuki, 2009). One of the constraints to dairy cattle improvement in Kenya is that most of the small-scale farmers lack the most basic skills in breeding management of animals and do not keep records of their animals' production and reproductive performance.

Beef cattle production

In the livestock sub-sector of Kenya, the beef industry is the largest contributor to the agricultural GDP and significantly contributes to food security (MLD, 2008). Beef is acceptable to a majority of consumers and its production is a major economic activity among the pastoral and agropastoral communities. Beef cattle also contribute to milk production, draught power, hides and skins, blood for human consumption, fuel (i.e. dry dung) and manure for use to improve soil fertility, as well as intangible benefits, e.g. serve as capital assets and an insurance against emergencies, and use for sociocultural or ceremonial purposes (Kosgey, 2004).

The genotypes kept comprise the indigenous *Bos indicus* breeds (70 percent), pure-bred exotic and crosses (30 percent) (MLFD, 2004). These together contribute 70 percent of the beef produced. About 30 percent of the beef emanates from dairy herds in the form of bull calves not used for breeding, culled heifers, cows and bulls (MLFD, 2004). The important indigenous genotypes kept are the East Africa Short Horned Zebu (EASHZ) and the Kenya Boran. The common exotic breeds reared are the Hereford, Simmental, Charolais, Aberdeen Angus, Limousin, Red Poll, Santa Getrudis and Dexter. The dual-purpose breeds include the Sahiwal and Brown Swiss, and their crosses (MLFD, 2004; Rewe *et al.*, 2006; NABP, 2009).

Beef cattle in Kenya are largely reared in low- to medium-potential areas (i.e. the rangelands with <625–750 mm of rain annually and a high evapotranspiration rate). These areas are located in central and eastern parts of the country, parts of the Rift Valley and the areas neighbouring the coastal strip. The low-potential areas have an annual rainfall of less than 625 mm and stretch from north and north-eastern Kenya to the southern parts bordering Tanzania (Muriuki, 2009). The animals are largely kept by the pastoralists in agropastoral or nomadic systems as an integral part of their sociocultural life, and by large-scale commercial ranchers; the pastoralists mainly keep the EASHZ while the ranchers keep the exotics and the Kenya Boran (Kilung'o and Mghenyi, 2001). Indigenous cattle are also kept for beef in some mixed crop–livestock farming systems.

A feedlot system was practised in Kenya in the 1970s to early 1980s under the Kenya Beef Industry Development Project funded by the United Nations Development Programme. This system aimed at strategically reducing the number of animals supported on the rangelands during dry spells, and improving the carcass quality for the market by "finishing" animals in feedlots (Creek, 1972). However, this proved uneconomical because of high competition for maize grain from the increasing human population, and a low turnover of steers.

State-owned farms reclaimed from European settler farmers who left Kenya at independence in 1965 were placed under the Settlement Trustee and the Agricultural Development Corporation (ADC), the latter being a government parastatal. A key responsibility of the ADC was to multiply livestock breeding stock to ensure that a continuous supply of various breeds was available to Kenyan farmers at affordable prices. Additionally, three research centres for beef cattle breeding and improvement were established at Kiboko, Lanet and Naivasha. These institutional farms, together with private commercial ranchers, actively participated in beef recording programmes

until the early 1990s. The implementation of the SAP of 1992, however, resulted in a rapid decline in beef cattle recording in the country.

Livestock recording in Kenya

Livestock recording has several important objectives: to help individual farmers make routine management decisions in order to produce products (e.g. meat or milk) more economically and to provide data for government administration, research, breeding and extension services (Lindström, 1976). Extensive guidelines on livestock recording and types of records to maintain are provided by the International Committee on Animal Recording (ICAR, 2002, 2004).

Organizations and bodies undertaking animal recording have existed in Kenya since 1963. However, numbers of livestock producers registering animals and recording their production have remained low, with less than 5 000 animals registered per year (Kenya Livestock Breeders Organization [KLBO] records) from an estimated cattle population of 11.5 million (FAO, 2005). The organizations that have been responsible for development and running of dairy and beef improvement in the country are discussed in the following sections.

Institutions and organizations for recording and genetic improvement

Since the year 1920, various organizations in Kenya have played different roles in supporting genetic improvement of dairy and beef cattle (Mosi, 1984; C.B. Chirchir, personal communication, 2009). The initial schemes were the East African Stud Book established in 1920 and the East Africa Milk Recording Service (1949), under the patronage of the Royal Agricultural Society of East Africa. Their operations and provision of information for management were confined to large herds owned by settler farmers. Following the initial breakdown of the East African Community, the Kenya Stud Book (KSB) was set up in 1963, and later in 1970 Kenya Milk Records (KMR) (Mosi, 1984). While the KSB initially remained a closed herd-book register with rules defined by various breed societies, the KMR was taken up as a government service under the Ministry of Livestock and Fisheries Development (MLFD). KMR was responsible for carrying out official milk recording and butterfat testing for all farmers within the country (KSB reports, unpublished, 1985–1990). Data collated by the KMR were to be made available to the Bull Purchasing Committee (BPC) and the Central Artificial Insemination Station (CAIS) for use in the selection of candidate bull-dams and sires to use in a contract mating scheme through which improved young sires were to be produced, acquired and selected for AI in the country (CAIS, 1990–2004; Okeyo *et al.*, 2000).

A critical review of the structure and recording system was carried out by Philipsson *et al.* (1988), and another on the support for provision of AI services by Israelsson and Oscarsson (1991). Recommendations from these reports were for the government to strategically support a reduction in the number of organizations supporting recording, and to increase farmer participation in making decisions concerning data collation and feedback mechanisms. However, these were not fully implemented because, after the SAP of 1992, the government withdrew direct management of livestock recording and provision of free support services to farmers. In 1994, the Dairy Recording Services of Kenya (DRSK) was set up by livestock farmers who were running the KSB, with some support from the MLFD, to maintain performance records on animals in the country (Ojango, 2000). The current structure and interrelationships among the organizations supporting livestock recording are illustrated in Figure 1.

All the organizations presented have vital and complementary functions in the implementation of genetic improvement programmes and have the same goal of improving livestock productivity. Detailed information on the characteristics and mandates of the various institutions is available in various publications (Mosi, 1984; MoA, 1998; Omore *et al.*, 1999; Ojango, 2000; Okeyo *et al.*, 2000; Mosi and Inyangala, 2003; MLFD, 2004; MLD, 2008). Briefly, the KLBO is an independent farmer organization formed under the auspices of the Agricultural Society of Kenya. It is responsible for the collection, collation and maintenance of livestock pedigree and performance data from farmers, and its subsequent authentication. Under the leadership of the KLBO, livestock breeders in the country organize annual exhibitions, trade fairs and breeding stock sales as a combined effort of all livestock breed societies to promote Kenya's livestock industry nationally and internationally. The KLBO also serves as a lobby organization through which participating farmers engage the various government institutions, and to a small extent the private sector and international institutions, on issues that affect them.

To achieve its objectives, the KLBO operates the KSB under the mandate of various breed societies and the DRSK. The KSB carries out livestock registration, and maintains authentic ancestral and identification registers, with animals classified by breed in different groups, namely foundation, intermediate, appendix and pedigree, depending on the breed standards set by each breed society according to rules inherited from the white settler farmers under the colonial government (Mosi, 1984).

The DRSK carries out all the official milk recording and collation of butterfat test results from farmers who raise animals for milk. From the data collected, individual lactation certificates are produced for milking animals and, for each farm, herd average information on milk production is provided. The data were then available to the Livestock Recording Centre (LRC) whose mandate is to undertake

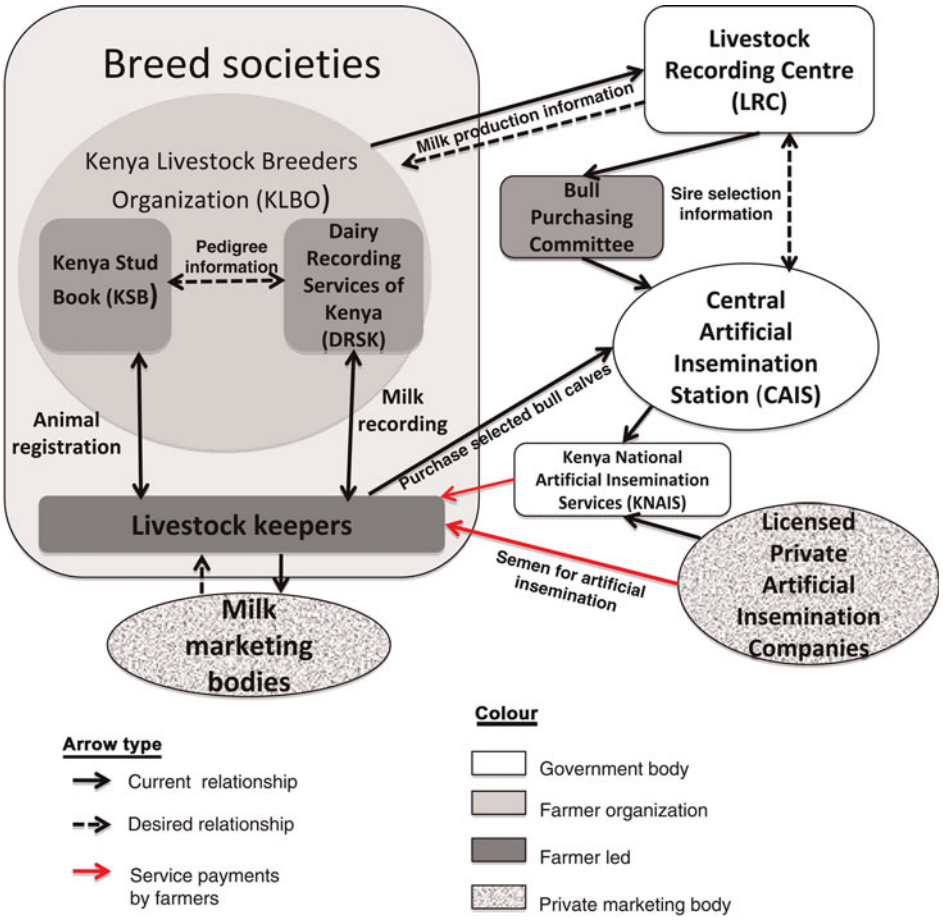

Figure 1. Organizations involved in livestock recording and dissemination of improvement in Kenya, and their interrelationships.

genetic evaluation of the animals and provide feedback to the BPC. Information from the BPC is used to determine which bulls should be retained at the CAIS and which bull-dams should be used in contract mating to produce young bulls.

As a government department, the LRC falls under the Director of Animal Production, in the renamed Ministry of Livestock Development (MLD), with operational funds from the exchequer. Its mandate includes supporting the National Dairy Cattle Breeding Programme objectives through the planning and execution of the progeny testing programme, and contract mating schemes for AI bulls, and support of the services offered by the KLBO. The LRC also provides support for beef recording through maintaining data on growth performance of the Boran cattle, a role undertaken on request from the Boran Breed Society. Pedigree data are, however, maintained by the KSB. The initial design of the breeding programmes and the LRC's operations were developed with support from the German Government. The breeding programme was, however, jeopardized by its complexity and its dependence on separate departments within the MLD. A recent overview of the background and status of AI provision in Kenya is given by Okeyo *et al.* (in press).

The CAIS, also a government body, operates under the auspices of the Director of Veterinary Services in the MLD, with operational funds from the exchequer. The station is currently exploring options for provision of *ex situ* conservation (cryopreservation of embryos and gametes) facilities to conserve the country's animal genetic resources (AnGR), and has recently acquired a high-capacity distiller to produce liquid nitrogen for use in the station and also to sell to AI providers in the country (CAIS, 2008). The station has also recently established a high-technology laboratory with the support of the International Atomic Energy Agency, to test pregnancy/infertility in dairy animals as a service to the farmers. Presently, opportunities for decentralization of the CAIS services through establishing satellite bull stations in other regions of the country are being explored.

Linking the CAIS with the farmers is the Kenya National Artificial Insemination Services (KNAIS) (Figure 1), an extension service department of the MLD under the Director of Veterinary Services, set up in the 1960s with support from the Swedish Government to distribute semen from the CAIS to farmers, and provide support services such as the control of ticks and tick borne diseases, particularly the dreaded East Coast Fever (Duncanson, 1975; Mukisira, 2002).

Numbers of livestock recorded and the trend since 1995

The numbers of animals registered annually by the KSB from 2000 to 2008 are presented in Figures 2 and 3, while numbers of animals with records on milk production by breed at the DRSK are presented in Figure 4.

Despite the large population of dairy and beef cattle in the country, a very small proportion is registered, and, from 2000 to 2008, there was a decline in registrations for most beef breeds. The EASHZ, indigenous to the country, have records neither in the KSB nor in the DRSK. Differences in numbers of animals registered and recorded for the different breeds illustrate the differences in the existing population structure of the breeds within the country. Reports on livestock raised within the country (Ojango, 2000; MLD, 2008; Muriuki, 2009) indicate that among the dairy breeds, the Holstein–Friesian is the most popular, while among beef breeds, the Kenya Boran is most popular.

Challenges and opportunities for improved livestock recording in Kenya

The SAP (GOK, 1986) that led to liberalization and cost sharing in provision of services within the livestock sector resulted in great challenges in securing adequate resources, developing strategic interventions for improvement, and drafting supportive policies for the industry. Despite the existence of a large number of institutions to implement livestock recording (Figure 1), numbers of livestock producers registering animals and recording their productivity remains low. Carrying out measurements and recording performance of animals cost time, personnel and other resources.

Identified challenges to the process of recording, including a limited amount of feedback received by livestock producers as pointed out by Philipsson *et al.* (1988), still remain a problem (KLBO, 2008). The perceived benefits from recording by livestock keepers are also few, and little time and resources are allocated for acquiring technical skills related to livestock genetic improvement. The lack of integration between the various services regarding pedigree and performance recording with the AI, genetic evaluation and selection activities (Figure 1) is a serious obstacle for value-added services and feedback to livestock keepers. This has hindered the potential genetic gains that could have been realized had such integration existed.

Improved communication between countries, expanded markets for livestock products and changes in consumer demands on quality of livestock products have resulted in a shift in national perceptions of the importance of livestock recording and its integration with other necessary activities. The livestock keepers in Kenya are beginning to demand better services and structures within the industry. There is also an increased awareness at the government level of the need for information on livestock numbers and productivity at the national level resulting from the process of developing the country reports on the State of the World Animal Genetic Resources in 2007 (FAO, 2007).

Low numbers of technically skilled individuals in the field of AnGR pose an additional challenge. This is further compounded by national extension services to farmers, which tend to limit their activities to promoting crop production, the treatment of livestock diseases and cross-breeding programmes. In response to this challenge,

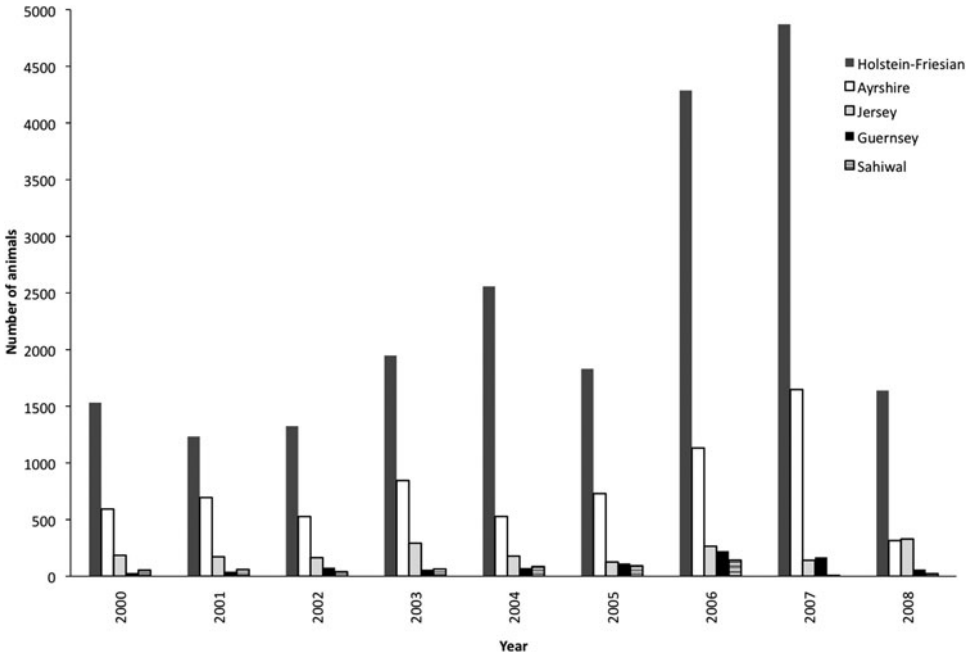

Figure 2. Number of dairy cattle per breed registered by the KSB (2000–2008).

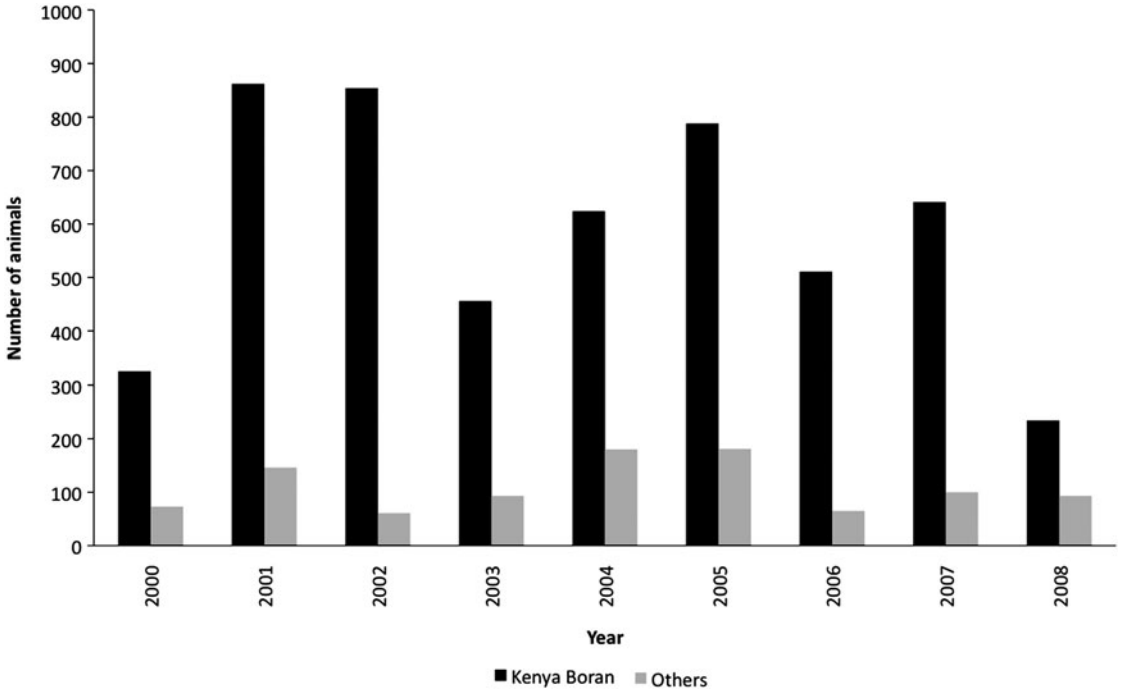

Figure 3. Number of beef cattle per breed registered by the KSB (2000–2008).

existing higher education training institutions are increasingly collaborating with the government and the public sector, and are incorporating training skills demanded by the industry within their programmes. Capacity development and strengthening efforts for the sustainable use of AnGR in developing countries need to be supported in order to build critical numbers of specialists to support positive changes (Ojango *et al.*, 2009).

Recording the entire livestock population is an unattainable objective with the large numbers of livestock in the country. However, more livestock keepers need to be mobilized to keep production records in order to obtain a representative number of animals as an information base. Rapid developments and changes in computing facilities and the availability of fast Internet connections provide new opportunities for the KLBO to

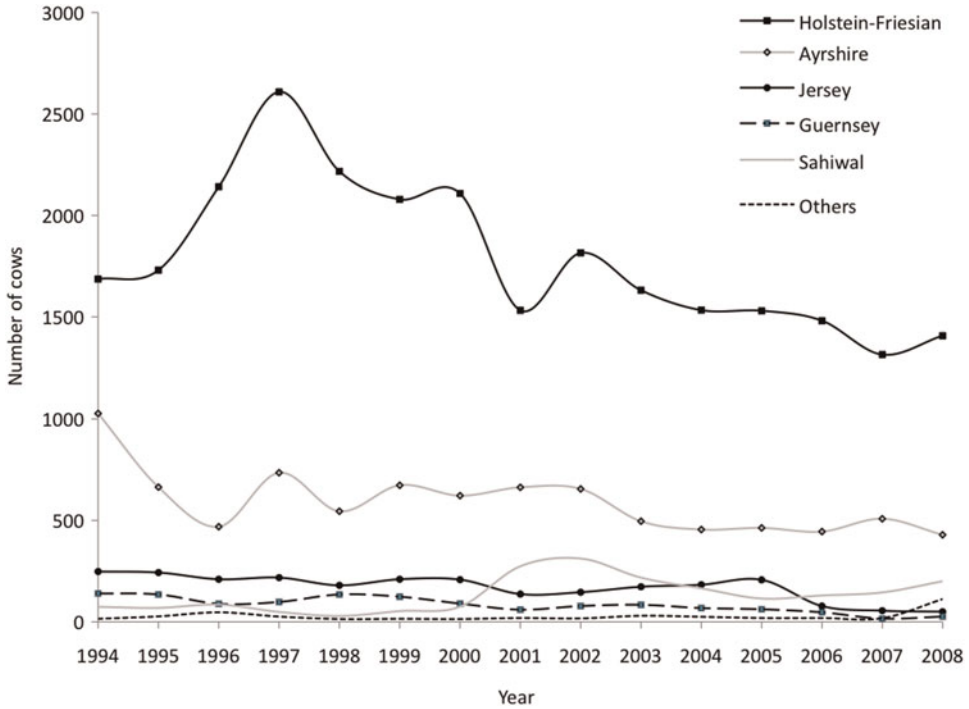

Figure 4. Number of dairy animals per breed with milk records at the DRSK (1990–2008).

enhance data collation, communication and feedback to farmers.

Increasing the levels of recording on beef-producing animals poses an even greater challenge as a large number of these animals are reared by pastoral communities in the arid and semi-arid lands (ASALs). Targeted awareness campaigns and the development of extension packages that take into account the peculiarity of these systems by players in both the public and the private sectors are required if any recording is to be carried out among the pastoral communities. The need to produce "safe" animal products free from diseases in order for the country to be able to export livestock and livestock products (GOK, 1994) and the increasing global demand for traceability programmes to be put in place are opportune drivers for the MLD to expand animal identification and recording within the ASALs (Kiptarus, Kamau, and Kimemia, 2002).

Other challenges include inconsistent legal frameworks, lack of supporting policies to implement livestock recording programmes (FAO, 2005) and political-related changes, especially with regard to relative departmental mandates for the ministries that have been responsible for livestock development over the years. The large number of players (Figure 1) and their "fragmentation" both in terms of service provision, linkages and location further reduce the efficiency of implementing recording within the country. Besides, a strong thrust of propaganda/lobbies to sell semen and live animals (bulls or cows) detracts attention from the pursuance of locally suitable solutions to animal recording and selection in developing countries (Madalena, 2002).

General discussion

Strategies for improvement

Improvement in the productivity of animals could increase incomes of farmers, create employment both on and off farm, and have massive economic spin-offs for other stakeholders. Besides, improved productivity is necessary given the increased pressure on the limited natural resource base on which dairy and beef cattle depend, especially in light of the predicted negative effects of climate change.

Integrated breeding programmes should be designed with long-term genetic improvement strategies in mind. In such systems, a harmonized decision-making process, where both government and private sector players actively engage the livestock keepers as custodians of the AnGR, needs to be developed. Such programmes should be supported by adequate extension services and an efficient genetic evaluation system incorporating optimal use of pedigree information to keep inbreeding levels under check, while allowing for the desired improvement within the populations. Ideally, the traits of interest identified by the livestock keepers should be objectively assessed. With supportive extension services, breeding goals, selection criteria and practices guided by existing operational conditions would evolve in response to changing market demands, rather than the current blind adoption of standards from other environments that favour different characteristics in animals (Philipsson, Rege and Okeyo, 2006). Key components for integrating livestock records from various sources, and how these could be used to produce results that are of practical use and benefit to both farmers and policy-makers are presented in Figure 5.

The number of institutions involved in a breeding programme depends on the role of each institution (illustrated in Figure 5), rather than adopting several fragmented organizations as is the case in Figure 1. Deliberate concerted efforts are required to restructure the organizational frameworks for livestock recording in the country.

Production levels and market linkages must be incorporated into the framework when defining the breeding objectives (Kosgey *et al.*, 2006). It is noteworthy that the apparent success in the Kenyan dairy sector was set many years back through substantial investment and support from the government. A national dairy master plan is currently being developed that will support new initiatives to enhance animal recording.

Little has been done to develop suitable recording procedures for smallholder and pastoral production systems that can generate objective data for use in breed improvement within these systems. Extension to support livestock improvement and infrastructure development involving farmers, extension agents, market agents and various service providers is vital. Simple and standardized recording systems for smallholders and pastoralists need to be developed, tested and validated by extension agents in collaboration with relevant researchers. It is also prudent to learn from successful cases, such as the milk recording systems developed in India for small-scale farmers that were initiated for the genetic improvement of indigenous animals and cross-bred populations (Trivedi, 2002).

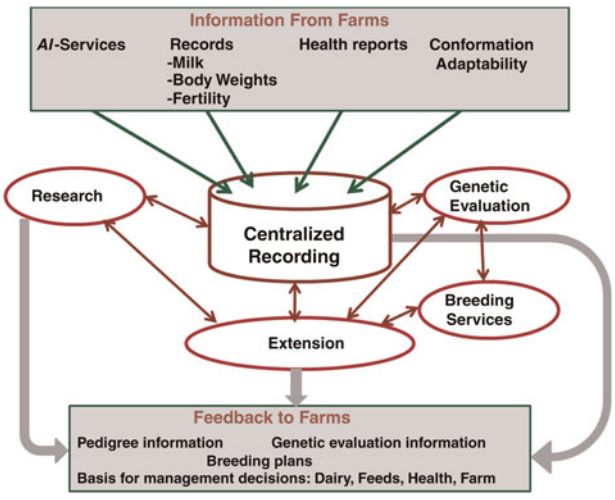

Figure 5. Interactive parts of a livestock breeding programme.

Improvement could be achieved through the initial use of nucleus breeding schemes, or a young bull programme that uses superior local cows and imported semen from selected sires to produce bulls for national use, with a quick turnover of bulls rather than a complex progeny testing scheme (Philipsson, Rege and Okeyo, 2006).

Organizational adaptations and resources for sustainable recording

Kenya needs to consider implementing changes in the organizational and institutional frameworks seriously to support livestock recording. Coherence in the design and implementation of genetic improvement programmes, and promoting the value chain linkage are vital. Recording activities need to be linked to breed improvement and other input and market services as part of the integrated value chain. Learning through forums that facilitate information exchange with countries that have developed strong institutions and more flexible recording procedures is critical.

As recording can involve substantial costs and logistics, the system adopted must be simple to understand and implement, reliable and inexpensive. Sustainable recording should depend on the farmers with support from the beneficiaries, including national governments (ICAR, 2002, 2004).

Organizations involved in collecting and processing records should be centrally linked to a hub, preferably a neutral institution (e.g. a university or a research institute) with requisite expertise and sustained capacity to analyse data, interpret the findings and provide feedback information immediately for use by the farmers through research and extension activities (as illustrated in Figure 5). In Brazil, for instance, a milk recording programme has been running as an extension activity of an agricultural school (Madalena, 2002). Strong inbuilt feedback mechanisms among all the players are vital for success. At the onset, it is more important to interest the farmers in the recording than to make the scheme self-fi nancing (Lindström, 1976). Options for obtaining additional feedback through international bodies such as the INTERBULL (www.interbull.org), which carries out evaluations of bulls on a global scale, would add value to such a scheme and could boost animal recording.

Mobilization of adequate finances and support services to run a recording scheme is necessary. Funds to support recording could be accumulated through levies on milk and meat sold, but this will only be feasible if sustainable value addition and feedback on desired product qualities by the processing organizations could be incorporated in the design of breed improvement programmes. New measures must be taken by the government, in collaboration with key stakeholders, to enhance the quality of extension services to support livestock production, notably in the context of using information generated on livestock to improve their productivity within different production systems.

Regular evaluation of the programme implemented with a view to monitoring progress is vital. All stakeholders have a critical role to play. Consequently, widespread campaigns to sensitize all players and stakeholders on the importance and benefits of recording in dairy and beef cattle improvement and national development are necessary.

Conclusions and recommendations

Kenya has in place a dairy and beef recording scheme, but, led by the MLD, the country needs to re-evaluate and restructure the existing fragmented institutional framework for livestock genetic improvement. Fewer organizations working collaboratively rather than competitively, with clear mandates and a good understanding of their linkages and synergies, are required. An initial step in this process requires a comprehensive mapping of all the stakeholders and their respective interests.

Recent international regulations on the traceability of livestock products sold within different countries mean that unless Kenya implements a robust animal registration programme, the country will be locked out of markets for its livestock products. Adequate resources must be allocated to support breeding programmes and the inherent animal recording. Resources also need to be allocated to the processing of information from the livestock producers and the provision of feedback that would facilitate change in response to changing market demands for livestock products. For these services to become self-sustaining, initial "external" investments with supportive government policies are necessary. The quality of extension services provided must be improved in order to holistically support livestock production.

The country should also establish regulations to ensure that sires whose semen is made available for use in AI schemes in the country are registered. This will provide national data for comparative performance of sires and could serve as a catalyst to greater involvement of diverse groups of farmers in recording their animal productivity in order to be able to make better selection decisions on AI sires.

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organization of dairy and beef cattle recording in Kenya are greatly acknowledged.

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Productivity and morphology of Ankole cattle in three livestock production systems in Uganda

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Summary
Phenotypic characterization is critical in breed improvement and conservation. To determine the performance and morphological features of Ankole cattle in three livestock production systems (LPS) of Uganda, 248 farms were studied. Height at withers (HW), heart girth (HG), body length (BL), ear length, horn length (HL), distance between horn tips (HS) and body weight (BW) were then measured on 120 bulls and 180 cows. Data were analysed using LPS (crop livestock, agropastoral, pastoral), county (Gomba, Kazo, Kiboga, Mawoggola, Nyabushozi) and sex (females, males) as main factors. In the results, age at sexual maturity was 23.6 ± 0.5 months for bulls and 22.7 ± 0.5 months for cows. Age at first calving was 33.2 ± 0.5 months, whereas calving interval was 12.9 ± 0.8 months. Lactation length differed between LPS (5.5 ± 0.4, 6.3 ± 0.3 and 7.4 ± 0.2 months in agropastoral, crop livestock and pastoral, respectively). Mean daily milk off take was 2.2 ± 0.1 kg/cow whereas preweaning calf survivability was 90.0 ± 6.5%. Sex and LPS significantly influenced HW, HL and HS. Positive correlations were observed between BW and HG, BL and HL. Correlation coefficients were much lower in females than in males, except for BW vs HG and BW vs HW. Results show wide variations both in performance and morphology suggesting that within breed selection scheme and/or management improvement may lead to productivity improvements.

Keywords: *morphometric, characterization, reproductive performance, Ankole cattle*

Résumé
La caractérisation phénotypique est fondamentale dans l'amélioration et la conservation de la race. Afin de déterminer la performance et les caractéristiques morphologiques des bovins Ankolé dans trois systèmes de production animale de l'Ouganda, on a entrepris des études dans 248 fermes. La hauteur au garrot, le périmètre thoracique, la longueur du corps, des oreilles et des cornes, la distance entre les pointes des cornes et le poids corporel de 120 taureaux et de 180 vaches ont été alors mesurés. On a ensuite analysé les données en utilisant comme facteurs principaux le système de production animale (mixte, agropastoral, pastoral), le district (Gomba, Kazo, Kiboga, Mawoggola, Nyabushozi) et le sexe (femelle, mâle). Les résultats ont été les suivants: l'âge à la maturité sexuelle était pour les taureaux de 23,6 ± 0,5 mois et pour les vaches de 22,7 ± 0,5 mois, l'âge à la première mise bas était de 33,2 ± 0,5 mois, tandis que l'intervalle entre les mises bas était de 12,9 ± 0,8 mois. La période de lactation variait selon le type de système de production (5,5 ± 0,4, 6,3 ± 0,3 et 7,4 ± 0,2 mois respectivement dans les systèmes agropastoral, mixte et pastoral). Le rendement moyen journalier de lait était de 2,2 ± 0,1 kg par vache tandis que la survie des veaux avant le sevrage était de 90,0 ± 6,5 pour cent. Le sexe et le système de production influençaient de façon significative la hauteur au garrot, la longueur des cornes et la distance entre les pointes des cornes. On a observé des corrélations positives entre le poids corporel et le périmètre thoracique, la longueur du corps et la longueur des cornes. Les coefficients de corrélation étaient nettement inférieurs pour les femelles que pour les mâles, à l'exception des rapports poids corporel/périmètre thoracique et poids corporel/hauteur au garrot. Les résultats montrent des écarts considérables tant dans la performance que dans la morphologie, suggérant ainsi qu'un programme de sélection et/ou l'amélioration de la gestion pourraient développer la productivité de la race.

Mots-clés: *morphométrique, caractérisation, performance de reproduction, bovins Ankolé*

Resumen
La caracterización fenotípica tiene una importancia fundamental en la mejora y conservación de razas. Se han estudiado 248 explotaciones en Uganda para determinar el rendimiento y las características morfológicas del ganado Ankole en tres sistemas de producción (LPS, por sus siglas en inglés) de Uganda. Se han medido en 120 toros y 180 vacas la alzada a la cruz (HW, por sus siglas en inglés), perímetro torácico (HW, por sus siglas en inglés), diámetro longitudinal (BL, por sus siglas en inglés), longitud de la oreja (EL, por sus siglas en inglés), longitud del cuerno (HL, por sus siglas en inglés), distancia entre las puntas de los cuernos (HS, por sus siglas en inglés) y el peso corporal (BW, por sus siglas en inglés). Los datos han sido analizados utilizando LPS (pastos para el ganado, agropastoral, pastoral), el condado (Gomba, Kazo, Kiboga, Mawoggola, Nyabushozi) y el sexo (hembras y machos) como factores principales. En los resultados, la edad de madurez sexual (ASM, por sus siglas en inglés) fue de 23.6 ± 0.5 meses para los toros y

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de 22.7 ± 0.5 para las vacas. La edad para el primer parto (AFC, por sus siglas en inglés) fue de 33.2 ± 0.5 meses, mientras que el intervalo entre partos (CI, por sus siglas en inglés) fue de 12.9 ± 0.8 meses. La duración de la lactación (LL, por sus siglas en inglés) difirió entre LPS (5.5 ± 0.4, 6.3 ± 0.3 y 7.4 ± 0.2 meses en agropastoral, pastos para el ganado y pastoral, respectivamente). La producción media de leche fue de 2.2 ± 0.1 kg/vaca mientras que la supervivencia antes del destete fue de 90.0 ± 6.5%. El sexo y LPS influyó significativamente en HW, HL y HS. Se observaron correlaciones positivas entre BW y HG, BL y HL. Los coeficientes de correlación fueron mucho más bajos en las hembras que en los machos, excepto en BW vs HG y BW vs HW. Los resultados muestran grandes variaciones entre rendimiento y morfología, sugiriendo que dentro del plan de selección racial y/o de gestión puede conllevar mejora sustancial en el campo de la productividad.

Palabras clave: *morfometría, caracterización, rendimiento reproductivo, ganado Ankole*

Submitted 25 July 2010; accepted 25 January 2011

Introduction

Approximately 70 percent of the world's rural poor depend on livestock as an important component of their livelihoods (Hoffmann, 2010). The African continent, where many of the poor live, is home to over 230 million cattle (FAO, 2008) constituted in about 150 breeds, most of them indigenous to the continent (Rege and Bester, 1998). These breeds have unique genetic attributes such as adaptation and tolerance to drought, heat, diseases and ability to utilize low-quality indigenous forages. Ankole are one such cattle and are kept under pastoralism and crop-livestock systems (Lamwaka, 2006; Wurzinger *et al.*, 2007). Ankole cattle also exist in other countries of the African great lakes region such as Burundi, Rwanda, Tanzania (Ndumu *et al.*, 2008) and Democratic Republic of Congo. Both male and female Ankole cattle have similar features, with the exception of a hump, which exists only in the adult males. The predominant colour is brown with several shades and patterns. The occurrence of white and black Ankole cattle is low as many farmers select against these colours. The predominant morphological feature of these cattle is the pair of white, large and long horns (Plates 1–7 and 9), although other horn conditions are also present (Plate 8).

Generally, indigenous livestock breeds of developing countries are scantily documented and under exploited (Philipsson *et al.*, 2006). There is limited information on the performance of Ankole cattle in East Africa (e.g. FAO, 2009). Although the role of livestock in providing products and services is generally known (Perry *et al.*, 2002), performance data under different agro-ecological systems in which these cattle are reared within Uganda are almost non-existent. The growing demand for livestock products in Uganda justifies the need to improve livestock productivity. This part of a wider study was aimed at characterizing the performance and morphological features of the Ankole cattle in Uganda, with a goal of contributing to the improvement of this unique breed.

Materials and methods

Study area and sampling procedure

The study used a descriptive, purposive and stratified survey design and was carried out in Ankole cattle keeping households of Uganda, in the districts of Kiboga (n = 60), Mbarara (n = 137), Mpigi (n = 30) and Sembabule (n = 21) (Figure 1, Table 1). These districts have the highest Ankole cattle density in Uganda. Each district is divided into counties. The counties selected for this study were Gomba in Mpigi district, Kazo and Nyabushozi in Mbarara district, Kiboga in Kiboga district

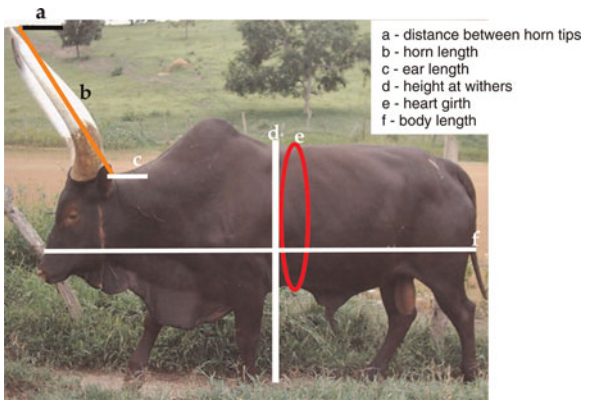

Plate 1. Measurements performed on Ankole cows and bulls.

Plate 2. An Ankole cattle herd of mostly the one preferred colour, dark brown (*Bihogo*).

Plate 3. A herd of Ankole cattle being driven to graze.

Plate 5. Ankole cattle at the water trough.

and Mawoggola in Sembabule district (Table 2). Each county (*Ssaza*) is further divided into subcounties (*Gombolola*) that are decentralized governments. The subcounties are made up of several parishes (*muluka*), each of which is subdivided into villages whose residents form the local council one, the smallest administrative unit.

Two perpendicular transects were drawn across each subcounty, and all parishes along each transect were selected. The number of farmer respondents per subcounty ranged between 10 and 20 depending on the geographical size and population density (Table 2). Three livestock production systems (LPS), namely agropastoral, crop livestock and pastoral were identified in the study area. Most respondents were from the pastoral system (Table 2).

Ankole cattle production systems

Agropastoralists are sedentary farmers who cultivate food crops both for subsistence and sale while also keeping livestock. Their animals use communal grazing land, fallow land and crop land after harvest (Twinamasiko, 2001). Livestock is used for draught, savings and milk production. The agropastoralists have little control over the feed resources. Milk production fluctuates with the seasonal availability of feed; hence, feed supply could be improved by saving grazing areas in the form of standing hay or establishment of fodder banks for dry season feeding (Mwebaze, 2002).

The crop-livestock system is characterized by the use of crop by-products as animal feed, whereas livestock provide their waste, used as a fertilizer (Ghotge and Ramdas, 2003). Milk and meat from the livestock provide income. Farm size is normally small (0–1.5 ha), with a moderate-to-high cropping intensity (Twinamasiko, 2001). In this system, dairy production is attractive because it offers opportunity for diversification, spreading risks and provides a continuous income (Mwebaze, 2002).

Pastoral systems are characterized by the use of range grasslands, migratory herding and livestock breeds that are tolerant to migration stress, droughts and periodic food and nutritional shortages (Groombridge, 1992). Livestock owners exploit natural grasslands mainly in the relatively dry areas of Uganda (Twinamasiko, 2001). Pastoralists are more sedentary today than in the past, and mainly move to find pasture and water in times of drought. The main source of food for pastoralists is milk; however, production per unit area is low (Petersen *et al.*, 2003). Producers generally have minimal control over

Plate 4. A herd of Ankole cattle grazing, note the tree cover on the range.

Plate 6. Ankole cattle approaching home, note the long and graceful horns.

Plate 7. Ankole cattle in a confinement crush during spraying against ecto-parasites.

the feed resources and therefore limited opportunity for their improvement. The pastoral system uses few commercial inputs and the cost of production is usually very low (Mwebaze, 2002).

Survey instrument, animals and tools

A questionnaire was administered to the 248 households to generate data on reproductive parameters in cows and bulls. Milk production data were provided by farmers who relied on their memorized records. One mature breeding bull and one cow were then randomly selected from each surveyed household. Live body weight (BW) and six body measurements were then taken on the selected 120 bulls and 180 cows. The studied animals were mature active breeders. Maturity was ascertained from possession of either three or four pairs of permanent teeth. A descriptor list of phenotypic characteristics to assist with the qualitative description of the animals, a colour chart to describe the coat colour of the animals, and calibrated tapes and callipers to measure the quantitative physical characteristics such as heart girth (HG) and body length (BL) were also used. The set of measurements taken for the six traits considered in this study were as described by Brown, Brown and Johnson (1983) and Adeyinka and Mohammed (2006), except for BL, which was taken as the absolute distance from the nose bridge to the tail.

Plate 8. The diversity of the horning condition among Ankole cattle. The names of the cows standing from left are *Kachweka* (i.e. broken horns), *Nkungu* (i.e. polled), *Nshara* (i.e. drooping horns).

Data analysis

The filled questionnaires were then coded and keyed into the SPSS computer software. Data analysis was then performed using Statistical Analysis Systems, Ver. 9.1.3 (SAS, 2004). Reproductive parameters were assessed using general linear models, with LPS and counties as fixed effects and age as a covariate. The model used was

$$y = \mu + l_i + c_j + c_j(s_k) + a_l + e_{ijkl} \sim \mathrm{N}(0,\ \sigma^2) \qquad (1)$$

where y is the observation of the trait in production system i, in county j, in subcounty k and for animal age l. μ is the overall mean, l_i the effect of production system ($i = 3$), c_j the county effect ($j = 5$), $c_j(s_k)$ the effect of subcounty within counties ($k = 19$), a_1 the effect of age ($l = 2$), e_{ijkl} the random effect on the trait, independently and identically distributed with mean = 0 and variance = σ^2.

Mixed models maximum likelihood procedure was used to analyse linear body measurements (Plate 1). The measurements were height at withers (HW), HG, BL, ear length (EL), horn length (HL), distance between horn tips (HS) and BW. Other than LPS and sex, all the other possible effects were not significant and were therefore dropped. The model used is

$$y = \mu + l_i(s_j) + e_{ij} \sim \mathrm{N}(0, \sigma_e^2) \qquad (2)$$

where y is the observation of the animal trait, μ the overall mean, l_i the effect of the production system ($i = 3$), s_j the effect of sex ($j = 2$) and e_{ij} the random effect as explained in (1).

Correlation coefficients between HW, HG, BL, EL, HL, HS and BW were computed on a within-sex basis to determine linear associations between them. Age was not a significant factor in equation (i), and the physiological status of cows sampled for the linear measurement analysis was similar (all were dry at the time of data collection); hence, the animals were evaluated as a homogenous group. Linear regression of HW on HG, HW on BL and HG on BW was conducted within each sex category of Ankole cattle.

Results

Reproductive and production performance of Ankole cattle

From the survey, age at sexual maturity (ASM) ranged between 12 and 36 months for both for male and female Ankole cattle, averaging 23.6 ± 0.5 and 22.7 ± 0.5 months, respectively. However, the age for females was not

Plate 9. Three generations in one photograph, standing in the front row, from left to right is a dam, daughter and grand-daughter.

affected ($P > 0.05$) by LPS and counties (Table 3). Average age at first calving (AFC) was 33.2 ± 0.5 months, and ranged between 24 and 45 months. Gomba and Kiboga counties had higher AFC ($P \leq 0.05$) than the other counties. Calving interval (CI) averaged 12.9 ± 0.8 months and ranged between 12 and 18 months, but did not differ significantly between LPS and counties. The average lactation length (LL) differed between LPS ($P \leq 0.01$) and counties ($P \leq 0.001$). LL was 5.5 months for the crop livestock, 6.3 months for agropastoral and 7.4 months in pastoral areas (Table 3). Kazo County had the highest mean LL (8.5 months) that differed ($P \leq 0.001$) from the rest.

Milking was being done once a day in 34.2 percent of all the households. In contrast, milking twice was found in 56.0 percent of the crop livestock, 60.0 percent of

Figure 1. Map of Uganda showing the study areas.

Table 1. Physical and demographic features of the districts studied.

District	Land area (km^2)	Human population	Annual rainfall (mm)	Altitude range[1] (m.a.s.l.)
Kiboga	4 045	231 231	560–1 272	1 400–1 800
Mbarara	7 346	1 093 388	875–1 200	760–900
Mpigi	3 714	414 757	1 000–1 200	1 000–1 300
Sembabule	2 470	184t178	750–2 000	1 200–1 350

Note: Source: Ministry of Local Government, Republic of Uganda (www.molg.go.ug).
[1]a.s.l means above sea level.

agropastoral and 70.0 percent of pastoral system households. The average daily milk off take per cow was 2.2 ± 0.1 kg. The milk off take ranged between 1 and 6 kg but was not significantly affected by LPS and county (Table 3). Over 96 and 83 percent of calves born in Nyabushozi and Kazo, respectively, survived to weaning age, giving an overall survival rate in the study area of 90.0 percent. Age at weaning of calves ranged between three and nine months, with an average of six months (Table 3). However, differences in the ages between LPS and counties were not significant.

Body morphometric characteristics

The average linear body dimensions of male cattle were higher than for females except for HL (Table 4). HW, HL and horn spacing of cows differed ($P \leq 0.05$) across LPS. However, bulls only differed ($P \leq 0.05$) in horn attributes across the LPS. Generally, bulls and cows from the crop-livestock system were smaller (had shorter body dimensions) than their pastoral counterparts (Table 4).

Table 5 gives the phenotypic correlation estimates between the various traits for male and female Ankole cattle. The correlation coefficients between HW and other body parameters for male cattle were positive and different from zero ($P \leq 0.05$), with the exception of HS. A high positive correlation was also observed between BW and HG, whereas correlations between BW and EL, and BW and HS were high but negative in males. For all pairs of body measurements, correlation coefficients were much lower in females than in males, with only BW and HG; BW and HW being close in value (Table 5). Generally, HS was negatively correlated to other traits both in male and female cattle. EL was negatively correlated to BL, HS and BW in female cattle.

Regression coefficients and equations for HW on HG and BL, and BW on HG for adult male and female Ankole cattle are presented in Table 6.

Discussion

The average AFC in this study of 24–45 months contrasts highly with estimates of 42–60 and 25–61 months reported by Payne and Wilson (1999) and Rege (1999), respectively. The observed difference may be attributed to improved cattle management that encourages early maturity. Disease and nutritional management in possible combination with increased selection for reproductive efficiency in Ankole cattle by farmers should be factors driving the AFC trend. This may also be a result of a shift from the conventional selection for aesthetic traits such as coat colour and horns. CI, a parameter related to AFC has also improved to 12–18 months, comparatively better than 16–24 months reported from earlier studies of this breed (Payne and Wilson, 1999).

Although AFC and CI estimates were expected to vary across production systems, this was not the case. This apparent anomaly could be attributed to related stress levels in the different production systems. For instance, although in the pastoral LPS, inadequate and poor-quality feeds could be due to poor pastures, bush encroachment and overgrazing; in the mixed crop livestock and the agropastoral systems, it could be due to inadequate pasture land.

The average daily milk off take for Ankole cows was 2.2 kg (Table 1), higher than 1.48 kg (Petersen *et al.*,

Table 2. Number of subcounties, parishes, villages and respondent households sampled in respective counties and LPS.

County	Administrative subunit[1]			Respondents	Production system		
	Subcounties	Parishes	Villages		Agropastoral $n = 68$	Crop livestock $n = 25$	Pastoral $n = 155$
					% of respondents		
Gomba	4 (2)	15 (10)	153 (21)	30	16.7	3.3	80.0
Kazo	5 (5)	28 (19)	233 (42)	60	63.3	16.7	20.0
Kiboga	10 (6)	20 (14)	154 (60)	60	25.0	0.0	75.0
Mawoggola	5 (1)	23 (04)	140 (07)	21	28.6	4.8	66.7
Nyabushozi	7 (6)	27 (23)	207 (44)	77	5.2	16.9	77.9
Total	31 (20)	113 (70)	887 (174)	248			

[1]The number sampled are in parentheses.

Table 3. Least-square means (± s.e.) of reproductive parameters and milk yield of Ankole cattle.

Category	Factor	*n*	Reproductive parameter (months)				Milk off take/cow/day (kg)[ns]
			ASMF[ns]	AFC	LL	AWC[ns]	
Production system	Agropastoral	65	22.9 ± 0.9	32.4 ± 0.8	6.3[a]±0.3	4.0 ± 0.1	2.2 ± 0.1
	Crop-livestock	22	21.7 ± 1.2	35.5 ± 1.3	5.5[a] ± 0.4	4.1 ± 0.2	2.4 ± 0.2
	Pastoral	140	22.8 ± 0.6	32.9 ± 0.8	7.4[b] ± 0.2	4.3 ± 0.1	2.1 ± 0.1
County	Gomba	30	23.7 ± 1.4	38.2[a]±1.6	6.2[a] ± 0.4	4.2 ± 0.2	2.5 ± 0.2
	Kazo	60	22.3 ± 0.8	32.2[b] ± 0.8	8.5[a] ± 0.4	4.4 ± 0.2	2.2 ± 0.1
	Kiboga	60	24.6 ± 0.9	36.4[a] ± 0.9	5.8[b] ± 0.2	3.9 ± 0.2	2.3 ± 0.1
	Mawoggola	21	19.9 ± 1.3	31.2[b] ± 1.3	5.2[b] ± 0.9	3.9 ± 0.4	2.5 ± 0.3
	Nyabushozi	77	21.9 ± 0.9	30.0[b] ± 1.3	6.1[b] ± 0.3	4.3 ± 0.1	2.0 ± 0.1
Overall		248	22.7 ± 0.5 (12–36)	33.2 ± 0.5 (24–45)	7.2 ± 0.2 (1–12)	4.2 ± 0.1 (3–6)	2.2 ± 0.1 (1–6)

Note: Means in the same column with different superscripts differ significantly ($P < 0.05$).
Numbers in parentheses are ranges.
ASMF, age at sexual maturity in female cattle; AFC, age at first calving; LL, lactation length; AWC, age at weaning of calf.

2003) for Ankole cows in the same location, and 1.08 kg (De Leeuw and Wilson, 1987) for indigenous Kenyan cattle kept under range conditions. Milk yield per cow per lactation, extrapolated from daily milk off take and LL was 550 kg in pastoral, 530 kg in agropastoral and 480 kg in crop- livestock areas. Differences between these values could be attributed to seasonal variations as affected by rainfall and pasture growth. Hence, better pastureland management and breeding strategies could improve milk production in Ankole cows. Values obtained in this study were comparable with 300–1100 kg for the Nkedi strain (SEA Zebu) (Payne and Hodges, 1997), a strain regarded as superior to the Ankole in milk production.

LL for the pastoral LPS was 7.4 months, 30 days longer than was reported by Twinamasiko (2001). This LL is nevertheless lower than 245–270 days for the Nguni (Rege *et al.*, 2001), which like the Ankole are Sanga cattle, but have undergone more intense selection for beef and milk production (Bester *et al.*, 2003). Ankole cattle therefore have a relatively good potential for milk production and would respond well to a combination of selection and improved management. Exceptionally high preweaning calf survival rates observed in this study may be attributed to good calf health care especially ecto- and endo-parasite control regimes among pastoralists, and to good adaptation of these cattle. The preweaning survival rate is important because it contributes to higher net calf crop (Rege *et al.*, 2001), resulting in more animals reaching breeding age, hence increased potential for more intense selection pressure and better overall herd profitability in beef ranching.

Ankole cows differed ($P \leq 0.05$) in HW across LPS, whereas bulls only differed in horn attributes. Bulls and cows in the crop-livestock system were shorter in body dimensions than in pastoral areas (Table 4). Linear body dimensions of Ankole cattle in the five counties that were studied clearly differed possibly because cattle in those areas have become subpopulations. Other causes could be variations in pasture biomass, livestock water

Table 4. Least-square means (± s.e.) for linear measurements (cm) for six traits in adult Ankole cattle of Uganda

Variable	Sex	*n*	Production system			Mean
			Agropastoral	Crop-livestock[1]	Pastoral	
HW	Male	120	144.8 ± 4.4	–	144.5 ± 6.9	144.6 ± 3.4
	Female	180	147.0[a]±4.4	126.1[b] ± 2.9	137.5[c] ± 2.7	139.5 ± 1.7
HG	Male	120	183.8 ± 3.2	–	181.5 ± 5.1	182.6 ± 2.8
	Female	180	169.6 ± 3.2	167.8 ± 2.2	172.6 ± 1.7	171.3 ± 1.3
BL	Male	120	212.6 ± 6.8	–	208.0 ± 8.8	210.3 ± 5.7
	Female	180	199.8 ± 6.8	204.3 ± 4.8	197.6 ± 3.8	201.4 ± 3.0
HL	Male	120	132.0[a] ± 13.0	–	176.5[b] ± 19.1	154.2 ± 12
	Female	180	151.8[a] ± 13.1	197.7[b] ± 8.2	195.1[b] ± 7.2	187.8 ± 5.6
Horn spacing (HS)	Male	120	26.2[a] ± 11.0	–	95.0[b] ± 16.3	60.6 ± 10.0
	Female	180	65.2[a] ± 11.2	81.0[a] ± 6.9	44.9[b] ± 5.9	60.2 ± 4.6
EL	Male	120	21.5 ± 0.6	–	20.0 ± 1.3	20.8 ± 0.7
	Female	180	19.8 ± 0.6	19.5 ± 0.4	19.6 ± 0.3	19.8 ± 0.3

Note: Means in the same row with different superscripts differ significantly ($P < 0.05$).
[1]In the crop-livestock system, farmers did not have crushes to confine animals; hence, bulls could not be measured.

Table 5. Correlation matrix for body measurements in adult Ankole cattle.

	HW	HG	BL	EL	HL	HS	BW
HW	1	**0.26**	0.12	**0.56**	**0.58**	0.23	**0.65**
HG	**0.82**	1	**0.28**	**0.39**	0.09	−0.03	**0.92**
BL	**0.67**	**0.68**	1	−0.15	−0.05	0.10	**0.28**
EL	**0.62**	0.18	0.61	1	0.16	−0.08	**− 0.39**
HL	**0.66**	0.43	0.32	0.55	1	0.16	−0.09
Horn Spacing (HS)	0.43	−0.02	−0.19	−0.06	**0.57**	1	−0.03
BW	**0.75**	**0.98**	**0.61**	**− 1.00**	**0.99**	−0.67	1

Above diagonal: female cattle; below diagonal: male cattle; bolded correlations are significant ($P < 0.05$).

availability and general climatic conditions associated with these areas.

Measurements for males and females significantly differed, similar to findings of other studies. Differences between linear measurements of bulls and cows are attributed to sexual dimorphism (Mwacharo *et al.*, 2006), normally associated with hormonal differences between males and females. HG and mean HW of Ankole cows were higher than previous studies (e.g. Ndumu *et al.*, 2008), possibly because of variation in the sampling frame and sample sizes used between the studies. HW in this study was also higher than data reported for other Sanga breeds (Payne and Hodges, 1997). Therefore, Ugandan Ankole cattle populations have a comparatively bigger body frame than populations elsewhere. Selective breeding of this breed could boost its competitive advantage over others and hence ensure its conservation.

Morphological descriptions are useful for distinguishing animal breeds and strains (Gatesy and Arctander, 2000) and in evaluation of breeding goals (Zechner *et al.*, 2001). Comparative measurements of morphometric traits can also provide evidence of breed relationships and size (Mwacharo *et al.*, 2006) and in some cases can be used to predict an animals' weight (Goe, Alldredge and Light, 2001; Mwacharo *et al.*, 2006). Withers height is useful for visual appraisal and determining show classes for beef cattle (Alderson, 1999). In contrast, skeletal measurements such as body height and length, and chest depth indicate inherent size better than measures related to muscle and fat deposition, such as width and girth measurements and BWs, which are affected by nutrition (Kamalzadeh, Koops and van Bruchem, 1998). For these reasons, the former were emphasized in this study.

The phenotypic correlations between the morphometric measurements were positive and generally significant (Table 5). Similar results have been reported in cattle breeds elsewhere (Mwacharo *et al.*, 2006). BW was highly and positively correlated with HL (0.99) and HG (0.98) in Ankole bulls; hence, the latter two traits can reliably be used as proxies for estimating BW for this breed. However, with the exception of BW and HG, correlations between traits in Ankole cows were much lower than the corresponding values for bulls (Table 5). Regression of HW on HG and BL was linear with high R^2 values (Table 6). Observing the correlation and regression analysis, HG would be the best estimator for BW, given the high R^2 values (>90) in both bulls and cows. Previous studies in Mubende goats have also showed similar relationships (Kugonza, Bareeba and Petersen, 2001).

Commercial milk and beef production from exotic genotypes is increasingly becoming popular in Uganda in response to increasing demand for milk and quality beef. However, the negative effects of the climate change, as witnessed by increased frequency and severity of droughts in the recent past, calls for caution. A careful introduction of Ankole and its crosses to the exotic commercial dairy and beef breeds may well provide the best option under the fragile Ugandan rangelands.

There is also need to mobilize cattle owners who maintain pure Ankole cattle herds to form a breeders association, to facilitate our proposed Ankole improvement programme. The National Animal Genetic Resource Centre needs a source of pure stock to ensure that inbreeding of their herds is avoided. A credible and sustainable source of such pure stock would be the traditional farmers/keepers/owners of the Ankole breed, if they became a breed association. Involvement of farmers in the planning phase of breeding programmes ensures that they provide their support when it is eventually needed (Kosgey *et al.*, 2006). Farmers' participation could include animal identification,

Table 6. Relationship of HG with HW and BW, and BL of Ankole cows and bulls.

Regressed factors	Sex	Equation	R^2	*P* value
HW on HG	Male	$y = 80.5 + 0.72x$	0.64	0.001
	Female	$y = 149.2 + 0.16x$	0.60	0.030
HW on BL	Male	$y = 117.6 + 0.65x$	0.45	0.008
	Female	$y = 175.9 + 0.18x$	0.50	0.030
BW on HG	Male	$y = 125.2 + 0.11x$	0.95	0.008
	Female	$y = 24.2 + 2.6x$	0.98	0.006

recording, ensuring vaccination programmes are adhered to and culling of undesirable stock (Willis, 2001). On the other hand, the central government has to play a key role in providing policy and enabling infrastructural as well as technical support for such a breeding programme to succeed (Philipsson *et al.*, 2006). For the case of Uganda, an act of parliament is in existence (The Animal Breeding Act, 2001), but most sections of it are yet to be operationalized.

Conclusions

Ankole cattle show a high productive potential, although their current performance is relatively low, largely because of the suboptimal management conditions and production area constraints. Wide variations in management activities and production levels were also observed in the three LPS. However, this variation in the production levels is indicative of potential for improvement under selection and improved husbandry. HG is the sole trait that best predicted live weight in both male and female cattle, although HL and absolute BL are also relatively good proxy traits for estimation of BW.

Recommendations

In view of the ongoing climate change and its negative effects, a carefully planned improvement programme involving pure Ankole and its crosses to the exotic commercial dairy and beef breeds is therefore recommended as a sustainable option for conserving this unique cattle genetic resource. Improvement of Ankole cattle could focus on a few traits and hence keep the costs and time requirements for an improvement programme low. Traits to focus on initially should include weaning weight and ASM. Herds to be used in the selection programme should be large in size, and these are available in the three LPS studied. Strengthening of the extension service by increasing the number of service providers and improving their facilitation should be undertaken. Farmer training in proper herd management should lead to improvement in the productivity of this breed, even at current genetic potential.

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A preliminary screening of genetic lineage of Nigerian local chickens based on blood protein polymorphisms

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Summary
Blood samples for blood protein analysis were collected from three strains of the Nigerian local chicken (normal feathered, frizzle feathered and naked neck) and one exotic strain (Anak Titan). Each of these populations represents a genotype. Blood samples from 50 birds per genotype were used to assess genetic diversity of the Nigerian local chickens. A total of 18 bands were observed from the four strains during resolution of the proteins using sodium dodecyl sulphate–polyacrylamide gel electrophoresis (SDS–PAGE). Dendrogram developed from the different bands observed revealed that the strains were clearly separated from one another and mean genetic similarity among the four strains was 55 percent with naked neck strain being the most diverged.

Keywords: *blood protein polymorphisms, Nigerian local chickens*

Résumé
Des échantillons de sang pour l'analyse des protéines dans le sang ont été collectées à partir de trois souches de la poule locale du Nigeria (Normal plumes, plumes et Frizzle Naked cou) et une souche exotique (Anak Titan). Chacune de ces populations représente un génotype. Des échantillons de sang de 50 oiseaux par génotype ont été utilisés pour évaluer la diversité génétique des poulets nigérians locaux. Un total de 18 bandes ont été observées dans les quatre souches pendant la résolution des protéines à l'aide de sodium dodécyl sulfate–polyacrylamide (SDS–PAGE). Dendrogramme développé à partir de différentes bandes observées ont révélé que les souches ont été nettement séparés les uns des autres et de dire la similarité génétique entre les quatre souches a été de 55 percent avec la souche cou nu étant le plus divergé.

Mots-clés: *polymorphisme des protéines sanguines, poule locale du Nigeria*

Resumen
Fueron tomadas muestras de sangre para el análisis proteico en tres variedades de gallinas autóctonas nigerianas (de plumaje normal, de plumaje rizado y de cuello desnudo) y una variedad exótica (Anak Titan). Cada una de estas poblaciones representa un genotipo. Se usaron muestras de sangre de 50 animales por genotipo para valorar la diversidad genética de las gallinas autóctonas nigerianas. Fueron observados un total de 18 grupos a partir de las cuatro variedades durante la resolución de la proteína utilizando electroforesis en gel de poliacrilamida con dodecilsulfato sódico (página de SDS). El dendograma desarrollado desde los diferentes grupos observados reveló que las variedades se encontraban claramente separadas unas de otras y con una semejanza genética media entre las cuatro variedades del 55 percent, siendo la variedad de cuello desnudo las más separada.

Palabras clave: *polimorfismo sanguíneo de las proteínas, razas autóctonas nigerianas*

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Introduction

Animal genetic resources are defined as animal species that are used, or may be used, for the production of food for man. In terms of biodiversity, conservation and utilization, these genetic resources require further identification and evaluation to assess their potential contribution to food and agricultural production now and in the near future. Biodiversity can be described at several levels ranging from phenotypic observations to molecular data. An increasing loss of genetic diversity has been observed for all agriculturally used species, and more than half of common livestock breeds especially poultry are now endangered or at risk of extinction (Dohner, 2001; Hoffmann, 2005).

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Biodiversity encompasses not only the world's species with their unique evolutionary histories, but also genetic variability within and among populations of species and the distribution of species across local habitats, ecosystems, landscapes and whole continents or oceans (FAO, 2009). According to FAO (2000), animal genetic diversity allows farmers to select stocks or develop new breeds in response to environmental change, threat of disease, new knowledge of human nutrition requirements, changing market conditions and societal needs.

The utilization of appropriate animal genetic resources to achieve and maintain sustainable production systems that are capable of responding to human needs is necessary to national and global food security. Over 75 percent of the world's food and agriculture is produced by fewer than 25 domestic plant and animal species (FAO, 2007). Adapted genetic material must form the foundation for improving food and agriculture production systems. Globally, this will involve the use of a much wider spectrum of farm animal genetic resources for each of the major species. Unfortunately, global farm animal genetic resources are disappearing very fast (FAO, 2007). The number of domestic animal species is low, perhaps 40 in total, and with less than 14 accounting for over 90 percent of global production (FAO, 2004).

Existing poultry varieties comprise a wide range of breeds and strains that have evolved in the process of domestication and systemic breeding programmes. Since domestication, chickens have been distributed to various countries, continents and cultures. The use of chicken for food has been limited to a few specialized commercial breeds and a vast range of non-commercial chicken breeds.

The Nigerian indigenous chicken is a dual-purpose bird that is used both for meat and egg production in the rural and peri-urban areas of the country. They are found in large numbers distributed across different agro-ecological categories under a traditional family based scavenging management system (Sonaiya and Olori, 1990). Most of the birds are kept in small flocks under a scavenging system and the feed resources for the birds are household refuse, homestead pickings, crop residues, herbage, seeds, green grasses, earthworms, insects and small amount of supplemented feeds offered by the flock owner. They are well adapted to the adverse climatic conditions of the tropical environment and low management inputs. They contain a highly conserved genetic system with high levels of heterozygosity (Wimmers *et al.*, 2000). These indicate that they are highly important farm animals, kept for good source of animal protein, for income and socio-cultural roles. Ebozoje and Ikeobi (1995) reported the adaptive potentials of the Nigerian indigenous chicken to varied ecological conditions, stresses and diseases.

There have been some efforts at characterizing the Nigerian indigenous chickens. These efforts include classification based on ecotypes (Sonaiya and Olori, 1990), plumage and shank colour (Ebozoje and Ikeobi, 1995; Ikeobi *et al.*, 1996), possession of the major genes of feather distribution and feather structure (Ibe, 1993, Ebozoje and Ikeobi, 1995; Peters *et al.*, 2002, 2005, 2007, 2008a, 2008b). Major genes effect on growth, fertility, hatchability and semen quality characteristics have also been reported (Peters *et al.*, 2002, 2005, 2008a, 2008b). Wekhe (1992) earlier reported that Nigerian indigenous chickens are more resistant to infectious disease agents than their exotic counterparts. These chicken population estimated at about 140 million (FAO, 2006) is currently underutilized in the development of acceptable improved breeds. There is a need to expand the narrow genetic base in which the world's poultry breeding company currently operates by including local chicken resources that has been widely reported to be well adapted to the local conditions.

In addition to the phenotypic characterization that has been done and reported above, there is a need to perform molecular characterization for information with regard to phylogeny, diversity and relatedness. To take advantage of the differences in the strain of chickens and bring about genetic progress in breeding, a diversity study is imperative. Most diversity and phylogenetic studies are mainly based on microsatellite loci (Erhardt and Weimann, 2007) although a number of other polymorphism systems such as protein polymorphisms, blood groups or other molecular markers systems were alternatively used (Baumung, Simianer and Hoffmann, 2004). The use of microsatellite has become a standard method to estimate genetic diversity in livestock. To define species-specific standards, the International Society for Animal Genetics (ISAG) formed a FAO/ISAG advisory group on animal genetic diversity in 1995, which set up recommended species-specific lists of microsatellites loci (about 30 per species) for cattle, chicken, sheep and swine to be used in diversity studies (http://dad.fao.org/). Protein polymorphisms have been used as marker systems to estimate genetic variation within and between chicken populations (Mina *et al.*, 1991; Romanov, 1994) and while we were aware that microsatellites and other DNA markers are more polymorphic and informative than protein markers in diversity studies, there is a need to use protein markers to do a preliminary screening on genetic diversity of Nigerian local chickens. This investigation therefore sought to find the genetic diversity, as a preliminary assessment, among Nigerian indigenous chickens reared intensively using blood protein polymorphisms by estimating genetic similarity.

Materials and methods

Local chickens comprising naked neck, frizzle feathered and normal feathered were collected from different villages of Abeokuta in Nigeria. The same strains were mated using artificial insemination to generate progenies raised for this study and the birds were maintained at the Poultry

Figure 1. Normal-feathered indigenous cock.

Figure 3. Naked neck indigenous cock.

Breeding Unit of the University of Agriculture, Abeokuta. A total of 15 sires were used in inseminating 80 dams belonging to three local chicken genotypes and one exotic chicken. A total of 200 blood samples (50 per genotype) from the chicken populations were used for this study. About 2 ml of blood was collected from wing vein of each chicken using 2 ml syringes. The blood was collected from purebred local chickens (normal feathered, naked neck and frizzled feather) and exotic broiler breeder (Anak Titan) shown in Figures 2–5.

Whole blood samples were taken to the laboratory for analysis. Serum was separated from the whole blood using centrifugation. The supernatant serum protein was carefully transferred into a clean 2 ml eppendorf microtube and stored at −35°C. The sodium dodecyl sulphate–polyacrylamide gel electrophoresis (SDS–PAGE) analysis was carried out using the Bio-Rad Mini Protean II (10 ml capacity) for three blood proteins: globulin, transferrin and albumin. This method of analysis is a discontinuous buffer system, which means that the buffer in the reservoir is of a different pH and ionic strength from the buffer used to cast the gel. The stacking gel contained distilled water (6.1 ml), 0.5 M Tris-HCl at pH of 6.8 (2.5 ml), 10 percent SDS (100 µl), acrylamide/bisacrylamide solution (1.3 µl), 10 percent ammonium tetraoxosulphate (vi) (50 µl) and Initiator or N'N'N'N-Tetramethylene diamine (TEMED) ($C_6H_{16}N_2$) (10 µl). B-mercaptoethanol (7.5 percent) in sample buffer was used for the preparation of the chicken blood samples. The serum and sample buffer were added at ratio 1:2 and heated at 95°C for 5 min in a water bath.

Figure 2. Frizzle-feathered indigenous cock.

Figure 4. Anak Titan cock.

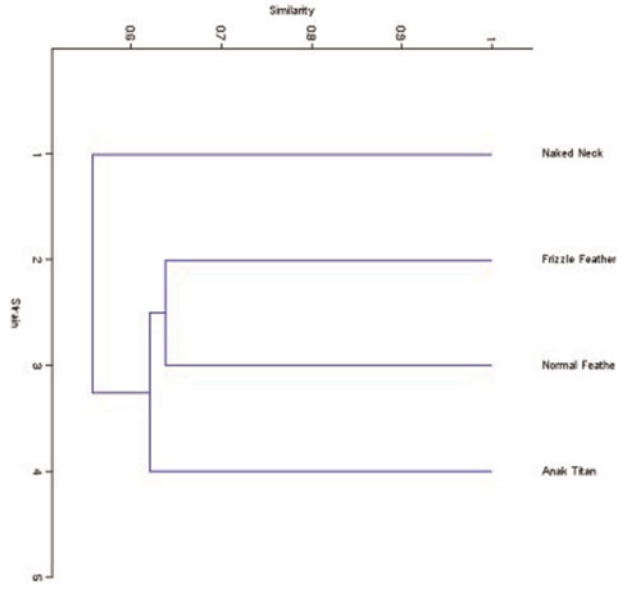

Figure 5. Dendrogram developed by UPGMA cluster analysis showing the coefficient of genetic similarities among the chicken populations studied.

The mixture was placed inside the deep freezer for 5 min and then loaded into the wells on the gel. The separation of protein was carried out with the aid of Bio-Rad Electrophoresis system using the Bio-Rad Mini Protean II Cell at 150 V for 2 h. The separating gel composed of 0.375 M Tris at pH of 8.8, distilled water (3.5 ml), 1.5 M Tris-HCl (2.5 ml), 10 percent SDS (100 µl), acrylamide/bisacrylamide (4.0 µl), 10 percent ammonium tetraoxosulphate (vi) (50 µl) and TEMED (5 µl). At the completion of the electrophoresis, the gels were carefully removed under water and placed in a staining solution of 0.1 percent Coomassie Blue in 1:4 glacial ethanoic acid (CH_3COOH) and methanol (CH_3OH). The staining solution was later removed and the gels were de-stained with the de-staining solution that contained 40 percent distilled water in 1:4 glacial ethanoic acid and methanol. The de-stained gels were then scanned and the bands visually scored.

Statistical analysis

The presence of bands was designated as (1) and band absent was coded as (0). The computer program PAST (Hammer, Harper and Ryan, 2001) designed for protein electrophoretic data analysis was used to develop the dendrogram produced by the unweighted pair group method with arithmetic mean UPGMA (Sneath and Sokal, 1973). Genetic distance was calculated using the formula: $D = 1 - S$, where D represents genetic distance and S the genetic similarity.

Results

Gene constitutions of Nigerian local and exotic chickens were compared using polypeptide chains at three loci controlling blood protein types. The electrophoretic banding patterns of SDS–PAGE of the four strains revealed a maximum of 18 bands for the three loci examined (globulin, transferrin and albumin). All these 18 bands were not necessarily present in all the four strains. Two postalbumin bands appeared to be present in only naked neck chickens. This might be taken as rare or uncommon alleles. The phylogenetic relationships among the strains studied were summarized in Figure 5. The dendrogram showed that the strains were clearly separated from one another. Mean genetic similarity among the four strains was 55 percent with the naked neck being the most distant among the chicken populations. Genetic similarity between Anak Titan and frizzle-feathered with normal-feathered breed was 63 percent while frizzle feathered and normal feathered being the same local strains were 65 percent similar. The birds were divided into two clusters, with the first cluster consisting of only naked neck as a distinct strain on the evolutionary scale with other strains diverging progressively. The second cluster composed of frizzle and normal feathered as first subcluster while Anak Titan formed the second subcluster, respectively. The values of the genetic similarities used for the construction of the dendrogram are presented in Table 1 with the genetic distances in parentheses.

Discussion

The strains were clustered according to their overall genetic similarity. Each band in the electrophoretic analysis corresponds to a different protein, the synthesis of which is controlled by one, two or polygenes. The protein phenotype (bands) observed on the gels can therefore be interpreted in terms of presence of alleles for the specific protein studied. Using different proteins, Mohammed *et al.* (2001) had earlier made similar observation on different breeds of chickens studied. They stated further

Table 1. Genetic similarities and distances among the chicken population studied.

	Anak Titan	Frizzle feather	Naked neck	Normal feather
Anak Titan	0.0000			
Frizzle feather	0.3825 (0.6175)	0.0000		
Naked neck	0.3927 (0.6073)	0.4983 (0.5017)	0.0000	
Normal feather	0.3780 (0.6220)	0.3632 (0.6368)	0.4415 (0.5585)	0.0000

Values in parentheses represent genetic distances.

that electrophoretic analysis of protein provides information on the molecular weights and charges of protein, the subunit structures of protein and the purity of the particular preparation. In addition, different forms of mutation may occur in the codon, particularly, the replacement of certain nucleotide by others which may explain the observed banding pattern across the different strains in this study. Two postalbumin bands present in naked neck appeared to be private/rare alleles (that is alleles detected in only one population but completely absent in another populations). Probably, these bands may have to do with feather distribution gene that gives its characteristic phenotype. Granevitze *et al.* (2007) also reported the presence of private alleles in the chicken populations studied with the highest number of five carried in H'mong chickens followed by Red Jungle Fowl with four private alleles.

The dendrogram constructed from this study showed that the strains were clearly separated from one another. This is in agreement with the phenotypic variation of these strains of chickens. Naked neck among these chicken populations appeared to be closest to the origin in the evolutionary trend, hence the most remote as shown by its distinct and separate cluster. The exotic breed (Anak Titan) in this study is the most outbred being the farthest from naked neck and also shows that Anak Titan has a line of descent with all the local strains examined.

The dendrogram constructed indicates that frizzle- and normal-feathered chickens in this study are closely related. This indicates that frizzle- and normal-feathered chickens share a more recent common ancestor than either shares with any of other strains on the phylogenetic tree. Investigating blood protein polymorphisms of local chicken in Laos, Okamoto *et al.* (1999) reported small genetic differentiation among the chicken populations studied. It appears from this preliminary analysis that native strains of chickens are good reservoir of allelic diversity that is the major basis for genetic improvement, although genetic diversity observed among the chicken populations was low. This, however, will have to be studied further using more polymorphic DNA markers.

Conclusion

Low polymorphism exists among Nigerian local chickens and Anak Titan with respect to the few blood protein types examined. Both frizzle- and normal-feathered chickens formed the same cluster and are genetically close to Anak Titan while these three strains are genetically far from naked neck chickens which appeared to be the most remote of all the strains examined. Nigerian local chickens, particularly naked neck, should be conserved as a reservoir of rare genetic chicken resource and its similarity and genetic distance between and among other ubiquitous chicken populations may be tested in further research using more polymorphic DNA markers.

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Distribution of prolific Garole sheep in West Bengal, India

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Summary
The Garole is a prolific breed of sheep. High prolificacy in sheep carrying the Booroola gene (*FecB*) is the result of a mutation in bone morphogenetic protein receptor-IB (BMPR-IB) (Wilson *et al.*, 2001a,b) which had previously been identified in Garole sheep from the Sunderban region of West Bengal (Davis *et al.*, 2002) . There is evidence that the breed has originated from the sheep brought by the Tibetan traders and traded in the plains of Bengal during the seventeenth till the nineteenth century. The present study was carried out to remap the distribution of the Garole sheep within the state of West Bengal (India) using the presence of the BMPR-IB mutation in the sheep flocks reared at different locations within the state of West Bengal. The breeding tract of Garole sheep was initially thought to be in the districts of 24 Parganas, South and North alone. However, the results from the present study indicate that the sheep is also reared in the district of Midnapur (East), besides in Jalpaiguri and Cooch Behar districts situated in northern parts of the state. The results of the present study indicate that the breeding tract of Garole sheep extends up to Jalpaiguri and CoochBehar districts of West Bengal at 26°16′ and 27°0′ North latitude and 88°4′ and 89°53′ East longitude. This study also indicates that the ancestors of the Garole sheep have migrated from China/Tibet, during the trading between West Bengal and Bangladesh during the seventeenth century till the early-twentieth century.

Keywords: *Garole sheep, FecB mutation, distribution, West Bengal, India*

Résumé
Le Garole est une espèce prolifique de mouton. Haut prolificacy dans le mouton qui porte le gène de Booroola (*FecB*) est le résultat d'une mutation dans BMPR-IB (Wilson *et al.*, 2001a, b) qui avait été précédemment identifié dans le mouton de Garole de la région de Sunderban de Bengale d'ouest (Davis *et al.*, 2002). Il y a de la preuve que l'espèce a provenu du mouton amené par les commerçants tibétains et échangé dans les plaines de Bengale pendant le dix-septième jusqu'à le dix-neuvième siècle. L'étude présente a été exécuté à remap la distribution du mouton de Garole dans l'état de Bengale d'ouest (l'Inde) utilisant la présence de la mutation de BMPR-IB dans les troupeaux de mouton a élevé aux emplacements différents dans l'état de Bengale d'ouest. L'étendue élevant de mouton de Garole a été pensée au début pour être dans les quartiers de 24 Parganas, le Sud et Nord seul. Cependant, les résultats de l'étude présente indiquent que le mouton est aussi élevé dans le quartier de Midnapur (l'Est), en plus dans Jalpaiguri et les quartiers de Behar de Cooch ont situé dans les parties du nord de l'état. Les résultats de l'étude présente indiquent que l'étendue élevant de mouton de Garole s'étend en haut aux quartiers de Jalpaiguri et CoochBehar de Bengale d'ouest à 26°16′ et 27°0′ la latitude du nord et 88°4′ et 89°53′ la longitude de l'Est. L'étude présente indique aussi que les ancêtres du mouton de Garole ont migré de Chine/Tibet, pendant le commerce entre Bengale et Bangladesh d'ouest pendant le dix-septième siècle jusqu'à le premier vingtième siècle.

Mots-clés: *mouton Garole, mutation du gène* FecB*, distribution, Bengal occidental, Inde*

Resumen
La Garole es una prolífica raza de ovejas. La alta prolificidad en las ovejas portadoras del gen Booroola (*FecB*) es el resultado de una mutación en BMPR-IB (Wilson *et al.*, 2001a, b), que había sido previamente identificado en el ganado ovino Garole de la región de Sunderban de Bengala Occidental (Davis *et al.* 2002). Existen pruebas de que la raza tiene su origen en las ovejas traídas por los comerciantes tibetanos y comerciaban en las llanuras de Bengala desde el siglo XVII hasta el siglo XIX.

El presente trabajo se realizó para reasignar la distribución geográfica de las ovejas Garole dentro del estado de Bengala Occidental (India), utilizando la presencia de la mutación BMPR-IB en los rebaños de ovejas criadas en distintos lugares dentro del estado de Bengala Occidental. Inicialmente se pensó que el área de cría de las ovejas Garole fuera en distritos de 24 Parganas, Sur y Norte solo.

Sin embargo, los resultados del presente estudio indican que las ovejas también se crían en el distrito de Midnapur (este), además de en los distritos de Jalpaiguri y Cooch Behar, situado en el norte del estado. Dichos resultados indican que la zona de cría de ovejas Garole se extiende hasta Jalpaiguri y CoochBehar, distritos de Bengala Occidental a 26°16′ y 27°0′ latitud Norte y 88°4′ y 89°53′ longitud

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Este. Asimismo, el estudio señala que los ancestros de las ovejas Garole fueron traídos desde China / Tíbet, a consecuencia del comercio entre el Oeste de Bengala y Bangladesh desde el siglo XVII hasta comienzos del siglo XX.

Palabras clave: *oveja Garole, mutación Fec B, distribución, Bengala Occidental, India*

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Introduction

The highly prolific Garole breed of sheep is prevalent in the state of West Bengal and Bangladesh (Ghalsasi and Nimbkar, 1993; Bose and Moitra, 1995; Sandip Banerjee and Soma Banerjee, 2000). Various authors (Ghalsasi and Nimbkar, 1993; Bose and Moitra 1995; Singh and Bohra 1996; Sharma *et al.*, 1999; Sahana *et al.*, 2001) have reported that the breeding of Garole sheep is localized in the Sunderban region of West Bengal and Bangladesh. Bose and Moitra (1995) reported that the habitat of the breed spans between 21° and 23° North latitude and 87° and 89° East longitude, spanning an area of 4 226 km^2. Sharma *et al.*, (1999) observed that the highest elevation inhabited by the Garole sheep is 200 m above the sea level. The present study was carried out to study the distribution of the Garole sheep within the state of West Bengal in India and also to study the reasons for prolificacy in sheep flocks reared in the districts of Jalpaiguri and Cooch Behar in India.

This project was done to identify the presence of the bone morphogenetic protein receptor IB (*BMPR-IB*) gene, which affects the fecundity of sheep in different sheep flocks reared in West Bengal. The presence of BMPR-IB mutation was initially identified in Garole sheep, reared in the Sunderban region of West Bengal and Bangladesh. The historical findings indicate that wool was traded from Tibet. Sheep were also used to carry merchandise by the Tibetan traders to Jalpaiguri and Cooch Behar districts from the seventeenth till the early-twentieth century. The *FecB* gene as observed in the flocks in the above-mentioned districts have been introduced to the local ovine population by the crossings with the sheep of Tibetan origin that occurred during the past, as has been observed in the present study (Binny, 2005). Davis (2004) reported that one copy of the *FecB* gene increases ovulation rate in Booroola Merino by about 1.5 and two copies by 3.0. These extra ovulations in turn increase litter size by 1.0 and 1.5, respectively. High prolificacy in Booroola sheep is due to a non-conservative mutation (q249r) in a highly conserved intracellular kinase signalling domain of the BMPR-1B expressed in the ovary and granulosa cells (Mulsant *et al.*, 2001; Wilson *et al.*, 2001a, b). The BMPR-1B, also known as ALK-6, is a member of the transforming growth factor-β (TGF-β) superfamily. These are multifunctional proteins that regulate growth and differentiation in many cell types. Members of this family play essential roles during embryogenesis in mammals, amphibians and insects as well as in bone development, wound healing, haematopoiesis and immune and inflammatory responses (Massague, 1998; Letterio and Roberts, 1998).

There are historical records indicating large scale trading of livestock in the districts of Jalpaiguri and Coochbehar, during the seventeenth till early decades of the twentieth century. The great silk route from China via Tibet terminated at the districts of Coocb Behar and Jalpaiguri (Figures 8 and 9). The exchange of goods from the hills took place in the regions and many fairs that sprang up at different places in this region. The fairs were generally held in winter and continued roughly for 4 weeks. The largest of such fairs one took place at Darwani (presently in Rangpur district of Bangladesh; latitude 25° 45′00″ and longitude 89°15′ 00″) where, according to a contemporary source, around 50 000 visitors participated. Here along with the traditional products, various live animals such as elephants, camel, sheep were sold here from the neighbouring states such as Bihar (Ratna Sarkar and Indrajit Ray, 2006). Similar fairs were also held at Panga Barabhita, Badarganj, Birat in different parts of Rangpur district and in Rangpur town itself (Ratna Sarkar and Indrajit Ray, 2006).

As sheep from different parts of eastern India and Tibet were traded in these fairs at Rangpur and adjoining area, there were chances of crossing among different breeds in the region as indicated in present results from Jalpaiguri and Cooch Behar region (Zone-3) of West Bengal. The aim of the present study was to study the prevalence of FecB mutation in sheep reared at different locations of West Bengal and to correlate the historical findings regarding the migration of sheep from Tibet to plains of Bengal during the past centuries.

Materials and methods

The state of West Bengal is situated between 22°34′10.92″ N and 88°22′10.92″E latitude and longitude. The state is situated in the eastern part of India, to the south is situated the Bay of Bengal, to the East is Bangladesh, the North is guarded by the Himalayas and in the West is situated the state of Jharkhand. The study was carried out using multistage sampling technique. For the study the state of West

Bengal was divided into six zones, where there could have been possibilities of the existence of sheep with high incidences of prolificacy.

The Zone-1, situated in the Midnapur (East) district 22°30′ 00″N and 87°30′00″E, located away from the Sunderbans and is divided by the river Hoogly, near to the Bay of Bengal. Zone-2, the district 24 Parganas (North) is situated between latitude: 23°15′ North–22°11′ North and longitude: 89°5′ East–88°20′ East, a part of the district comes under the Sunderban region. Zone-3, the districts of Jalpaiguri and Cooch Behar, is situated between 26°16′ and 27°0′ North latitude and 88°4′ and 89°53′ East longitude is in the Northern part of the state at the foothills of the Himalayas, the place is situated nearly 800 km away from the currently known Garole sheep breeding tract. The Cooch Behar and Jalpaiguri districts boundary Bangladesh in the south, state of Assam in the east, Bhutan in the north and the district of Darjeeling in the west. Zones 4, 5 and 6 district 24 Parganas (South) located between latitude North 20′20″ South 22′06 and longitude East 88′20″ West 88′60″ and is the district where maximum Garole population is found and is taken as a control district. The locations of the various districts are presented in Figure 1.

The present literature reviewed on the breeding tract of Garole breed indicates that the same is limited only to 24 Parganas (North and South) in West Bengal.

A total of 114 of sheep were included in the present study. The locations/areas/regions were the blood samples were collected from the sheep have been presented in Table 1.

The samples were collected through multistage sampling process and the villages within the zones were selected randomly and purposive sampling (for their prolific status) was done within the village. Sheep with prior history of multiple births and lambs and rams born from multiple births were considered for the present study. The history of multiple births in the sheep was obtained from the rearers by formulating informal questioners. There were also instances where the blood was collected from the ewes with multiple lambs at foot. The blood was collected by puncturing the veins of the animal's ear. The samples were collected in duplicate on easi Trace™ DNA labels (Hally Labels, Christchurch, New Zealand) and were analysed for the presence of the BMPR-IB mutation.

Preparation of blood samples

DNA was extracted from each 2.0 mm punch using alkaline lysis at 75 °C as described by Rudbeck and Dissing (1998). The punches were incubated for 5 min in 20 µl 0.2 M NaOH and then 180 µl 0.04 M Tris-HCl, pH 7.5 was added. An aliquot of 1–5 µl of extract was used per polymerase chain reaction (PCR).

Forced restriction fragment length polymorphism PCR for *FecB*

The process was carried out as per the methodology suggested by Davis *et al.* (2002). However, in the present process easi Trace™ labels were used. PCR was carried out using a modification of the forced Restriction fragment length polymorphism (RFLP) method described by Wilson *et al.* (2001a, b). The primer TestR15 has been engineered to introduce a point mutation such that PCR products from the *BMPR-1B* gene with the Booroola mutation contain an *Ava*II (New England Biolabs, Beverly, MA, USA) restriction site (G|GACC),whereas products from non-carriers of the mutation lack this site. Genomic DNA (~100 ng) was amplified as described by Wilson *et al.* (2001a, b). The samples on easi Trace™ DNA labels were punched (single 1.2 mm punch) and were amplified in a 25 µl reaction volume using an alternative primer set CCAG AGGACAATAGCAAAGCAAA, Test F2, and CAAG ATGTTTTCATGCCTCATCAACACGGTC (Test R15).

The amplification was carried out using 35 cycles at 94 °C for 15 s, 60 °C for 30 s and 70 °C for 30 s, followed by 72 °C for 5 min and 99 °C for 15 min. The 190 bp product was then digested using *Ava*II. The resulting products were separated by electrophoresis on a 5 percent agarose gel and visualized with ethidium bromide. Products containing the FecB mutation yield 160 and 30 bp fragments, while non-carrier products remain uncut at 190 bp.

Results

The results obtained from the present study are presented in Table 2. The results indicate that, FecB was observed in most of the samples analysed from all the zones. The results also show that the samples from zones, 1, 2, 4, 5 and 6 are having either BB or B+ mutation, as evident from Figure 2.

The results further indicate that the sheep reared at Jalpaiguri and Cooch Behar districts of West Bengal at 26°16′ and 27°0′ North latitude and 88°4′ and 89°53′ East longitude too carry the BMP IB mutation. However, results from this zone indicates the presence of all the three genotypes i.e. BB, B+ and ++ . Suggesting that, in the past some out crossing has taken place among the sheep breed reared in the districts of North Bengal (Figures 3–5).

Historical findings

The erstwhile Government of Bengal records indicate that sheep were brought to Bengal by the traders from Tibet (Rennie, 1866; Firminger, 1920; Hunter, 1879). Therefore, there are possibilities that the *FecB* gene may also be present in the Sipsu sheep breed of Bhutan. The breeding tract of the Sipsu sheep is South Bhutan, adjacent to Cooch Behar and Jalpaiguri districts of India. Dorji

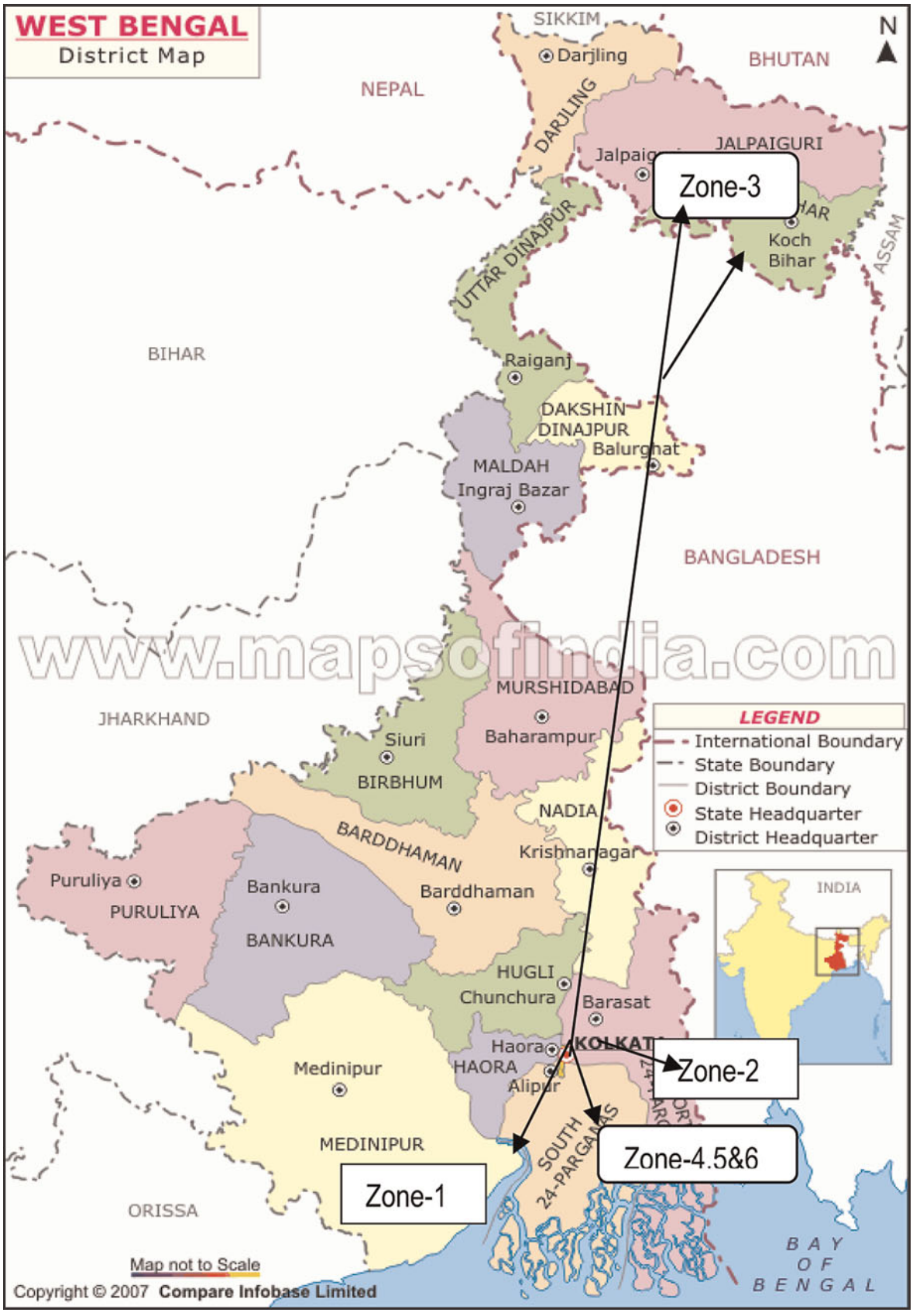

Figure 1. Location of all the zones from where the blood samples were collected.

Table 1. Zones from where the samples were collected

Zones	Neighbouring villages	District
1	Mahisadal, Geokhali	Midnapur (East)
2	Tona, Machibhanga, Rajarhat	24 Parganas (North)
3	Mynaguri, Malbazar, Dhupguri, Changrabadha, Pundibari*	Jalpaiguri, Coochbehar*
4	Joynagar Mazilpur (Hari Narayanpur, Rajapur Korabeg, Sripur and Uttar Durgapur)	24 Parganas (South)
5	Mandir Bazar (Laksmi-Narayanpur Dakshin, Laksmi-NarayanpurUttar, Mathurapur Paschim and Mathurapur Purba	24 Parganas (South)
6	Villages adjoining Basanti, Canning	24 Parganas (South)

*signifies that the villages around Punibari (from where the samples were collected) are situated in the district of Cooch Behar.

et al. (2003) reported that the Sipsu sheep is also a prolific sheep breed, in the region. Grenard (1974) reported that the sheep were used as a beast of burden by the transhumance community in Tibet. Pemberton (1839) in his observations also mentioned that the caravans from Tibet usually comprised mules, ponies, horses, yaks, sheep, etc. who could negotiate the narrow rugged paths in the mountains. Sheep was reared in Tibet for wool and most of the wool was traded to eastern India from the Jelep la pass, via Chumbi valley to Kalimpong, presently in Darjeeling district of West Bengal. Many traders from Bhutan terminated their journey at Cooch Behar, disposing their wares there. It was a commercial centre that developed from the sixteenth century onwards as a centre of exchange among various traders from Tibet, Bhutan, Sikkim and India, The last leg of the journey for the traders was from Cooch Behar to Rangpur. Hunter (1876) reported that the price of a Tibetan sheep was lower than that of a Nepali sheep (Bonpala). As the former had a lower body weight the Tibetan sheep could carry a load of 15–20 kg each as against the carrying capacity of 6–12 kg for the Bhutanese sheep and goat (Ratna Sarkar and Indrajit Ray, 2005).

Discussion

The presence of the *BMPR IB* gene both in Small Tail Han and Hu sheep of China (Yan Ya-Dong *et al.*, 2005; Chu *et al.*, 2007), support the present results. The Hu sheep originated from Mongolian sheep as early as in the Song Dynasty (AD 420–479). Mongolian sheep were introduced from the pastoral region of North China to the Taihu lake basin which borders the present provinces of Zhejiang and Jiangsu (Feng *et al.*, 1996). The migration of the ancestors of the sheep to India during the colonial era via the silk route may have led to the transfer of the gene to the sheep reared in West Bengal. Bell (1928) reported that merchants from Bhutan traded with China through Tibet during the nineteenth century. The major items of trade between China and Bhutan were sheep and woolen products besides other items such as rock salt and silk. Moreover, as the traders travelled long, it is logical to conclude that they used the rams as beast of burden. The rams being slightly heavier could take more loads. Moreover, ewes could delay movements of caravans due to lambing en-route. Therefore, suggesting that the *FecB* gene in sheep reared in the plains of Bengal and Bangladesh could have been transferred from the paternal linage only, similar inference regarding the transfer of *FecB* gene through paternal lines has been suggested by Davis (2008). This inference is in accordance with the mitochondrial (mt) DNA results, which suggests that the Hu sheep has haplotypes A, B and C (Chen *et al.*, 2006), while Garole has only haplotype A, (Meadows *et al.*, 2005). The mt DNA results on both the breeds suggest that the two breeds have distinctly different maternal lines while may be have similar paternal lines.

The currently available literatures on ovine breeds of India (Acharya, 1982; ICAR, 2002) indicate that the sheep reared in the Jalpaiguri and the Cooch Behar districts of

Figure 2. Garole ewe carrying *FecB* gene with her twins, Zone-4.

Table 2. Presence of *Fec B* gene in sheep at different locations studied.

Zones[1]	Number of observations	Fec BB/Fec BB	Fec BB/Fec B+	FecB+/FecB+	% homozygous
1	16	15	1	–	93.8
2	21	17	4	–	81
3	36	25	9	2	69.4
4	20	20	–	–	100
5	8	8	–	–	100
6	13	13	–	–	100

[1]Refer to Figures 1 for different zones.

Figure 3. Sheep carrying *FecB* gene, with her triplets, Moynaguri, district: Jalpaiguri, West Bengal, Zone-3.

Figure 4. Garole ewe with FecB mutation and her quadruplets, a case of super foetation, Zone-3.

Figure 5. Owner of sheep reared at Jalpaiguri, North Bengal, Zone-3.

India are of Bonpala breed. The Bonpala sheep (Figure 6) is a large breed of sheep and is reared in the district of Darjeeeling and some parts of the neighbouring state of Sikkim (Vij *et al.*, 1997). The Bonpala is not a prolific breed and does not harbour the BMPR-IB mutation.

At the termination of the journey at Cooch Behar and furthermore at Rangpur the sheep and ponies were traded off as it was not worthwhile to take them back all the way to Tibet. These animals were purchased by the local traders who then transported the sheep by boats to the southern parts of Bengal (now Bangladesh and West Bengal).

Figure 6. Bonpala sheep from Sikkim.

Hunter (1875) in his report on the Sunderban region of erstwhile Bengal reported that sheep were not traditionally reared by the farmers of the region. William Milburn (1813) reported trading of sheep at Fulta port which is situated on the bank of the river Hoogly, opposite to Geokhali in Zone-1.

The traded sheep at Fulta were the ones that were transported from Rangpur to the Sunderbans and were allowed to regain their condition at the local villages.

The sheep traded from Fulta were slaughtered for consumption by the sailors en route to different ports. It is possible that some of these sheep might have escaped or may have been dropped off or exchanged by the sailors in Java, the hypothesis is in accordance with the report by Bradford and Inounu (1996) regarding the progenitors of the Javanese thin-tailed sheep. They were also in opinion that of the Javanese thin-tailed sheep probably originated from the sheep brought from Bengal and Bangladesh. The presence of *FecB* gene in Garole sheep strongly supports the earlier claim by Austin (1943) and Guthrie (1957) regarding the transportation of Bengal sheep to Australia in the eighteenth century.

The present findings conclude and support the historical findings that the breeding tract of Garole sheep extends up to the Northern districts of West Bengal and is not limited to Sunderbans alone. Binny (2005) was in the opinion that the sheep transported to New South Wales, Australia during the nineteenth century by the ship Shar Hormuzear (from Bengal) were in fact the long haired Tibetan sheep. It can therefore be concluded that the *FecB* gene of the Garole sheep may have its origin from the ovine breeds of Tibet which were traded in the Northern parts of Bengal during the colonial era.

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Genetic and cultural significance of indigenous pigs in Papua New Guinea and their phenotypic characteristics

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Summary
Pigs are the most important livestock species in Papua New Guinea (PNG) from economic as well as cultural perspectives. Most of the estimated population of 1.8 million pigs are maintained by smallholder farmers. The genetic attributes, differentiation and production capacities of indigenous pigs are largely unknown. But the rich socio-cultural diversity of rural communities living in geographically isolated pristine environments, with long and strong attachments with indigenous pigs implies that indigenous pigs may harbour unique genetic diversity. This study reports preliminary survey of indigenous pigs sampled from major pig farming areas of the country as part of a South Asia-wide regional indigenous pig genetic diversity study. It assesses farmers' perceptions about the origin, population trend and utility value of indigenous pigs, as well as their trait preferences. Average herd sizes and external physical forms and appearances of pigs are described. About 19 percent of the sampled indigenous pigs were identified through pedigree checks to have an admixtured genotype with some distant indigenous or exotic parentage. The importance of indigenous pig genetic resources in PNG requires a policy and legislative framework to support sustainable utilization. As a first step in informing such development, a comprehensive molecular genetic study is required to elucidate the genetic attributes of this unique genetic resource.

Keywords: *Papua New Guinea, indigenous pigs, genetic diversity, phenotypic characterization*

Résumé
En Papouasie-Nouvelle-Guinée, les porcs représentent l'espèce d'animaux d'élevage la plus importante tant du point de vue économique que culturel. La plupart de la population estimée de 1,8 million de porcs est élevée par des petits exploitants. Les caractères génétiques et les capacités de différenciation et de production des porcs indigènes sont largement inconnus. Mais la riche diversité socio-culturelle des communautés rurales qui vivent dans des environnements vierges isolés et ont des liens forts et de longue durée avec les porcs indigènes laisse supposer que ces derniers pourraient conserver une diversité génétique unique. Cette étude présente le rapport d'une enquête préliminaire sur les porcs indigènes des principales zones d'élevage du pays, dans le cadre d'une vaste étude régionale sur la diversité génétique des porcs, mise en place en Asie du Sud. Dans cette étude, on évalue les perceptions des agriculteurs sur l'origine, l'évolution de la population et la valeur d'utilité des porcs indigènes, ainsi que leurs préférences de caractères. On y décrit les tailles moyennes des troupeaux et les formes et aspects physiques extérieurs des porcs. Par le biais des contrôles généalogiques, on a déterminé qu'environ 19 pour cent des porcs indigènes pris en considération présentent un génotype provenant d'un mélange avec une ascendance lointaine indigène ou exotique. L'importance des ressources génétiques des porcs indigènes de la Papouasie-Nouvelle-Guinée demande un cadre politique et législatif soutenant leur utilization durable. La première étape pour accompagner ce développement consiste à entreprendre une étude génétique moléculaire détaillée pouvant préciser les caractères génétiques de cette ressources génétique unique.

Mots-clés: *Papouasie-Nouvelle-Guinée, porcs indigènes, diversité génétique, caractérization phénotypique*

Resumen
El cerdo representa la especie de ganado más importante en Papúa Nueva Guinea (PNG) tanto desde un punto de vista económico como cultural. La mayor parte de la población estimada, de 1,8 millones de cerdos, es mantenida por granjeros minifundistas. Las características genéticas y las capacidades de diferenciación y producción de los cerdos indígenas se desconocen ampliamente. Pero la riqueza de la diversidad socio-cultural de las comunidades rurales que viven aisladas geográficamente en ambientes en perfecto estado, con antiguas y fuertes relaciones con cerdos indígenas, implica que los cerdos indígenas posean una diversidad genética única. Este trabajo está basado en el estudio preliminar de cerdos indígenas muestreados en las más importantes áreas de cría de cerdos del país, como parte de un estudio de la diversidad genética de una amplia región del sur de Asia. Se valora la percepción de los ganaderos acerca del origen, tendencia de la población, valor de utilidad de los cerdos indígenas, así como sus rasgos preferidos. Se describe

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el tamaño medio de las piaras, sus formas físicas externas y la apariencia de los cerdos. Alrededor del 19 percent de los cerdos indígenas muestreados fueron identificados por medio del pedigrí como poseedores de una mezcla genética con algún origen lejano indígena o exótico. La importancia de los recursos genéticos porcinos en PNG requiere de un marco de trabajo político y legislativo para apoyar su utilización sostenible. Como primer paso para informar de tal desarrollo, se ha requerido un exhaustivo estudio genético molecular para aclarar las características genéticas de este recurso genético único.

Palabras clave: *Papúa Nueva Guinea, cerdos indígenas, diversidad genética, caracterización fenotípica*

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Introduction

Country background

Papua New Guinea (PNG) is located in the South Pacific region from longitude 141°E to 156°E and latitude 1°S to 11°S, sharing a land border only with Indonesia to the East (Figure 1). It has a total land area of about 470 000 km^2 constituting the mainland and more than 700 Islands including atolls. It is mostly mountainous with coastal lowlands and rolling foothills. The Owen Stanley Ranges, which has a peak elevation of 4 793 m at Mt. Wilhelm runs through the middle of the mainland of PNG from west to east. Up to 60 percent of the land mass is covered by pristine natural forest providing natural habitat to a wide range of flora and fauna (Kambuou, 1996; MoA&L, 2004). It also has numerous rivers and over 5 000 lakes with an extensive system of marshes located on the north and south parts of the country.

About 87 percent of the total population depend on subsistence agriculture for their livelihood. The main livestock species are pigs, poultry, cattle, goats, sheep and rabbits. Although PNG harbours large numbers of introduced exotic pigs of European origin, indigenous pigs are by far the most important to the farmers considering their social and cultural roles. They are raised by several hundred ethnic groups (Reilly, 2008) residing in various agro-ecological zones. Historically and culturally, pigs have been associated with PNG people much earlier than any other livestock species. However, the genetic structure and diversity of this invaluable resource remains unknown.

Introduction of pigs to PNG

Archaeological and linguistic evidences have suggested the first introduction of pigs to PNG between 10 000 and 2 500 years ago (Hide, 2003). However, the origin, taxonomy and diversity of the indigenous pigs of PNG are not well understood. Recent DNA evidence suggests that the indigenous pigs of PNG belong to the species *Sus scrofa* and were introduced by humans to the main island of PNG (Allen *et al.*, 2001; Larson *et al.*, 2005; Lum *et al.*, 2006; Larson *et al.*, 2007). Larson *et al.* (2007) suggest that Austronesian-speaking people (Kirch, 1997), whose putative homeland was present-day Taiwan introduced pigs into the region some 3 500 years ago, although pigs involved were not of Taiwanese origin. They argued further that the so-called wild pigs of PNG are probably feral pigs derived from the initial introductions from Southeast Asia. This argument is supported by observations in some parts of the country where hunters capture young piglets alive and take them home to be raised (Figure 2c).

Socio-cultural importance of pigs

In the largely traditional and subsistence rural communities of PNG, in particular in the fertile and densely populated highlands, pigs have strong socio-cultural significance. Pigs are culturally the most important animals used extensively in many forms of exchange, alms-giving, feasting, compensation and as symbols of social status and rank. Pigs are used for bride prize payments, as gifts to establish or maintain social relations and as payments to resolve social disputes or strengthen relationships between individuals, families, clans and tribes. Pigs are also slaughtered during initiation rites, funerals for the dead and during elaborate ceremonies or gatherings where feasting is involved. Lemonnier (2002) surmises that the use of pigs in these ways symbolizes the transformation of strength and maleness embodied in the pig into a substitute or token of life suitable for compensation and exchange. In many parts of PNG, the number of pigs owned and their body size and conditioning is used to judge the social rank of a person. Furthermore, the pig husbandry system followed reflects gender relationships whereby women in some communities look after the pig but do not own them, although pigs cannot be disposed off without their consent (Dwyer, 2006).

Traditional methods of pig breeding and feeding in PNG often portray cultural differences among various ethnic communities. In the central highlands and some lowland areas, boars are often castrated and sows mated with wild boars; young piglets are captured from the wild and either eaten or cared for by women who sometimes carry them in string bags or walk them on tether to food gardens till they reach maturity. In some coastal and eastern highland areas, however, wild pigs are less common. Availability of feed resources varies among various communities. For instance, surplus sweet potato tubers and vines are commonly used for feeding pigs in the Eastern

Figure 1. Political map of Papua New Guinea and location of three sample sites (*source:* http://www.infoplease.com/atlas/country/papuanewguinea.html#axzz0zSNfxZKM 25 March 2010)

Highlands province. Pigs are allowed to root in fallow food gardens and this is seen as a way of cultivating the land in some places. In coastal and island regions, however, coconuts, taro and sago are often used to feed pigs. All these differences in feeds and feeding system suggest that the indigenous pigs are adapted to dealing with various types of feeds.

Pig population

The pig population of PNG is not known with certainty. The frequently quoted figure is 1.8 million, estimated in 2003 (FAOSTAT, 2010). Quartermain (2002) estimated that at least one million of this population could be genetically isolated indigenous populations maintained by rural communities, with the rest being increasingly influenced by introduced and cross-bred pigs that are mainly raised by market-oriented pig farmers. Gibson and Rozelle (cited by Hide, 2003) estimated the village (indigenous) pig numbers at 1.7 million in 1998 based on a sample of 830 rural households from different parts of PNG. The number of indigenous pigs per household in the four regions of Papua, Highlands, Momase and New Guinea Islands was 1.9, 3.3, 1.7 and 1.3, respectively.

The current pig population of PNG consists of indigenous, exotic and cross-bred pigs. Only one indigenous type is reported in FAO's Domestic Animal Diversity Information System (FAO, 2010). This is because indigenous pigs are regarded as non-descriptive type without any geographical pattern of morphological variation (Figures 1 and 2).

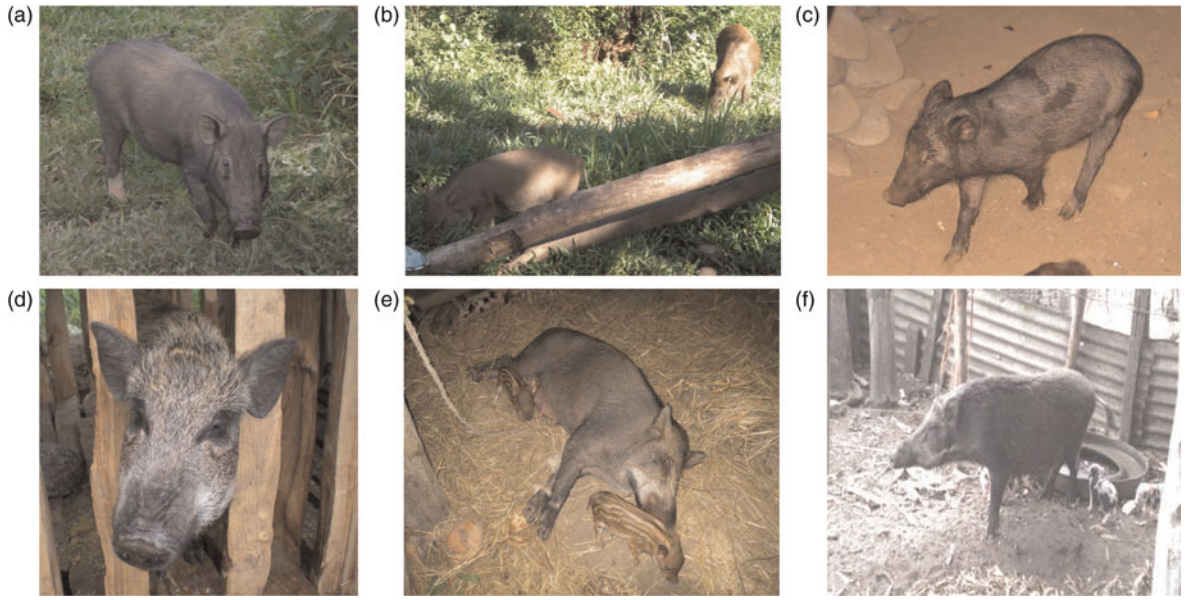

Figure 2. Indigenous pigs of Papua New Guinea. (a, b) Typical indigenous pigs seen in Nawaeb district; (c) captured wild pig being raised in confinement; (d) indigenous sow in a sty at Kabwum village in Finschhafen district; (e) a nursing indigenous sow in Finschhafen village, Finschhafen district. Piglets have ochre, chocolate and cream coloured stripes lengthwise over their bodies suggesting gene flow from wild pigs; (f) nursing indigenous sow in Tambul village, Tambul district.

However, it does not imply lack of variation among indigenous pigs. For instance, Near East sheep that are all of "generic type" phenotypically and not easy to tell apart, display much more genetic variation than readily distinguishable European breeds (Peter *et al.*, 2007). In addition to this, the preliminary analyses of microsatellite data also suggest the presence of at least four distinct populations of indigenous pigs in PNG (Nidup *et al.*, 2010). Therefore, indigenous pigs of PNG may be shown to have a high level of genetic variation in productive ability regardless of the fact that there is no obvious partitioning into breeds.

Exotic pigs (Figure 3a) are mostly European breeds, such as Large White, Landrace, Berkshire, Tamworth, Saddleback and Large Black. These breeds are mostly used for intensive commercial production and cross-breeding with the indigenous pigs (Figure 3b, c).

Cross-breeding between exotic and indigenous pigs was a policy of the Australian colonial government soon after Second World War in an effort to restock and improve pig populations which were devastated by the war in many parts of PNG (Malynicz *et al.*, 1973a, b; Hide 2003). Unabated loose disseminations of these European breeds and their cross-breds now constitute a threat to the continued survival of indigenous pigs.

Importance of genetic diversity

Present and potential future animal production is underpinned by the genetic diversity in the existing breeding populations. Even though it is not clear whether or not the indigenous pigs of PNG belong to the same breed, it is conceivable that, through natural and artificial selection, the different populations found in various parts of the country, including those in geographically isolated valleys, plateaus and islands, may have accumulated various specific genetic adaptations to different environmental challenges leading to population differentiation. Indigenous pigs are vital for supporting household economies, livelihoods and cultures of a significant proportion of the human population. However, they have received very little attention from the policy-makers because they

Figure 3. (a) Introduced exotic pigs of Large Black and Duroc origins; (b) Cross-bred sow with her highly heterogeneous looking piglets; (c) progenies of wild pig and improved or exotic sows. Large ear and belted-white phenotype suggest exotic pig origin while stripes indicate wild pig origin.

are regarded as "low producers" without considering important traits such as adaptability to poor feed quality, resistance to several diseases and adaptation to wide range of environments. It should be noted that indigenous pig genetic resources will continue to be useful for food security and rural development of current and future generations. To meet the needs of the present as well as future generations, it is necessary to document and characterize the indigenous pigs for conservation, promotion and sustainable utilization.

Objective of the study

This study was conducted in the larger framework of an analysis of genetic diversity in South Asian pigs (Nidup *et al.*, unpublished data). It has the specific objectives of providing a preliminary phenotypic description of indigenous pigs and prevailing husbandry practices in major pig-growing regions of PNG as a prelude to the genetic analyses.

Materials and methods

Three divergent sampling sites (Table 1; Figure 1) from major pig-raising areas of the country were selected for the study. The first site (Tambul) covered a wide area in the highlands region of the country from Kandep district in Enga province to Tambul district in the Western Highlands. The second site (Garaina) consisted of agriculturally fertile valleys in Bulolo and Huon Gulf districts in the west of Morobe province. The isolated villages in Finschhafen and Nawaeb districts on the east side of Morobe province were the third sampling areas (Finschhafen). Purposeful sampling was employed to identify major pig raising villages far from urban centres, which are considered less likely to have been influenced or contaminated by the expanding distribution of cross-bred pigs. Hair and blood samples of 91 pigs (Table 1) from three sampling sites were collected for microsatellite and mitochondrial DNA studies. At least 82 households from six districts of three provinces were interviewed on a semi-structured questionnaire (Table 1). Each of the respondents was asked to identify their indigenous pigs by breed type. The questionnaires covered origins and sources of pigs, reasons for keeping them, current herd sizes, husbandry practices as well as their perceptions of pig population trends. Linear body measurements, which were taken with standard measuring tape coated with plastic film graduated to the next half-centimetre, were recorded from adult pigs. The external body forms and appearances of pigs were also documented. Although every possible attempt was made to ensure that only households with indigenous pigs were included in the study, some of the households later revealed that one or more of their pigs were of mixed (cross-bred × indigenous) or of unknown genetic background. Data were collected between November 2009 and March 2010. Simple descriptive statistics were used to analyse these data.

Results and discussion

Local names and purpose of raising pigs

Three quarters of the respondents ($n = 82$, Table 1) mentioned local names of pigs, which appear to be local linguistic terms given to pigs in general (e.g. Buc, Ambi, Pi, Kong, and Kareh) and have some similarities between sampling sites. The names relate more to linguistic differences between sites rather than genetic distinctiveness of the pigs. Although indigenous and cross-bred pigs were clearly distinguishable, the term "breed" was neither clearly understood nor used. The pedigree observation on 91 "indigenous pigs" revealed that 19 percent have a known parent that is considered a cross-bred with either known exotic cross or an indigenous type from a distant source within the country. At site level, this figure is 14 percent for both Tambul and Finschhafen but as high as 30 percent for Garaina. This merely indicates the extent of spread of various levels of exotic cross-bred pigs but not necessarily commercialization tendencies.

The main reasons of keeping pigs (Figure 4) are meat production (25 percent) followed by breeding (23 percent), wealth creation (22 percent) and savings (22 percent), with slight differences between those for males and

Table 1. Number of households interviewed and samples collected from six districts of PNG.

Sampling site	District	Province	Number of samples (blood and hair)	Total number of samples from each site	Total number of households interviewed from each site[a]	Households with herd size data
Tambul	Kandep	Enga	4	21	19	4
	Tambul	Western highlands	17			13
Garaina	Bulolo	Morobe (west)	17	27	22	14
	Huon Gulf	Morobe (west)	10			5
Finschhafen	Finschhafen	Morobe (east)	10	43	41	10
	Nawaeb	Morobe (east)	33			28
Total			91	91	82	74

[a]Some households without herd size data were also interviewed.

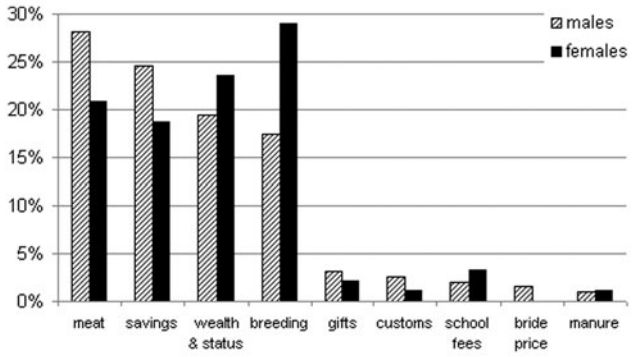

Figure 4. Frequency of reported reasons for raising indigenous pigs ($n = 91$).

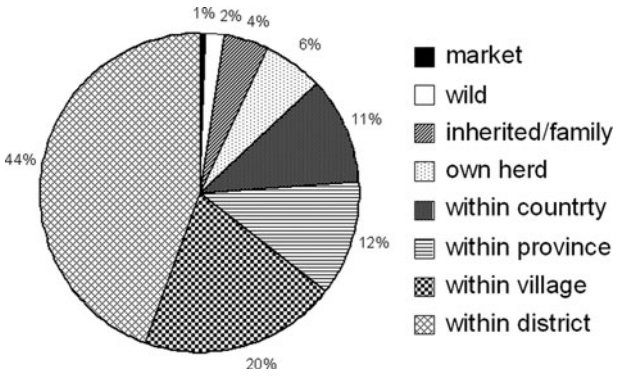

Figure 5. Frequency of reported sources of sample indigenous pigs at study sites ($n = 91$).

females and between sites. Male pigs are preferred for meat, savings and bride prices, as are females for breeding and status symbol. The other reasons include needs to honour social obligations (gifts, deity), pay school fees and secure manure for farmyards.

Sources of pigs

Over three quarters of the pigs originated from within the study district, 12 percent from outside the district in the same province and another 11 percent from a neighbouring province within the country, indicating a large-scale gene flow from one part of the country to another (Figure 5). Farmers also mentioned multiple sources of boars used in their herds. Only 12 percent reported using boars from their own herd, 39 percent used boars in their village, while 20 percent depended on communal boars. Half of the respondents did not have any control of mating as they rely on communal mating, or any available boar for mating. A few wild pigs (2 percent) also contributed as breeding boars.

Herd size and composition

The herd size differed between sampling areas ranging from 3.24 head in Tambul to 9.21 in Garaina (Table 2) with an average of 6.23 heads per household. Individual herd sizes ranged from 1 to 138. Breeding sows and boars constitute 14 and 8 percent, respectively, with the number of boars varying from zero to five.

Eighty percent were identified by their owners as having known indigenous dam and boar parentage, whereas 20 percent had a mixed parentage of known and unknown genotype. One of the farmers maintained a breeding boar of feral origin. Two other boars with known feral parentage were also observed giving a total frequency of 4 percent for pigs regarded by owners as half-feral or wild.

Population trend

Farmers had mixed views on the population trend of the indigenous pigs. From the 64 responses, just over a third indicated that the population of indigenous pigs in their area is increasing while the rest indicated decreasing (31 percent), stable (30 percent) or unknown (5 percent) trends. Some of the reasons stated for a decreasing trend of indigenous pigs are decreased interest of farmers who have switched to other alternative livelihoods (41 percent), unavailability of breeding stock (29 percent), competition from exotic and cross-bred pigs (8 percent) and competition from pigs of neighbouring areas (8 percent).

Important traits

When pig owners were asked to indicate the importance of a selected set of common desirable production and adaptation traits as unimportant, marginally important, moderately important and important, at least half of the respondents identified the following traits as important in descending order of ranking; scavenging ability, meat taste, general appearance, compact body, feeding habits, coat hair cover and tolerance to heat or heat load, most of which relate to adaptation attributes (Figure 6). Traits that were least frequently identified as important were mothering ability, reproductive performance, general appearance and longevity/durability.

External features

Overall breeding males measured 78.2 cm on heart girth and 56.6 cm on body length; the respective averages for sows were 78.3 and 54.4 cm (Table 3). But some of these values are those of growing boars and sows and hence cannot be taken as typical values of the adult populations. Females have from 7 to 16 teats when compared with males with 8 to 12 teats (Table 3).

Only preliminary descriptions of phenotype of the whole sample herd of 54 growing sows and 29 young boars sampled for genetic diversity study (Nidup *et al.*, 2010) are presented here:

The snout is often short (37 percent), cylindrical (34 percent) or elongated, thin and long (26 percent), but rarely (2 percent) concave. The head profile is mostly (79 percent) straight and convex profiles appear only in 6 percent

Table 2. Herd size and percentage of different categories of pigs in three sampling sites.

Sampling sites	Number of pigs sampled at each site	Piglets (%)		Growers (%)		Adults (%)		Average herd size
		Female	Male	Female	Male	Female	Male	
(1) Finschhafen	38	22	25	18	12	12	10	6.03
(2) Garaina	19	18	18	13	38	11	2	9.21
(3) Tambul	17	14	15	24	2	25	20	3.24
Total	74	18	20	17	23	14	8	6.23

of the cases. Slightly concave foreheads are also observed in low (15 percent) frequencies. Ear sizes can be small (27 percent), medium (57 percent) or large (16 percent), with mostly (88 percent) prick orientation. Few droopy (2 percent) and semi-lopping (10 percent) forms are also observed on both indigenous and admixture genotypes. Ear orientations are dominated by those that point upwards (65 percent) and backwards (24 percent), but some (11 percent) have forward pointing ears. Bristles are mostly (69 percent) found on the dorsal backline, and also form parallel lines on the backline (15 percent) or found scattered throughout the body (16 percent). The hair coat is normally straight (53 percent) and dense (18 percent); about 16 percent of pigs of both sexes have sparse hair throughout the body. Both smooth and wrinkled forms of skin are evenly observed on both sexes.

Tails on the indigenous pigs are normally straight (93 percent) but can also be curly or twisted (7 percent). None of the pigs identified as admixtures were observed with curly or twisted tails. Most pigs had normal udder, while 5 percent of pigs had asymmetrical udder. Most (83 percent) of the pigs were identified by their owners as having a placid and friendly temperament, with the rest 17 percent showing various levels of aggressiveness both in indigenous and admixture pigs.

Pig housing

No patterns were apparent in the type of housing provided, with semi-intensive sties and pens observed only in 41 percent of the sample households (Figure 2c–f). One in ten farmers keep their pigs tethered all the time around the homestead and gardens, and another 21 percent combine tethering and day-time scavenging. About one in ten pig farmers do not provide any shelter at all, and another 17 percent provide only night sheds, indicating that the rearing practices are predominantly of very low input. Generally, farmers reside in village settlements with at least several households residing close together, with the food gardens not far away. It is therefore expected that pigs are often tethered or kept in pen enclosures around the homestead.

Feeding and watering

Only 10 percent of the pig farmers mentioned the use of commercial feeds, which were fed to their pigs at least

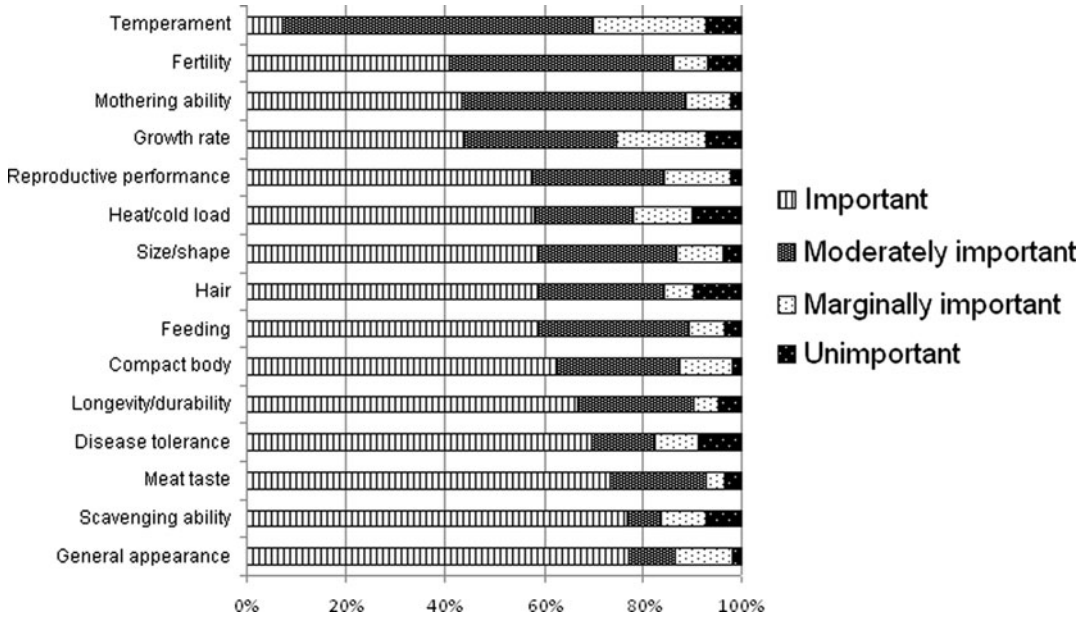

Figure 6. Rankings of importance of selected traits of indigenous pigs by their owners ($n = 82$) in three sampling sites.

Table 3. Body measurements (cm) of breeding males and females.

Statistical measures	Boar			Sow		
	Heart girth	Body length	Number of teats	Heart girth	Body length	Number of teats
Number of pigs measured (*n*)	22	22	29	46	46	54
Mean	78.2	56.6	10.1	78.3	54.4	10.7
Median	80	51	10	74.5	52	10
Minimum	48	39	8	45	30	7
Maximum	104	90	12	125	105	16
Standard deviation	17	15.9	1.06	20.3	16	1.54
Standard error of mean	3.62	3.31	0.2	3	2.34	0.21
CV (%)	21.7	28	10.4	26	29.4	14.4

once a week. The majority of farmers use a variety of local feeds (52 percent), let the animals freely scavenge (9 percent) or a combination (29 percent) of these two. Supplementary feeds are provided twice a day in some cases. Water supply to pigs was never mentioned as a constraint to pig production, but when water is made available, it is mostly (71 percent) supplied once everyday.

Relevant policy and legislation

PNG needs a national strategy for the identification, sustainable use and conservation of its pig genetic resources. Such a strategy is needed to provide direction and guidance to maintain and develop the vital livelihood support and socio-cultural services of PNG indigenous pigs in much of the country. It can provide a common platform for interaction and collaboration between various stakeholders such as livestock owners and farmers, policy-makers, scientists, private sector, civil society organizations and donors. In planning the effective use of this genetic resource, it is necessary to take account of limited human and financial resources available within the country. It is therefore important to engage all stakeholders in drawing up a national strategy to ensure comprehensive understanding of the potential of these pig genetic resources towards their optimal utilization for the benefit of present generations without unduly compromising options for future generations.

A critical constraint towards the development of a national strategy is the incomplete (or lack of) baseline information on the identity, diversity, distribution, utilization and current status of the indigenous pig genetic resources of the country. It is a general concern that in the face of uncontrolled continued spread of exotic and cross-bred pig genotypes through commercialization in hitherto unaffected natural habitats of PNG indigenous pig populations, no indigenous pig genetic evaluation or improvement activities are underway or firmly planned. This is compounded by the inadequate technical and logistic capacity in the design and operationalization of appropriate programmes for the management of pig genetic resources.

PNG has legislation governing quarantine and sanitary aspects of management of animal genetic resources, implemented by the National Agricultural Quarantine and Inspection Authority. This legislation prevents indiscriminate import of animal genetic materials and imposes strict quarantine protocols in the movement of both indigenous and exotic genetic resources into and out of the country. A standard (generic) germplasm transfer form is also available to regulate the import and export of live animals or biological samples from them. However, no action is being taken to at least sensitize the general public on the negative long-term effects of uncontrolled distribution of unknown grades of cross-bred pigs emanating from commercial piggeries for mating in the villages. The unintended and undesirable consequences of indiscriminate mating of these crosses with indigenous pig populations need to be discussed at various research and development forums in the country and acted upon.

Existing sanitary and quarantine legislation concerning food production standards does not affect the actual use, development and conservation of animal genetic resources. There is not a single operational conservation farm or herd of indigenous pigs in the country, although the National Agricultural Research Institute (NARI) plans to establish such herds at Labu in the lowlands and/or Tambul in the highlands.

Needs for research and development

A primary consideration for research and development of PNG indigenous pigs is a need to have a national inventory of the indigenous pig genetic resources and their production environment through a baseline survey. This study should also cover estimation of pig population size, their structure and dynamics. Along with comprehensive phenotypic characterization, the genetic differentiation of PNG indigenous pig populations needs to be explored through molecular genetic studies. The apparently age-long practice of castrating boars in village herds to allow sows to mate with wild pigs may have genetic significance. Sampling of wild (feral) pigs in PNG may be needed to provide molecular genetic data that could be integrated

with available morphological and biogeographical information to help elucidate the origin, taxonomic affinities and level of differentiation among the different populations of indigenous pigs of PNG. This could help to identify evolutionarily significant units (Moritz, 1994) and the planning of management plans for indigenous pigs in PNG.

As established through nation-wide stakeholder consultation by NARI, the public livestock research system should focus on addressing: (1) inadequate feeds and nutrition for both subsistent and commercial production operations; (2) high mortality of piglets and (3) low reproductive rates (NARI 2006a, b). Action is also needed to address the limited preparedness to manage likely major outbreaks of contagious diseases such as swine flu and swine cholera. The public veterinary services do not have the capacity to handle this. Although a limited number of large commercial piggeries continue to struggle with rising cost of feed made from imported ingredients, the formal pork market supplies imported cuts at competitive prices. On the other hand, emerging smallholder market-oriented pig growers, required to comply with safety standards to enter the market chain, are constrained by limited capacity as well as high cost of public inspection protocols. These policy related issues need to be closely investigated with the view of encouraging participation of smallholder farmers in the fast growing domestic pig meat market and providing immediate incentives for sustainable use of indigenous pigs in the country.

Conclusion and recommendations

The largely indigenous but loosely interbreeding population of pigs of PNG has considerable economic, genetic and cultural significance to the people of PNG. This population has remained under continuous genetic introgression from introduced local and cross-bred pigs from commercial piggeries as well as from public extension services that unsuccessfully promoted cross-breeding with exotic pigs to increase subsistent pig production at village level. To date even in isolated rural villages up to a third of pigs maintained by subsistent pig farmers are considered to be admixtures of indigenous and introduced genotypes. A third of surveyed pig farmers believe that the population of indigenous pigs is decreasing, while another third thinks it is on the increase.

Local names of PNG indigenous pigs do not suggest breed identities, and animals show variable body form and appearance across major pig growing areas of the country. Village pig herds range in size from 1 to 138, with an overall average of 6.23. Breeding boar numbers vary from zero to five, but only 12 percent reported to be using their own boar, whereas the rest mentioned use of boars in their village (39 percent), rely on known communal boars (20 percent), or opt to leave the sows to freely mate. Very little, if any, external inputs are used in raising pigs, and much of feed comes from scavenging, garden fodder and kitchen waste.

The genetic differentiation of this population is yet to be explored. It is therefore recommended that a nation-wide baseline survey of indigenous pig populations be conducted to identify and document genetically distinct indigenous pig populations in the country to provide the basis for a national management plan. It is also recommended that comprehensive molecular genetic studies be undertaken to elucidate the genetic attributes and differentiation of this probably unique genetic resource.

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Farming and biodiversity of pigs in Bhutan

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Summary
Pigs have socio-economic and cultural importance to the livelihood of many Bhutanese rural communities. While there is evidence of increased religious disapproval of pig raising, the consumption of pork, which is mainly met from imports, is increasing every year. Pig development activities are mainly focused on introduction of exotic germplasm. There is an evidence of a slow but steady increase in the population of improved pigs in the country. On the other hand, indigenous pigs still comprise 68 percent of the total pig population but their numbers are rapidly declining. If this trend continues, indigenous pigs will become extinct within the next 10 years. Once lost, this important genetic resource is largely irreplaceable. Therefore, Government of Bhutan must make an effort to protect, promote and utilize indigenous pig resources in a sustainable manner. In addition to the current *ex situ* conservation programme based on cryopreservation of semen, which needs strengthening, *in situ* conservation and a nucleus farm is required to combat the enormous decline of the population of indigenous pigs and to ensure a sustainable source of swine genetic resources in the country.

Keywords: *Bhutan, biodiversity, conservation, exotic breeds, farming, indigenous pigs*

Résumé
Les porcs ont une importance socio-économique et culturelle pour les moyens d'existence de nombreuses communautés rurales du Bhoutan. Bien qu'il existe des preuves de la désapprobation croissante de la religion pour ce qui est de l'élevage des porcs, la consommation de leur viande, principalement satisfaite par l'importation, augmente chaque année. Les activités de mise en valeur des porcs sont surtout concentrées sur l'introduction de matériel génétique exotique. Certaines indications montrent un accroissement lent mais régulier de la population de porcs améliorés dans le pays. D'autre part, les porcs indigènes représentent encore 68 pour cent du total de la population porcine, mais ils sont en baisse rapide. Si cette tendance se poursuit, les porcs indigènes seront disparus d'ici dix ans. Une fois perdue, cette ressource génétique importante est en grande partie irremplaçable. Par conséquent, le Gouvernement du Bhoutan doit faire des efforts pour protéger, promouvoir et utiliser de façon durable les ressources des porcs indigènes. Pour lutter contre la baisse considérable de la population de porcs indigènes et pour assurer dans le pays une source durable de ressources génétiques porcines, il est nécessaire d'organiser, en plus du renforcement du programme en cours de conservation *ex situ* basé sur la cryoconservation du sperme, la conservation *in situ* et une exploitation de base.

Mots-clés: *biodiversité, Bhoutan, conservation, élevage, porcs indigènes, races exotiques*

Resumen
Los cerdos tienen importancia socio-económica y cultural para el sustento de muchas comunidades rurales de Bután. Si bien existen evidencias de que ha aumentado la desaprobación religiosa de la cría de cerdos, el consumo de su carne, que es principalmente conocido por las importaciones, crece cada año. El desarrollo de actividades relacionadas con el cerdo se centra principalmente en la introducción de germoplasma exótico. Se ha constatado un aumento lento pero constante de la población de cerdos mejorados en el país. Por otra parte, los cerdos autóctonos siguen constituyendo el 68 percent de la población porcina total, pero su número está disminuyendo rápidamente. Si esta tendencia continúa, los cerdos pertenecientes a poblaciones locales se extinguirán en los próximos diez años. Una vez perdido, este importante recurso genético es en gran parte insustituible. Por lo tanto, el Gobierno de Bután debe hacer un esfuerzo para proteger, promover y utilizar los recursos porcinos autóctonos de manera sostenible. Además del actual programa de conservación ex situ, basado en la crioconservación de semen que es preciso reforzar la conservación in situ y el establecimiento de un núcleo de producción, necesario para combatir la enorme disminución de la población de cerdos autóctonos y para asegurar una fuente sostenible de recursos genéticos en la especie porcina en el país.

Palabras clave: *biodiversidad, Bután, cerdos autóctonos, conservación, crianza, razas exóticas*

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Introduction

Bhutan is a small kingdom situated in the Eastern part of the Himalayan range between latitudes 26°45′ N and 28° 10′ N, and longitudes 88°45′ E and 92°10′ E. It is a land-locked country bordered by Tibet (autonomous region of China) in the north, the Indian states of Bengal and Assam in the south, Arunachal Pradesh in the east and Darjeeling and Sikkim in the west.

Bhutan has an area of 38 394 km^2 (14 824 sq mi) with a population of 634 982 (RGoB, 2009). It has 20 districts, which are broadly divided into four developmental regions namely (Figure 1a): eastern region, east-central region, western region and west-central region.

In addition to a rich flora and fauna that make Bhutan one of the ten global biodiversity hotspots, the country is also endowed with diverse domestic animal species including yaks, cattle, horses, sheep, goats, buffaloes, poultry and pigs. Domestic animals are found in almost all the six agro-ecological zones ranging from the subtropical to the alpine region (Figure 1b).

Bhutanese pigs have been an important contributor to human welfare in the past, and may possess characteristics that will be needed again to meet new or re-emerging needs. The loss of these genetic resources would be catastrophic to the livelihood of many poor rural communities. Therefore, it is urgent to draw up an inventory and understand the nation's pool of swine resources for promotion and sustainable utilization as envisaged in Bhutan 2020 vision (PCS, 1999).

Objectives

To document the socio-economic and cultural importance of pigs to the Bhutanese people, review current state of rural pig farming and its development initiatives, and assess the biodiversity and population trends of both improved and indigenous pigs. This paper will provide baseline information for future studies.

Importance of pigs in Bhutan

Bhutan has both indigenous and imported exotic breeds of pigs. The former are also called native or local to distinguish them from exotic breeds. The exotic breeds are frequently crossed with indigenous animals to generate composite breeds, commonly called "improved breeds" that are considered an upgraded form of the indigenous breed with a good blend of "superior quality" exotic germplasm. To be consistent with the terminology used within the country, both exotic and composite breeds are hereafter referred to as "improved breeds".

Pigs are found throughout Bhutan, despite the strong Buddhist sentiment against rearing and slaughtering of pigs. The Southern Bhutanese, who are mainly Hindus, consist of multiple ethnicities with a caste system and pigs are reared by certain ethnic groups only (Rai, Limbu, Magar, Tamang, Sherpa, Tharu and Biswakarma). Unlike the Buddhist, there is little religious disapproval of raising and slaughtering of pigs among Hindus. Irrespective of ethnicities, pig raising has been economically beneficial, particularly to the rural poor and socially disadvantaged people (Timsina and Sherpa, 2005).

Bhutanese rear pigs for many purposes, including social, cultural and economic reasons. Traditionally, pig ownership and slaughtering conveyed status, wealth and informal power. In the early Bhutanese cashless society, pigs were a very important medium by which social significance was measured. Meals served with pork promoted group cohesion and identity, and facilitated civic and private celebrations. Even today, pork is one of the vital components of Bhutanese cuisines, be it during marriages, festivals or New Year celebrations. Penjor (2008) provides an account of the important roles of pigs during marriages in the lower Kheng of the Zhemgang district. In remote villages, people still carry pigs from one place to another either as a gift or in exchange for other commodities.

Pigs also serve as sacrificial animals, as votive offerings to local deities (*Yul-Lha* or *Naep*). Bonism and Shamanism (native religion of Tibet) rituals, which still prevail in many parts of Bhutan, require the sacrifice of pigs to the local deities for bountiful crops, to reduce the risk of natural calamities, to improve the health of an ailing person, and for peace, happiness and prosperity of the community. Such practices in the Bongo village of the Chukha district and in the Trashi Tokha village of Wangdue district have been documented by Wangchuk (2005) and Dorji (2004), respectively. Animal sacrifice provides a good source of protein for those involved in the rituals, which in some cases involve distribution of meat immediately after the sacrifice.

Consumption of pork is well imbedded in Bhutanese gastronomic tradition and continues to rise (DoL, 2007), despite increasing prices per kg of pork. The current cost of a kg of pork sold with bones intact is about Nu. 100 (~US$2.00). The consumption of pork is increasing every year (Figure 2) while domestic production remains static.

Over the last five years, pork importation has increased significantly, more than threefold, in contrast to a negligible rise in domestic production. This averages Nu. 73.48 million (US$1.63 m) per year (DoL, 2007) contributing significantly to the trade deficit of the national economy.

Origin of indigenous pigs

It is not recorded when domestic pigs were introduced to Bhutan or who introduced them nor is there archaeological evidence. Linguistic evidence shows that there are not many words for pig in Bhutan despite several dialects.

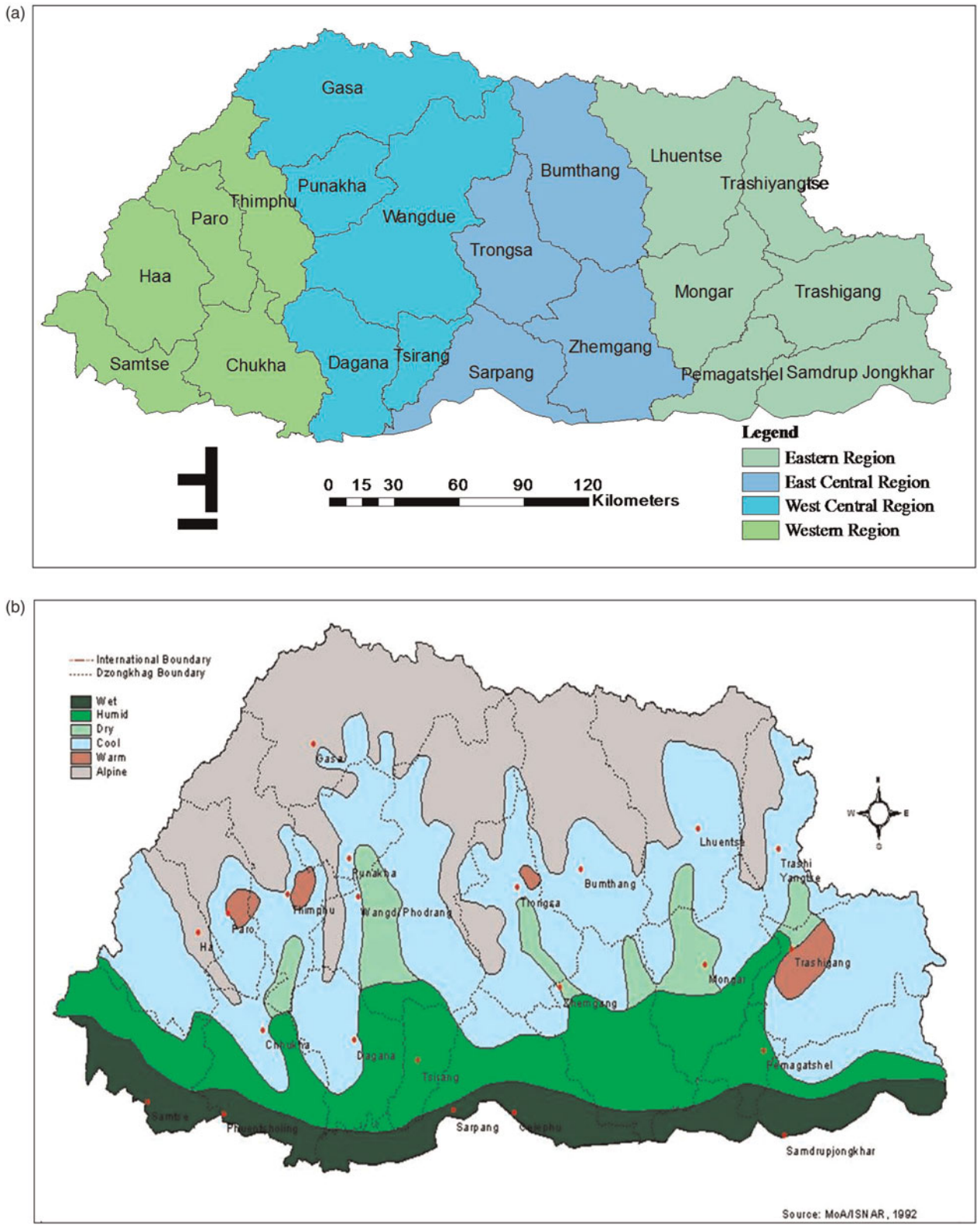

Figure 1. (a) Twenty districts of Bhutan according to regions (Courtesy: Dorji, 2010a); (b) agro-ecological zones in Bhutan (MoA/ISNAR, 1992).

This suggests that pigs could have been introduced from one particular region and spread slowly towards other parts of the country relatively recently. Timsina and Sherpa (2005) suggest that indigenous domestic and wild boar (*Sus scrofa*) could be considered to share a common genetic pool due to mating between village sows and wild boars. Feral pigs that are domestic pigs, which have escaped captivity, have not been reported in Bhutan.

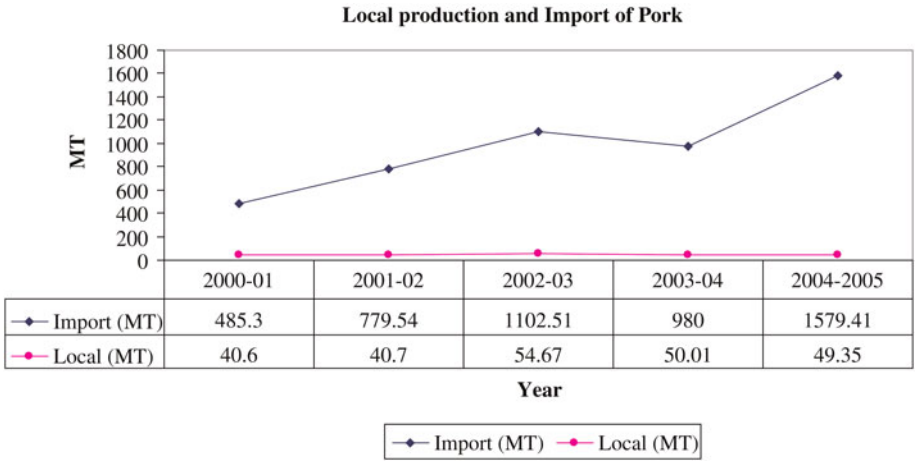

Figure 2. Trend in pork consumption.
Source: Unpublished data from Department of Livestock (DoL, 2007).

A recent study of mitochondrial DNA sequences from 30 domestic and 3 wild pigs suggest three origins for Bhutanese pigs. (i) East Asia probably Tibet or China, (ii) Southeast Asia and (iii) East Indian wild boars (Tanaka *et al.*, 2008). The East Asian type was found to be distributed widely in Bhutan, whereas the Southeast Asian types were found only in the Mongar district. The native pigs in the southwest part of Bhutan were found to have experienced gene flow from East Indian wild boars. Because the sample size used in the study (Tanaka *et al.*, 2008) was small, further investigation is required to provide more comprehensive information on the origin of the indigenous pigs of Bhutan.

Rural pig farming in Bhutan

Pig farming in Bhutan is typically divided into two systems: the backyard pig farming seen in the villages and modern intensive farming seen in state operated farms. The village farming is normally characterized by small numbers of pigs reared by the subsistence farmers, either in a small confined pigsty constructed usually with locally available materials (stones, mud, wood, bamboo thatch) or pigs are tethered near the house or in a paddock. While farmers are required to enclose their pigs to comply with national health regulation, some still allow free-range scavenging for various reasons ranging from scarcity of feeds to the ease of management. More than 13percent of Bhutanese farmers rear pigs as free-range scavenging pigs (Timsina and Sherpa, 2005). Feeds consist of mainly brewery wastes, kitchen wastes (leftover foods, vegetable peels), bran (maize, millet and rice), wild weeds, nettle leaves, pumpkins, yams and taro. Oil cakes, flour and maize grain supplements are used to fatten pigs.

The indigenous pigs are hardy, resistant to many diseases and can adapt to harsh rural environment under low inputs (Timsina and Sherpa, 2005). Under scavenging, they have better mothering ability and increased survival of litters per farrowing than exotics (Timsina and Sherpa, 2005).

Exotic pigs and development programmes

Realizing the importance of pig farming in the livelihood of rural poor, the Royal Government of Bhutan (RGoB) initiated development programmes to improve pig production. Several exotic breeds of European origin have been introduced to the country since the early 1960s. The main objective was to generate lines of improved piglets or F1 (exotics vs local). The purebred progeny or F1 were hoped to have better production than pureline indigenous stock. The overall goal of the programme was to improve nutritional status of the rural population, increase income and alleviate poverty through increased meat and protein production.

The first exotic breed, Wessex Saddleback, was introduced to Bhutan during the First Five-year Plan (1961–1965) and reared in Samtse and Wangchutaba livestock breeding farm. Subsequently, Large White (Yorkshire) was introduced towards the end of the First Five-year Plan. This was followed by introduction of Landrace, which was imported from India. The focus on the white breeds aimed to exploit their relatively large litter size, higher growth rate and earlier sexual maturity than the indigenous pigs or most coloured exotic breeds.

The RGoB formulated another phase of the piggery development programme in 1981. Through a (United Nations Development Programme) UNDP/FAO (Food and Agricultural Organization)-funded project, 44 Duroc Jersey pigs were imported from the Philippines in 1981. With further assistance, Bhutan imported 30 head of Large Black from Australia in 1985, followed by 24 more Large White and Duroc Jersey from Bangkok, Thailand. These high productive breeds of pigs were reared in the government central farms at the National Pig Breeding Centre (NPBC), at Serbithang, and the Regional Pig and Poultry Breeding Centre (RPPBC) at Lingmithang (Mongar) and Gelephu. Various crosses were produced and the piglets were sold to the farmers at a government subsidized rate of Ngultrum 672.00 (~US$15.00) for a piglet weaned at 35–42 days.

While there were reports of difficulty in management of exotic piglets at the village level, the major problem was the colour of the Large White and the Landrance pigs. Many white pigs suffered severe sunburn, with inflammation followed by scabbing and necrosis. The white parts of the body became reddened, oedematous and irritable, and the animals appeared to be in pain. The presence of reddening blistering and peeling of skin on the dorsal surface and flanks is an indication of exposure to sunlight and poor sanitation. In adults, exposure to such extreme environment would reduce fertility and prevent mating. Most white pigs with skin diseases had low production and some died in severe cases. Consequently, white pigs are unpopular among farmers in Bhutan. In practice, white pigs should be given good feed, shade, plenty of water and access to wallow. Figure 3a shows poor body conditioning and skin problems with government supplied white pig of Landrace origin. Hybrids (Figure 3b) thrive better than exotics whereas pure indigenous are the best suited under harsh rural environment.

Figure 3. Body conditioning of three different breeds of pigs reared in similar housing condition in Rinchengang village. Government supplied white pig of Landrace origin (a); hybrid of Saddleback origin (b); and pure indigenous with agouti coat (c).

Considering these problems, the RGoB changed its approach by supplying coloured animals of the Large Black, Saddleback and Duroc breeds to the farmers. In 2000, a review was conducted on the status of this exotic pig germplasm in the country. It was found there were no proper records maintained on this pureline exotic germplasm in the country. Subsequently, coloured pureline breeds, namely Large Black, Saddleback and Duroc, were imported from the United Kingdom in 2003 with the assistance of FAO. Today, these pureline breeds (Figure 4) are carefully bred in the nucleus farm at Gelephu.

Biodiversity of pigs in Bhutan

At least four types of indigenous pigs (Dempha, Dromfak, Sofak and Jitu) have been reported in FAO's Domestic Animal Diversity Information System (DAD-IS) (FAO, 2010). However, caution must be taken as there are no evidences or adequate rational to this form of categorization. During the nationwide blood sampling of indigenous pigs for genetic study (Nidup *et al.*, 2009, 2010), it was observed that Bhutanese indigenous pigs were generally non-descript. Their physical characteristics are described briefly based on distribution across four developmental regions in the country.

Eastern region pigs

Eastern Bhutan constitutes six districts namely Mongar, Lhuntse, Tashigang, Pemagatshel, Samdrup Jhongkhar and Tashiyangtse (Figure 1). Most of the pigs found in Eastern Bhutan (Figure 5) have long dense hair, whereas some have sparse hair, medium-sized body, bristles along the dorsal line, medium snout, medium-sized prick ears and curly to straight tail. Some of the indigenous pigs in Tashiyangtse are found to have white forehead and coat around their shoulders (Figure 5b).

East-central region pigs

The east-central region constitutes four districts, namely Sarpang, Zhemgang, Trongsa and Bumthang (Figure 1). Almost no pigs are present in Bumthang and very few pigs are found in Trongsa. Pigs from Bardo (Figure 6a) in the Zhemgang district have medium-sized body, sparse

to medium hair density, medium-sized prick ears, straight snout, mature females have a sagging belly and most have a long straight tail.

Most pigs in the Sarpang district (Figures 6c and d) are not indigenous but illegally imported across the Bhutan-Assam (India) border. These smuggled pigs are called "Machay Sunggur" after one of the tribes of the Indian state of Assam.

Similarly, pigs found in Darla and Sampheling in the Chukha district are called "Madhuri", which is another phenotypically similar pigs smuggled through Bhutan West Bengal (India) border. For simplicity, these similar looking smuggled pigs will be termed "Machay madhuri" in Bhutan. Machay madhuri are also becoming increasingly popular in other parts of the country particularly in west, west-central and east-central regions. Machay madhuri have similar phenotypic characteristics to Pakhribas and Kalo Dharane Sunggur of Nepal (Nidup *et al.*, unpublished). Machay madhuri with shorter snouts look similar to Pakhribas and the longer snout to that of Kalo

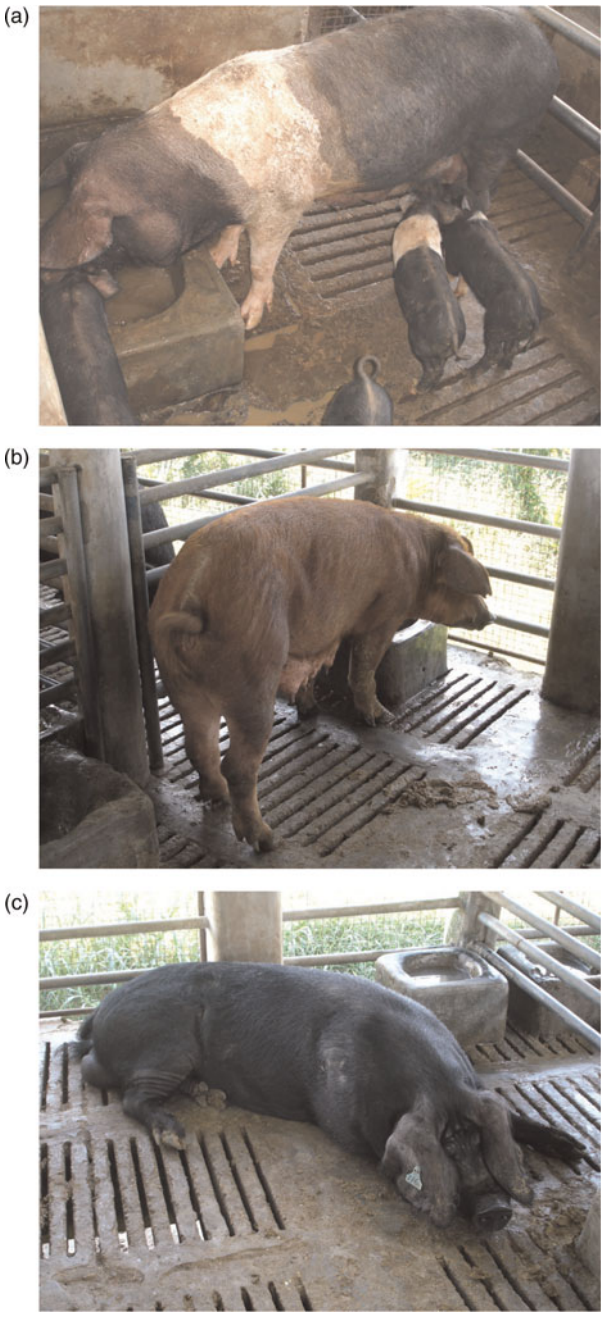

Figure 4. Saddleback (a) and Duroc (b) and Large Black (c) in Gelephu nucleus farm (Courtesy: Dorji, 2010b).

Figure 5. Eastern region pigs: indigenous pigs in Ramjhar, Tashiyangtse (a, b); and indigenous grower in Uzorong, Tashigang (c).

Figure 6. East-central region pigs: (a)indigenous pigs found in Bardo, Zhemgang. Machay madhuri pigs found in Trong, Zhemgang (b), Sarpang (c) and Dekiling, Sarpang (d).

Dharane Sunggur. The most common characteristics of Machay madhuri are wrinkled and diamond-shaped face, large floppy ears and firm body.

Western region pigs

The western region constitutes five districts namely Chukha, Thimphu, Haa, Paro and Samtse (Figure 1). The most common characteristics of pigs (Figure 7) in this region are straight hair ranging from sparse to dense, short to medium with some cylindrical-shaped snout and most with short to medium-sized prick ears.

There is not much difference between the pigs found in Chukha, Haa and Paro districts. Paro and Haa pigs had slender body length. Machay madhuri pigs were also found in Chukha and Samtse districts.

West-central region pigs

The five districts in the west-central region are Gasa, Punakha, Wangdue, Dagana and Tsirang (Figure 1). There are virtually no indigenous pigs in Gasa, only a few head of exotic pigs supplied from the central farm. Some differences between indigenous pigs in Rinchengang and Phagyul-Kazi in the Wangdue district were seen. Rinchengang pigs (Figures 8a and b) have bristles along the dorsal line, broad rectangular-shaped body with females having a slightly sagging belly, small-to-medium-sized prick ears, medium snout and dense hair. On the other hand, Phangyul-Kazi pigs (Figures 8c and d) have longer bodies bristles along the dorsal line, medium to slightly large ears, most with prick ears but some with slightly droopy ear, a somewhat cylindrical snout and long straight tail.

The Dagana district has diverse pigs. For instance, pigs from Lhamoizingkha (Figures 8f, g and h) have sparse hair, prominent prick ears and pointed head, whereas pigs from Drujegang (Figure 8e) are slightly smaller with dense hair over their entire bodies. Some live piglets from Drujegang are usually sold at a weekly open market in Tsirang. For this reason, there are similarities between Drujegang and Tsirang pigs.

Characteristics of indigenous pigs

The official nationwide survey on the characterization of indigenous pigs (Timsina and Sherpa, 2005) concluded that there was only one type of indigenous pigs in Bhutan. It was based on the phenotypic similarities of indigenous pigs across the country. The phenotypic data that were merged to obtain a national average shows indigenous pigs attain sexual maturity at nine months of age. The litter size at birth and weaning is 6.0 and 5.0, respectively, with 2.0 farrowing index. In general, males have longer snouts and ears than their female counterparts (Table 1).

The live weight of indigenous pigs was estimated based on body length and heart girth measurements. The males are bigger and heavier than females. The live weight of indigenous pigs in various age groups is given in Table 2.

However, caution should be taken with the above findings because of the method used for compilation and analysis of

Figure 7. Pigs found in Western Bhutan. Pigs of Bongo (a, b, c, d) and Darla (e, f, g, h) both in the Chukha district; Dogar (i, j) and Naja (k) both in the Paro district; and Katsho in the Haa district (j).

the data. In consistent geographical pattern of morphological variation does not imply lack of variation. For instance, European sheep breeds are readily distinguishable phenotypically but they do not possess that much genetic variation (Peter *et al.*, 2007). On the other hand, sheep breeds in the Middle-East are all of the "generic type" phenotypically and not easy to tell apart, but they display much more genetic variation than European breeds (Peter *et al.*, 2007). Similarly, Bhutanese indigenous pigs may retain high levels of genetic variation and potentially variation in productive ability regardless of the fact that there is no obvious portioning into breeds. Therefore, a nationwide survey to record on-farm production and phenotypic characterization of indigenous pigs across the country would be required once again.

On-station performance

A breeding trial was conducted at NPBC (MoA, 1999) using exotics boars and indigenous female lines (Table 3). The performance of indigenous sows (mated with exotic boars) was better than exotics in terms of average litter size and piglets weaned per sow. The average daily weight gains of the piglets were more similar. However, piglet and maternal mortality was caused by a high incidence of dystocia since large exotic boars were mated with smaller indigenous sows. On the other hand, there was no piglet mortality seen with pureline indigenous (Table 3) whereas high percentage of piglet mortality (22 percent, Table 3) was observed with pureline exotic breed. The trial suggests that the overall performance of indigenous pigs under good management (feeding,

Figure 8. West-central pigs. Indigenous pigs found in Rinchengang (a, b) and Phayul-kazi in the Wangdue district; Drujegang (e) and Lhamoizingkha (f, g, h) in the Dagana district; crossbreds (i, j, k, l) found in various parts of west-central region.

housing and sanitation) is reasonably comparable with the exotic breeds. In spite of this, the RGoB did not make an attempt to improve indigenous pigs. Instead, it constantly pursued its policy of importation and introduction of exotic livestock into the country.

Population of pigs in Bhutan

Overall population

The populations of exotic and composite breeds have been merged as "improved breeds". The overall pig population recorded in 1986 was 87 987 and this reduced to 27 501 in 2008.

The western part of the country has the highest number of pigs followed by west-central and eastern regions (Table 4). Today, Chukha district has the highest overall pig population whereas Gasa has recorded the least number of pigs (Figure 9). As expected, east-central region, particularly Bumthang and Trongsa districts, recorded the least number of pigs because of increasing Buddhist sentiments against raising and slaughtering of pigs.

Bumthang, which is the most religious centre, was the first district to prohibit pig farming. Trongsa, a historically important district, which shares its border with Bumthang, is influenced by the largest monk body in the country. Similarly, pig farming is becoming increasingly unpopular in the eastern region (Table 4) due to the influence of

Table 1. Body measurements of indigenous pigs according to age and sex groups.

	<1 year female		<1 year male		1–2 years female		1–2 years male	
Measurements	***N***	**Mean**	***N***	**Mean**	***N***	**Mean**	***N***	**Mean**
Ear length (cm)	13	7.31 ± 0.75	12	7.63 ± 0.55	17	9.18 ± 0.49	10	9.55 ± 0.73
No. of teats	13	10.31 ± 0.21			17	9.53 ± 0.21		
Tail length (cm)	13	14.23 ± 1.73	12	17.58 ± 1.20	17	20.29 ± 1.43	10	17.7 ± 1.92
Body height (cm)	13	60.69 ± 3.13	12	64.42 ± 3.64	17	74.35 ± 5.38	10	86.9 ± 6.53
Heart girth (cm)	13	52.46 ± 2.93	12	56.67 ± 3.27	17	72.06 ± 4.51	10	84.7 ± 7.93
Shoulder height (cm)	13	39.92 ± 3.88	12	37.5 ± 2.29	17	49.88 ± 1.84	10	51.4 ± 3.25
Face length (cm)	13	19.31 ± 0.91	12	20.17 ± 0.94	17	24.97 ± 1.05	10	25.1 ± 1.34
Measurements	>2-year female	> 2-year male						
Ear length (cm)	8	9.5 ± 0.46	3	12.33 ± 1.20				
No. of teats	8	10 ± 0.0						
Tail length (cm)	8	19.75 ± 1.06	3	26.33 ± 2.19				
Body height (cm)	8	84.75 ± 2.58	3	107.33 ± 6.69				
Heart girth (cm)	8	82.25 ± 2.09	3	95.67 ± 9.94				
Shoulder height (cm)	8	51.63 ± 4.93	3	62.67 ± 5.21				
Face length (cm)	8	26 ± 1.74	3	28.67 ± 2.19				

Source: Generated from the original data (national average) obtained from Timsina and Sherpa (2005).

religious communities. However, there is no sign of reduction of pork consumption in these regions.

Looking at the national trend, the pig population in the country declined sharply from 1986 to 1995 (Figure 10) with slight increase between 1993 and 1996. After 1996, the population declined steadily but seems to have plateaued since 2006.

The possible reasons for this decrease in population are increased influence of religion on animal slaughter and growing social stigma against pig farming. Other reasons include shortage of feeds and increased purchasing power of the people coupled with availability of freshly imported pork. While overall pig population is decreasing, the population of improved breeds is slowly increasing (Figure 11).

Increasing improved pig population

In spite of a declining overall pig population in the country, improved breeds of pigs are slowly increasing in numbers (Figures 11 and 12). Today, improved breeds constitute about 38percent of the total pig population with 5 383 males and 5 159 females when compared with a total of 2 055 heads in 1986. There was gradual increase in the population from 1986 to 1992 which picked up between 1992 and 2008 (Figure 12).

Table 2. Live weight of indigenous pigs according to age and sex.

Age group (years)	**Sex**	***N***	**Mean**
<1	Female	13	12.64 ± 2.05
<1	Male	13	14.40 ± 2.37
1–2	Female	17	30.38 ± 4.99
1–2	Male	10	51.10 ± 11.20
>2	Female	8	40.07 ± 2.72
>2	Male	3	71.80 ± 17.00

Calculated based on body length and heart girth measurement (Table 1).

Records from the three government breeding farms indicate distribution of approximately 20 000 improved piglets in the last six years alone (Table 5).

Today, Chukha has the highest number of improved pigs followed by Mongar, Thimpu, Wangdue and Sarpang (Figure 13). The high record of pig population in Mongar, Sarpang and Thimphu is due to the presence of government farms where exotic or improved breeds are reared.

Despite of the intensity of introduction of exotic breeds since 1964, the current number of improved pigs in Bhutan is relatively low but increasing steadily. There are several factors to this slow pace of growth. First, because of the prolific growth rate of exotic pigs, the government supplied piglets were often fattened and slaughtered instead of being used for crossbreeding. Exotic breeds can attain market weight of 100 kg in less than a year. This fetches up to Nu. 10 000 (=~US$220.00), which is more than average annual rural income (Nu. 7 488 = ~US$166.40) of the Bhutanese farmers. Second, increasing incidence of "dystocia" or farrowing difficulty has been observed when crossbreeding exotic boars with indigenous sows and gilts leading to high piglet and maternal mortality. Finally, exotic breeds require good housing, sanitation and relatively good feed, and are more vulnerable to diseases when compared with local pigs. The mortality rate of exotic breeds is higher than indigenous pigs. In spite of these bottlenecks and slow population growth, the increase in numbers of improved pigs is seen as a threat to the survival of indigenous pigs.

Alarming loss of indigenous pig population

The status of indigenous pigs is alarming. More than 85 932 indigenous pigs were recorded in 1985 and this reduced to 16 959 in 2008 comprising 9 863 males and

Table 3. Performance evaluation of indigenous sows (mated with various exotic boars), pureline indigenous and exotic breeds at NPBC, Serbithang (NPBC, unpublished data)

Parameters	DU ♂ X native ♀	LB ♂ X native ♀	LW ♂ X native ♀	SB ♂ X native ♀	Native ♂ X native ♀	Exotic ♂ X exotic ♀
No. of sow farrowed	23.00	4.00	8.00	11.00	1.00	5
Average litter size at birth	6.87	7.75	8.25	9.00	8.00	7.6
Average birth weight (kg)	0.93	1.09	1.03	0.98	0.70	1.06
Average piglets weaned	6.35	6.75	7.38	8.18	8.00	6.07
Piglet mortality (%)	7.57	12.90	10.55	9.11	0.00	20.13
Average weaning age (days)	54.94	45.75	40.50	46.90	45.00	42
Average weaning weight (kg)	6.53	7.03	6.52	6.48	5.00	7.06
Average daily weight gain (kg)	0.10	0.13	0.14	0.12	0.10	0.14

Note: DU = Duroc; LB = Large Black; LW = Large White; SB = Saddleback.

Table 4. 2008 Pig populations according to the regions.

Regions	Indigenous		Improved		Total
	Male	Female	Male	Female	
Eastern	1 873	1 746	1 414	1 506	6 539
East-central	919	648	633	900	3 100
Western	4 519	2 540	2 375	1 689	11 123
West-central	2 552	2 162	961	1 064	6 739
Overall Pig Population					27 501

Source: Unpublished data from DoL (2009).

7 096 females (Figures 14 and 16); a fivefold loss in the last two decades alone (Figure 14).

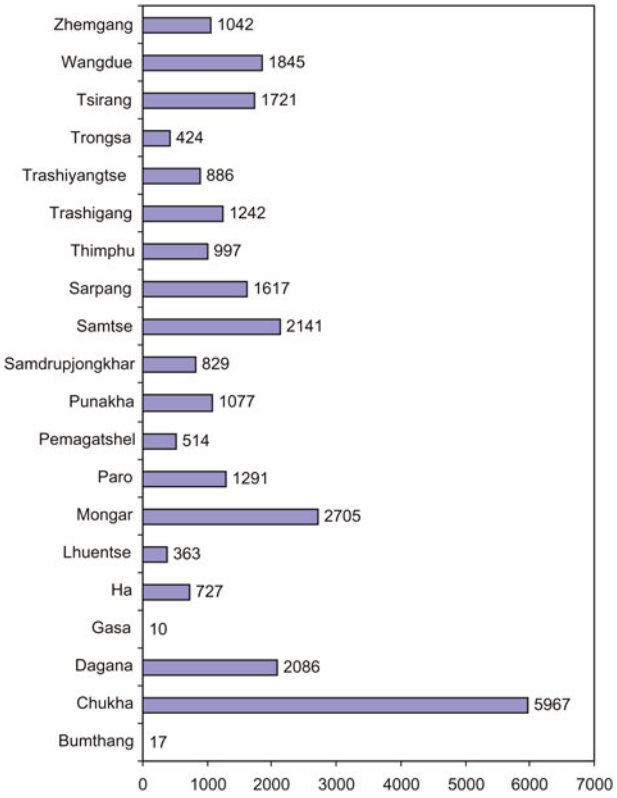

Figure 9. Current population of pigs across all 20 districts.
Source: Unpublished data from DoL (2009).

There were similar observations from the farmers in the field. In a mini survey ($n = 55$) conducted by Nidup (unpublished) in Haa, Wangdue, Samtse and Tashiyangtse districts, more than 56 percent of the farmers felt that the population of indigenous pigs is decreasing.

Today, of 20 districts in Bhutan, only 7 have equivalent to or more than 1 000 indigenous pigs. Chukha district has the highest number of indigenous pigs followed by Samtse, Dagana, Tsirang, Wangdue and Mongar. All other districts have less than 1 000 animals (Figure 15). Indigenous pigs in the Bumthang district are completely extinct.

There are more males than female (Figure 16) in almost all the districts in Bhutan because male pigs (*Pho pha*) are usually used as sacrificial animals. In addition, most males are castrated, fattened and slaughtered for various purposes. Since there is limited information on the number of breeding males, it is difficult to determine the risk status of indigenous pigs in Bhutan.

The rapid decline of indigenous pigs coupled with steady increase in the number of exotic pigs (Figures 11, 12 and 14) is a clear evidence of marginalization of indigenous population by the exotics. Such widespread practice that threatens the indigenous populations, particularly the pigs, is also evident in Sri Lanka and Nepal (Nidup and Moran, 2010, Subalini *et al.*, 2010). Considering the current population trend (Figure 14), indigenous pigs in Bhutan are likely to become extinct within the next decade, unless a serious effort is made in conservation,

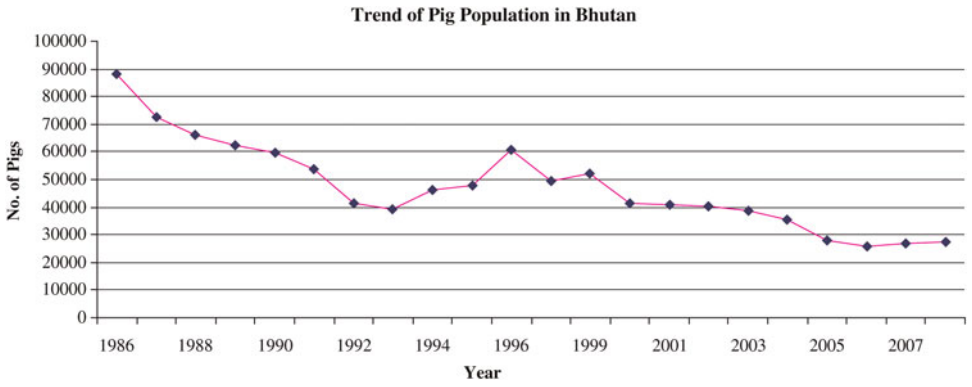

Figure 10. Pig population trend in Bhutan.
Source: Unpublished data from DoL (2007, 2008a, 2008b, 2009).

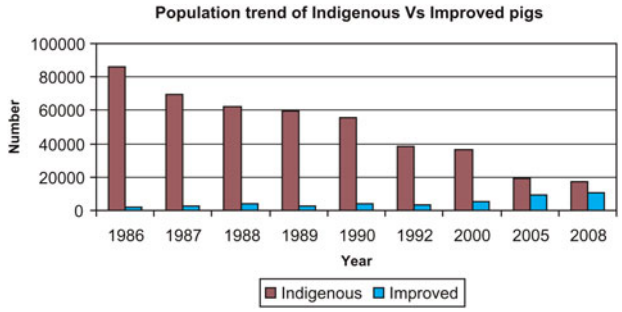

Figure 11. Population trend of indigenous and improved pig breeds.
Source: Unpublished data from DoL (2007, 2008a).

promotion and sustainable utilization of these important genetic resources.

Conclusion and recommendation

Pigs have socio-economic and cultural importance to many Bhutanese people, particularly the rural poor communities. Domestic pork production has remained constant, whereas imports have increased several folds contributing to a large trade deficit for the country. Government initiatives to improve pig farming are mainly focused on introduction of exotic breeds to crossbreed with indigenous pigs. Despite several bottlenecks and slow pace of population growth rate of exotic pigs, their presence in the country is now a threat to the survival of indigenous pigs. This is a clear evidence of growing marginalization of the indigenous pigs mainly driven by the introduction of exotic breeds. In addition to this, religious disapproval of pig breeding and slaughter, increasing purchasing power of the people and readily available imported pork are factors accelerating the reduction in the population of indigenous pigs in the country. Bhutan has lost more than 60 486 heads of pigs since 1986.

Bhutan can draw a lesson from a bird flu outbreak in the bordering Indian states, during which import of poultry and related products from India and other countries were banned (Nidup and Tshering, 2007). The cost of poultry-related products increased dramatically due to limited production within the country. As a result, many people including middle-income earning could not afford to buy eggs (Nidup, 2008), let alone chicken meat which were virtually unobtainable. Similarly, a ban on live pigs and pork imports because of swine flu or other related

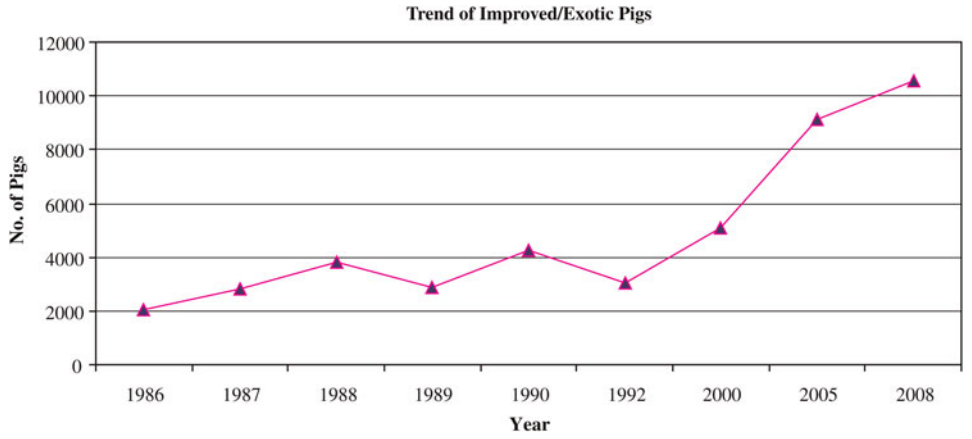

Figure 12. Increasing trend of improved breeds of pigs in Bhutan.
Source: Unpublished data from DoL (2007, 2008a).

Table 5. Record of piglets supply from government breeding farms (unpublished data)

Year	[1]NPPBC Thimphu	[2]RPPB Lingmithang	[2]RPPBC Gelephu
2003–2004	1 465	Not available	662
2004–2005	1 446	30	670
2005–2006	1 032	112	696
2006–2007	1 089	6 350	848
2007–2008	984	623	796
2008–2009	1 038	1 070	1 063
Total	7 054	8 185	4 735
Overall total piglets supplied			19 974

[1]National Pig Breeding Centre.
[2]Regional Pig and Poultry Breeding Centre.

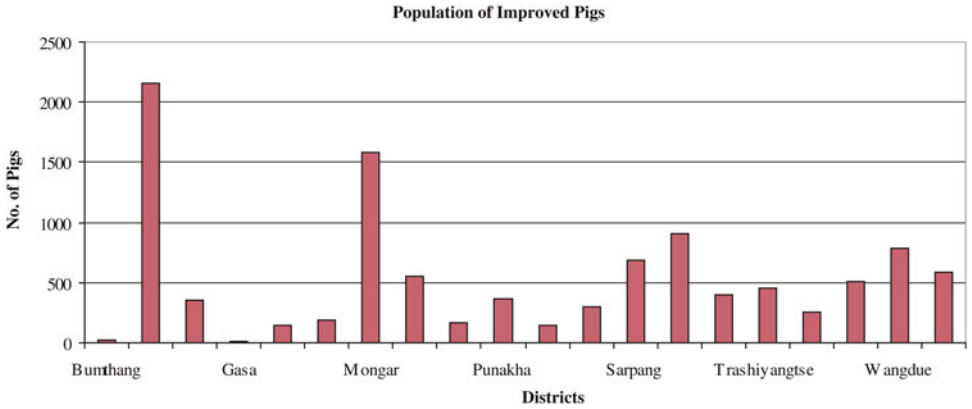

Figure 13. Distribution of improved pigs across 20 districts in the country. *Source:* Unpublished data from DoL (2009).

outbreak of diseases in the neighbouring countries, and coupled with already depleted indigenous pig genetic resources, would endanger the food security of the country. Therefore, better understanding of the diversity of indigenous pig resources, their value and the environment in which they are reared is crucial so that government and other stakeholders will be able to fully appreciate this biodiversity and make strategic decision for its conservation and sustainable use.

In an effort to implement the *Global Plan of Action* (FAO, 2007a, 2007b), indigenous pigs should be protected, promoted and utilized in a sustainable manner. They have been genotyped using FAO and International Society for Animal Genetics recommended microsatellite markers (Nidup *et al.*, 2009, 2010) and their mitochondrial DNA sequences are currently being analysed. These will provide baseline for both *in situ* and *ex situ* conservation. The *in situ* conservation includes protected areas or conservation farms, and payment of other support (e.g. subsidy) for those who keep rare breeds within their production environment. Cryopreservation or *ex situ* conservation of genetic material can provide a valuable complement to *in situ* approaches.

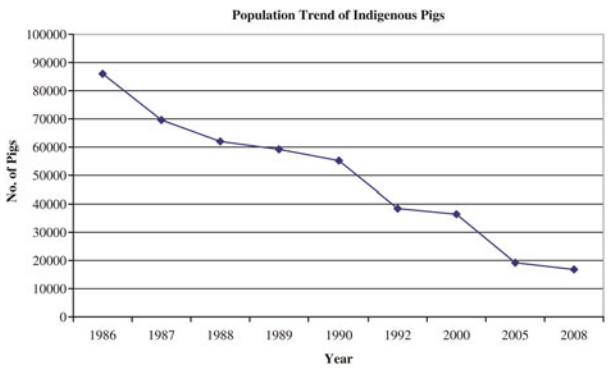

Figure 14. Population trend of indigenous pigs of Bhutan. *Source:* Unpublished data from DoL (2009).

Efforts should be made to coordinate conservation activities, such as the participation of local communities, government institutions and NGOs. For instance, *in situ* conservation through community-based approach can be one of the viable options. Such strategy has been proven successful in maintaining indigenous Pelong pigs and Creole breed in rural Mexico (Pattison, 2002; Pattison *et al.*, 2007). The National Biodiversity Centre (NBC) of the Ministry of Agriculture (MoA) has national mandate on the conservation of biological resources in the country. They should work together with the Department of Livestock (DoL), MoA, to establish conservation and nucleus farm so as to combat the dramatic decline of population of indigenous pigs in the country. The current *ex situ*

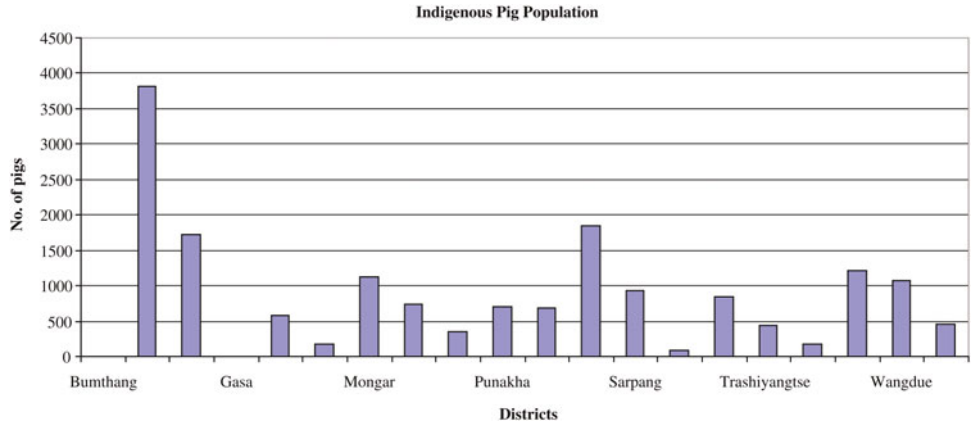

Figure 15. Distribution of indigenous pigs in 20 districts of Bhutan.
Source: Unpublished data from DoL (2009).

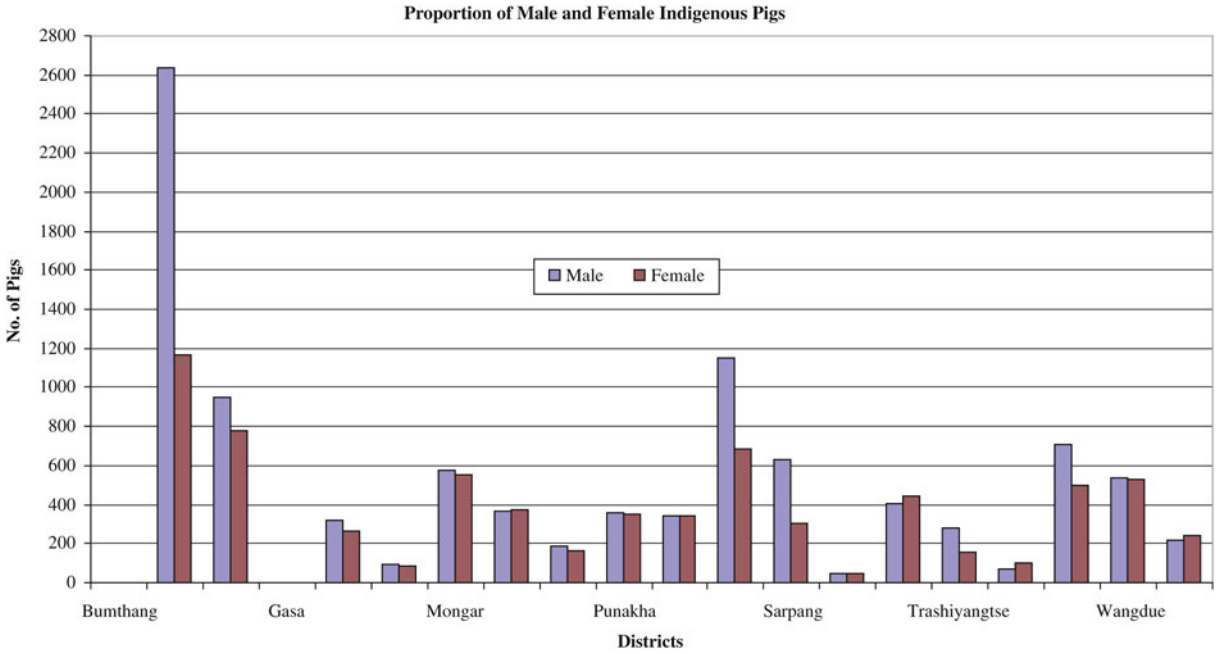

Figure 16. Proportion of male and female indigenous pigs across 20 districts of Bhutan.
Source: Unpublished data from DoL (2009).

conservation or cryopreservation facility at NBC needs to be strengthened with appropriate facilities including human resources. In addition, the Department of Livestock should start the recording number of breeding males and females in the Annual Livestock Census record so that risk status of indigenous pigs could be easily determined.

On the other hand, the livestock research institution should make an attempt to develop a synthetic breed with better litter size, growth rate, resistance to diseases and ability to cope with the harsh rural environment. While the Pakhribas breed in Nepal (Nidup *et al.*, unpublished) is a good example, synthetic breeds containing a reasonable level of indigenous genes could provide viable source of parent stocks for meeting the consumption requirements of Bhutan, although this would do little to conserve biodiversity.

Finally, the role of local and indigenous communities and farmers as custodians of much of the country's agricultural biodiversity should be cherished and strengthened further. It must be noted that preservation of AnGR is linked with the promotion of historical, economical, social and cultural importance, and they are important components of Bhutan's development philosophy of Gross National Happiness.

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The indigenous domestic livestock of the County of Devon, England

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Summary

Pastoral habitats in the County of Devon in southwest England range from lowland temporary pastures to upland rough grazing. These habitats have resulted in the development of locally adapted livestock types. In 2010, Devon is repository to two cattle, five sheep and two equine breeds: Historically there were sheep, equine and pig breeds now extinct or subsumed into existing types. Breed origins are discussed and physical descriptions and main production characteristics are provided. Information is given on organizations in England and overseas that promote the breeds and are responsible for maintaining pedigree records. Available numerical data are presented and conservation status discussed. All sheep and equine breeds are at risk because of low numbers or restricted geographical distribution. The government provides no direct assistance for conservation or preservation although there is limited support for native breeds from agrienvironmental schemes. Owner awareness of breed values, "designer" made for thriftiness under harsh conditions, supported by civil society organizations, will render them "fit for purpose" for new uses in conservation grazing in environmentally sensitive areas, maintenance of plant diversity and sustainable production, and assist in ensuring survival of these invaluable genetic resources.

Keywords: *native breeds, origins, breed description, breed societies, global distribution, conservation status*

Résumé

Le milieu pastoral du comté de Devon dans l'Angleterre du sud-ouest varie entre les pâturages temporaires des plaines et les pâturages grossiers des zones montagneuses. Ces milieux ont eu pour résultat la valorisation de types d'animaux d'élevage adaptés localement. En 2010, dans le Devon étaient conservées deux races de bovins, cinq races de moutons et deux races de chevaux: auparavant, il y avait des races de moutons, de chevaux et de porcs qui sont maintenant disparues ou englobées dans les types existants. Le document examine les origines des races et fournit les descriptions physiques et les principales caractéristiques de production, ainsi que des informations sur les organisations, présentes en Angleterre et dans les pays d'outre-mer, qui s'occupent de la promotion des races et qui sont responsables des livres généalogiques. Il présente également les données numériques disponibles et analyse l'état de la conservation. Toutes les races de moutons et de chevaux sont à risque en raison de la faible taille de leur population ou de la distribution géographique limitée. Le gouvernement ne fournit aucune assistance directe pour la conservation ou la préservation bien que le soutien des programmes agro-environnementaux en faveur des races indigènes soit limité. La sensibilisation des propriétaires, soutenue par les organisations de la société civile, sur les valeurs génétiques conçues pour que les animaux se développent normalement et produisent même dans des conditions difficiles, les rendra adéquates aux nouvelles utilisations relatives aux pâturages de conservation dans les zones écologiquement sensibles, au maintien de la diversité végétale et à la production durable, et contribuera à garantir la survie de ces ressources génétiques très précieuses.

Mots-clés: *Races indigènes, origines, description raciale, sociétés de sélection, distribution mondiale, état de la conservation*

Resumen

Los distintos hábitats pastorales en el Condado de Devon, en el suroeste de Inglaterra, se extienden desde los pastos temporales de las tierras bajas hasta las duras tierras altas de pastoreo. Estos hábitats han dado como resultado el desarrollo de diferente tipo de ganado adaptado localmente. En 2010 Devon se considera un depósito de dos razas de ganado bovino, cinco de ovino y dos de equino: históricamente existían razas de ganado ovino, equino y porcino que actualmente se han extinguido o han sido incluidas dentro de las existentes. Se analizan los orígenes de las razas y se proporcionan sus descripciones físicas y sus principales características productivas. Se informa acerca de las organizaciones que en Inglaterra y en el extranjero promueven las razas y son las encargadas del mantenimiento de los registros genealógicos. Se presentan los datos numéricos disponibles y se analiza su estado de conservación. Todas las razas ovinas y equinas se encuentran en peligro de extinción debido al bajo número de individuos existentes o a su limitada dispersión geográfica. El gobierno no proporciona ayudas directas para su conservación o preservación; aunque existe un limitado apoyo para las razas locales a partir de proyectos agroambientales. La sensibilización de los propietarios acerca de los valores de las razas, el "diseño" llevado a cabo por ahorro bajo duras condiciones y el apoyo de organizaciones de la sociedad civil las harán "aptas para el propósito" y su uso en el pastoreo para la conservación medioambiental en determinadas áreas, para el mantenimiento de la diversidad vegetal, la producción sostenible y para ayudar a asegurar la supervivencia de estos recursos genéticos de valor incalculable.

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Palabras clave: *Razas locales, orígenes, descripción racial, asociaciones de raza, distribución mundial, estado de conservación*

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Introduction

The County of Devon in southwest England has always been a pastoral as opposed to an agricultural area. In 2006, permanent grassland occupied 50 percent of farms compared to 36 percent nationwide. The southwest region (of which Devon is part) also had a higher proportion of lowland livestock farms (21 percent) than the national average (17 percent) (DEFRA, 2006). Within the generic "grassland" there is a wide range of habitats from sea level marshes and meadows through mid-level short- and medium-term leys to upland moors of fine grasses and heather. Within this rich ecological region, there is a concomitant richness of domestic livestock species and types.

Devon is a major repository of farm animal diversity. It is home to two breeds of cattle (Devon and South Devon), five sheep breeds (Devon Closewool, Devon and Cornwall Longwool, Exmoor Horn, Greyface Dartmoor and White Face Dartmoor) and two pony breeds (Dartmoor and Exmoor): The general area of distribution of these species and breeds in Devon and its neighbouring counties is shown in Figure 1. Formerly, there were several earlier sheep breeds, one equine (Devon Pack Horse) and at least two pig breeds (Molland, Devon). One source considers all the sheep and both pony breeds at some degree of risk on numerical or restricted geographical area grounds (RBST, 2009). A second source lists the pony breeds alone as at risk (Scherf, 2000). The Plymouth Rock poultry breed carries a Devon name but was developed in the United States in the mid-nineteenth century (Oklahoma State University, 2009).

Devon's native breeds, as those of other areas, are unique and must be conserved for future generations. In general, they do not demand high inputs and were developed to be kept economically in and adapted to their zones of origin. This paper describes the history, development and current use and status of these domestic livestock on which, and for sheep in particular, there have previously been very few publications.

Materials and methods

This paper results from several years of personal study of Devon's native livestock. Formal and informal contacts were made with breed societies and livestock producers at a variety of venues including agricultural shows, breed events, demonstrations and farm visits. Conventional literature sources have been used where available. Much of the information presented has been extracted from the Web sites of the breeds under discussion: In order to avoid "overloading" the text with repeat citations, a list of these Web sites is provided following the References section.

Cattle

British breeds of cattle were dominant in the United Kingdom until the second half of the twentieth century. During the 1960s, consumer demand was for more beef at lower prices with little thought for quality. The beef industry went through a revolution to satisfy these changes and supplied larger cattle that could be reared quickly to produce lean meat in bulk mainly from commercial concentrate feeds. These larger breeds were imported from continental Europe and rapidly displaced the old standard breeds. This scenario applied to both Devon cattle breeds. There were considerable reductions in numbers and, although neither came as near to extinction as some other county breeds, it was many years before they adapted to the new supply situation and populations began to recover. Historically, the native cattle breeds of Britain have been more influential in world animal husbandry than those from any other country, and in spite of problems at home they have largely retained their influence overseas.

Devon

The first indication of a red animal – references to colour were then few – that was clearly a prototype Devon appears when a bull came into Tavistock Abbey in 1366 as a tenant's ha'p'orth (Finberg, 1951). Before the end of the seventeenth century, the Devon's progenitors were "as good as any in the Kingdom" (Trow-Smith, 1957). There is much evidence for concentrations of cattle in northwest Devon spanning the period Domesday to the end of the seventeenth century, giving an unbroken ancestry of 600 years and providing a lineage as ancient as any British bovine. Cattle were still small as this period closed, as naval purveyors fixed the minimum weight of a fat ox – aged 4–5 years – at 6 cwt (672 pounds, 305 kg) (Hamilton, 1878). The elite Devon herd of the late eighteenth century was that of the Quartly family who farmed on Exmoor's southerly slopes. During wars with France and the United States in 1800–1815, many better animals were sold for beef to feed the armies resulting, in many cases, in degeneration of the stock. Quartly set about improving this situation by buying in animals, outbidding butchers, and – as one noted breeder remarked – taking the trump in every hand and retaining it for breeding (Hall and Clutton-Brock, 1989). Early-nineteenth-century Devons were bred for meat and draught, with milk production

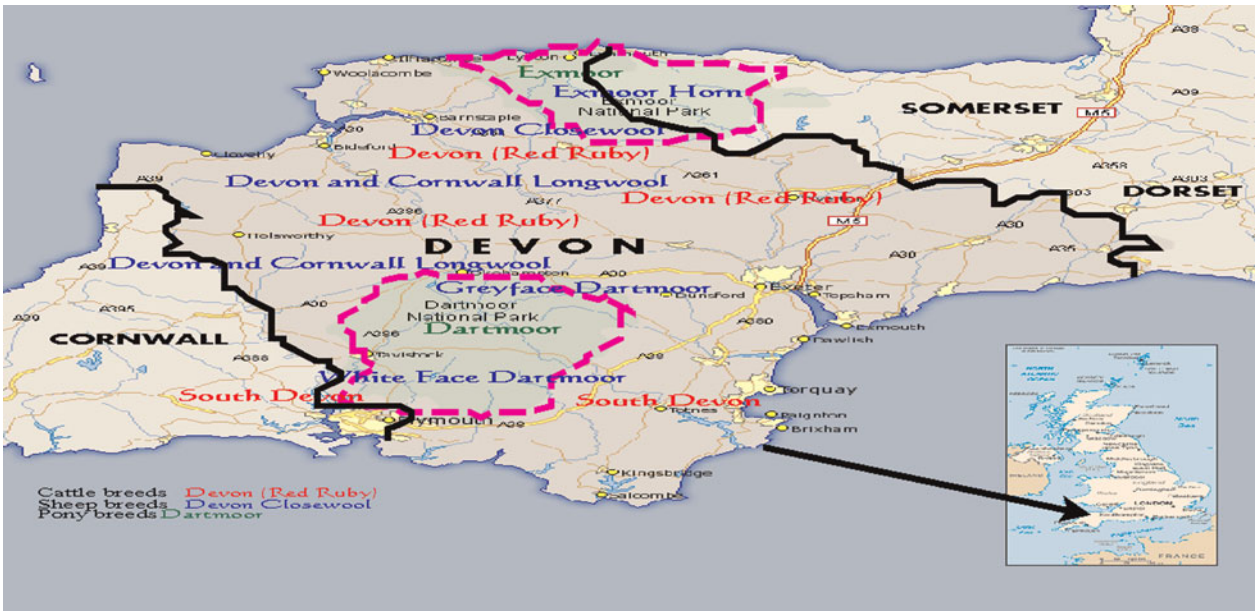

Figure 1. General distribution of indigenous livestock in Devon and neighbouring counties.

being only a minor consideration (Tanner Davy, 1869). The Devon is also known as Beef Devon, North Devon, Red Devon and Red Ruby (Mason, 1996).

A medium-large middle-horned beast, the Devon, is deep cherry red in colour. The breed is renowned for its thriftiness, ability to thrive under adverse conditions, docility, fertility and mothering ability (for much of the twentieth-century cows suckled two calves). Attempts were made to promote Devons as dairy animals during the 1920s and 1930s, and a special section was introduced in the *Herd Book*. Long noted for milk quality – butterfat and solids-not-fat – rather than quantity there was little support for this initiative and any impetus soon faltered. Since the early nineteenth century, however, and with less use of oxen for draught, the Devon has been developed as a specialist beef breed. During the first half of the twentieth century, it maintained its eminence in major show rings in interbreed competitions and at fatstock shows at Smithfield and elsewhere. In the early 1900s, Devon bullocks on grass weighed about 12 cwt (1 344 pounds, 611 kg). The champion Devon at Smithfield's Christmas Fatstock show in 1912 weighed 17 hundredweight and 2 pounds (1 906 pounds, 866 kg) at 33 months (Kidner, 1912). Average bulls at that time probably weighed about 800 kg and cows about 500 kg. Weights of both sexes have risen in response to competition from continental breeds, mainly from within-breed selection, although there has been limited cross-breeding by some breeders in attempts to improve size. Bull calves are now expected to gain in excess of 1 000 g/day and heifers more than 750 g/day from birth to 2 years, but these values are regularly exceeded. Today's bulls weigh 1 000–1 100 kg and cows 650–750 kg. The modern Devon has emerged from its own global recession, mainly through outcrossing but with some assistance from cross-breeding, and is a larger, longer and leaner beast than its ancestors (Figure 2).

Figure 2. A modern pure-bred Devon yearling bull (Bartridge China Boy 8th M08044, 18 month [556 days], weight 668 kg, average daily gain 1 125 g).

Pedigree records (Davy's *Devon Herd Book*, volume 1) were first published in 1851. These related to the lineage of 132 bulls and 483 cows. Volume 4 (1863) brought details of 768 bulls and 2 474 females on to the record (Tanner Davy, 1869). The Devon Cattle Breeders' Society was formed in 1884. The *Herd Book* has been published annually and has now reached volume 132. The society has almost 600 members in 2010. The transition from the nineteenth to the twentieth century was a golden age for the Devon. The breed spread throughout the country from its southwestern homeland. By 1908, it was the second most numerous breed in the United Kingdom. At 454 694 head it had, admittedly, only about 10 percent of Shorthorn numbers (4 413 040 heads) but was ahead of Herefords (384 877) by 70 000 heads and Aberdeen Angus (193 960) by more than a quarter of a million animals (BoA, 1908).

Cattle from Devon were taken to the British North American colonies in 1624 (Deane, 1851), to Cape Colony (South Africa) in 1800 (SASB, 1971), to Van Dieman's Land (Tasmania, Australia) in 1825 (DCBSA, 2009) and to New Zealand in 1836 (NZRDCBA, 2009). By the mid-1860s, Devon cattle had been exported to France, Mexico, Jamaica and Canada (Tanner Davy, 1869). Over succeeding years, Devons were exported to many countries (Figure 3). Brazil has been the main destination of UK exports, followed by South Africa and then Australia, United States and Rhodesia (Zimbabwe). Between 1901 and 1990, at least 1 751 Devons, comprising 722 bulls and 1 029 cows/heifers, were exported. Most animals were exported just prior to and immediately after the First World War when bulls seemed in greatest demand and then in the 20-year period following the Second World War when females were mainly sought. Devons overseas were kept pure, crossed on other beef or dairy animals, or used to create new breeds. Examples of the last include Tambov Red in Russia (Dmitriev and Ernst, 1989; Mason, 1996), Jamaica Red (Mason, 1996) to a limited extent, Australian Sahiwal (Mason, 1996) and a composite Zebu x British type for use in northern Australia (Kelley, 1959). In the early twenty-first century, there were Devon breeders' societies in Brazil (300 members), Australia (80+ members), New Zealand (50+ members) and the United States. In South Africa and Canada, Devons are registered in the respective national *Stud Books*.

Success of the Devon at home and overseas is associated with its ability to produce top-quality beef as a pure bred and as a cross under varying climatic conditions. In a period when other breeds were being modified irredeemably by cross-breeding in "improvement" programmes, the Devon made greater use of within-breed selection. This has been more the case abroad than at home, however, where it is often the proud boast of the breed societies that Devons retain the genetic purity that was developed over several centuries in their original homeland. This does not mean that the breed has not continued to develop. Progressive management and breeding techniques have seen Devons adapt well to the modern beef industry worldwide. Performance recording has identified superior animals and polled strains (developed by limited cross-breeding with polled breeds) are widely available. Today's consumers are demanding that the beef they eat is more natural, produced from grass, has not been tainted with growth promoters or truck loads of veterinary pharmaceuticals, tastes better and has generally caused little damage to the environment in its production. If farming is to be sustainable, it will be the hardy most efficient breeds that fulfil environmental and economic criteria and Devons are among those best placed to satisfy these demands.

South Devon

Once known as Hammer and South Hams (Mason, 1996) from the district to the north of Plymouth where the breed originated, the South Devon was in the course of developing in the late eighteenth century (Trow-Smith, 1959) although others claim they had "been in the south part of Devon from time immemorial" (Fraser, 1794). Even at that time the South Devon was a large beast (mature oxen weighed up to 12 hundredweight [1 344 pounds, 611 kg]) and produced a fairly high yield of extremely rich milk. There is little doubt that this light red curly coated animal was a result of a Channel Island or Normandy cross on the red middlehorn that was the Devon itself and the use of "Alderney" cattle in southern Devon at this time is well attested. South Devon breeders tend to deny the use of Channel Island or French animals but blood typing in the 1950s showed common haemoglobin properties in Jerseys, Guernseys and South Devons (Trow-Smith, 1959). In the mid-nineteenth century, the South Devon was still largely restricted to the South Hams as elsewhere, as a beef animal, its carcass was considered to have "more of the *fourpenny* and less of the *ninepenny* beef". In the following years, within-breed selection led to considerable improvement. Early in the twentieth century, the breed was dual purpose for beef and milk although milk was used both as liquid whole milk and, for its high fat content, for making butter.

The South Devon is much the largest of Britain's native breeds and is known for docility, mothering instinct, easy calving and longevity (SDHBS, 2010). Hardiness and adaptability, fast early growth from a plentiful supply of rich milk, an excellent ability to convert grass to flesh and early maturity are further breed characteristics. These traits are important for modern beef production, which is reliant on limited labour and minimum replacement costs. Rapid growth and early maturity mean a bull can begin to be used at 15–18 months of age and can often work 11–12 years. Females may calve at 2 years, although calving at 2½–3 years is still common, and produce calves annually for up to 15 years. In the 5 years 1907–1911, South Devons were always among the prize winners at the Royal Agricultural Society of England annual show. Cows at one show weighed 1 400–1 800 pounds (636–823 kg) and having been in milk for 50–140 days produced 24 h yields of 43 pounds 12 ounces (19.9 kg) to 72 pounds 6 ounces (32.9 kg). An animal that was "probably the heaviest beast yet bred" weighed 30 hundredweight (1 527 kg) when slaughtered at Plymouth in 1907 and yielded a carcass of 18 hundredweight and 7 pounds (919 kg) for a dressing percentage of 60.2 (Drennan, 1912).

The main expansion of the breed away from the southwest to the rest of the United Kingdom took place in the twentieth century. Exports helped support farm income at this time. Progression towards a specialized beef breed began in the 1960s when recording was introduced. Because of its size, length and width of carcass and its lean beef, the South Devon was better able to combat the onslaught of continental breeds in the 1960s/1970s than other native

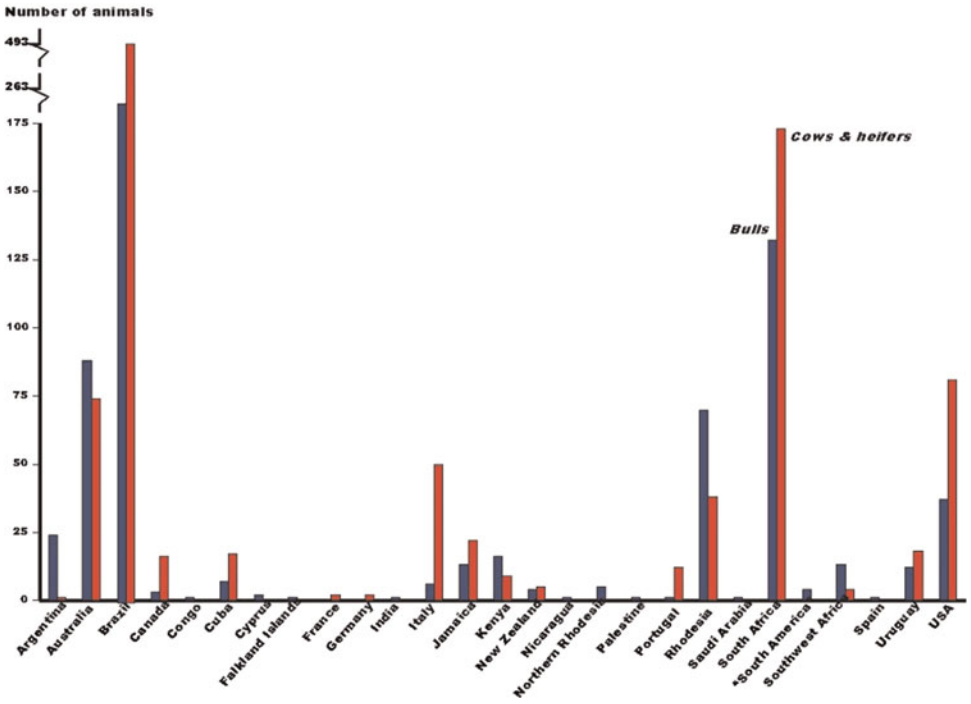

Figure 3. Numbers of Devon cattle exported to various countries from United Kingdom, 1901–1990.

breeds. This saw increased demand outside Devon and Cornwall and some 5 000 heads were sent each year to other parts of the country for finishing or as breeding stock. Exports also increased with 170 bulls going to Canada, 150 to the United States and 90 to South Africa.

The South Devon is well placed in both intensive and extensive modern suckler systems (Figure 4). For the pedigree breeder it produces excellent replacements. As a crossing sire the bull allows production of replacement females on the farm. Good beef conformation and good milking and mothering abilities enable the South Devon to assist in improving a suckler herd's base stock. The South Devon is also used in two- or three-sire breed systems for increased hybrid vigour at each generation (SDHBS, 2010). As a terminal sire the South Devon reduces time to finishing and improves dressing percentage, carcass grades and meat quality.

Figure 4. South Devon cow and calf in extensive suckler system (Grove Willow Herb 23rd and calf Grove Willow Herb 33rd, photo courtesy of Grove Farms Limited).

The South Devon Herd Book Society was founded in 1891. At that time it was considered that the breed's "recognition has been tardy; it has no aristocratic backing; its breeders are chiefly – almost mainly – tenant farmers, and it has had to overcome many prejudices …" (Drennan, 1912). By 1912, South Devons were present in South Africa, East Africa, Australia, New Zealand, United States, Brazil, China, Jamaica, Columbia and Japan (Drennan, 1912). The first overseas society was the South Devon Cattle Society of South Africa established in 1914. The North American South Devon Association was formed in 1974, as was the Canadian South Devon Association. Australia has two associations: the South Devon Cattle Society of Australia and the South Devon Cattle Breeders Australian Association. There is a South Devon Cattle Society of New Zealand and there are South Devons in Ireland and Zambia. The current popularity and versatility of the breed are attested to by the many other countries to which it has been exported.

Sheep

Britain probably has the largest range of native sheep breeds in the world. They are integral to national history and are descended from local types which successfully adapted to particular environmental and geographical conditions. The diversity of British sheep owes much to the versatility of the species itself but also derives from

generations of careful shepherding and selection based on acute observations that long pre-date the scientific manipulation that is now taken for granted.

Early types

In the mid-eighteenth century, introduction of (old) Leicester blood converted some local Devon types from coarse middlewools on the one hand into a polled medium-longwool that became the Devonshire Nott ("Nott" in Devon dialect means polled) and on the other hand to a horned medium-longwool that became the Exmoor (Fraser, 1794; Trow-Smith, 1957). Sometime later, Devonshire gentry formed an improvement society to import New Leicester rams to improve local Devon or Bampton stock. Initial results were not promising, in part because rams brought in prior to 1794 were "by no means the best of the Leicestershire" (Fraser, 1794). In the early nineteenth century, the Notts were infused with further Leicester blood and became Bamptons, which, in the 1830s/1840s, weighed 120–150 pounds (54–68 kg) at 2 years of age and produced 7 pounds (3.2 kg) of wool valued rather highly at 12½–13 pence per pound. These in turn gave rise to the Devon Longwool and (Greyface) Dartmoor such that by the middle of the nineteenth century remnants of the original mountain types remained only in the remotest localities (Trow-Smith, 1959).

Devon and Cornwall Longwool

Two long-established native breeds – South Devon and Devon Longwoolled – were amalgamated in 1977 to form the Devon and Cornwall Longwool with its own Flockbook Association (Mason, 1996). The breed is also recognized in the Netherlands where it is registered with the Vereniging van Speciale Schapenrassen (VSS, 2009). Both original breeds emerged from transformation of the earlier local middlewools – Southam Nott and Bampton Nott – developed through the use of the New Leicester (Trow-Smith, 1957, 1959). The South Devon was a long wool and meat type very similar to the Devon Longwoolled but larger. In the mid-nineteenth century, it weighed 100–120 pounds (45–54 kg) and produced a fleece of 9 pounds (4.1 kg) of a mediocre value of 9 pence per pound. The Devon Longwoolled, a north Devon mutton and long wool type, became a recognized breed in the 1870s, a breed society existed from 1898 to 1977 and a *Flock Book* was established in 1900 (Mason, 1996). Their wool was very strong and used mainly for rugs and carpets.

The modern Devon and Cornwall Longwool is dual purpose and produces a good carcass lamb and a heavy fleece (Figure 5). Mature rams weigh up to 136 kg and ewes up to 100 kg. Both sexes are polled. Prolificacy off grass is about 160 percent. Head and body are covered in long curly, white wool. Average fleece weight of rams is around 12 kg (but up to 20 kg is known) and of ewes 7 kg.

Figure 5. Devon and Cornwall Longwool 2-shear ram in full fleece.

The staple length is 20–25 cm. The hard wearing coarse wool – Bradford wool count 32–40 (40–36 μm) – is best for carpet manufacture. Unusually, Devon and Cornwalls are shorn as lambs when they produce a particularly warm, resilient and valuable fleece. The breed is suitable for producing lean heavy lambs of 18–21 kg carcass weight finished on fodder crops for the winter market. When crossed with British Milksheep, Border Leicester, Cheviot or Suffolk a prolific halfbred ewe is produced, which is ideal for early lamb production.

In spite of the amalgamation of two different breeds 30 years ago, the new breed remains rare. On the Rare Breeds Survival Trust (RBST) Watchlist it is placed in Category 3, Vulnerable (RBST, 2009).

Greyface Dartmoor

The Greyface Dartmoor, also known as the "Dartmoor" or "Improved Dartmoor", was developed between 1820 and 1909 by selection from the original Dartmoor and by judicious crossing with the New Leicester (Mason, 1996). Descended from original types that grazed the lower ground in and around Dartmoor it has a strong constitution developed by exposure to the prevailing severe winters and harsh conditions.

The hornless breed is of medium–large size (ewes 64 kg, rams 102 kg), deep bodied and short legged with a well-woolled head and legs (Figure 6). The white face is mottled or spotted with black or grey with matching feet. Ewes are docile, easily handled, good milkers and capable of rearing twins although they are not very prolific with a lamb crop of about 140 percent. The breed is of lustre longwool type (others in this group are the Wensleydale and Leicester Longwool). Ewes clip 7–9 kg and mature rams yield up to 15 kg. The long, curly, white wool of 25–30 cm staple length and a Bradford wool count of

Figure 6. Greyface Dartmoor ewe in its natural habitat (Photo courtesy of Dartmoor Sheep Breeders' Association).

36–40 (38–36 μm) are used for serge, blankets, carpets and a variety of artisanal applications (Figure 7).

The Dartmoor Sheep Breeders' Association was established in 1909 to standardize, promote and develop the breed that was then well established in its local areas. A *Flock Book* was produced in 1911 (Mason, 1996). In the early 1960s, the national flock comprised 7 000 breeding ewes, 3 000 ewe lambs and 300 rams in 140 individual flocks. The nadir of the breed was in 1985 when there were only 650 breeding ewes, 250 ewe lambs and 50 rams in 30 registered flocks but with only 15 "active" units. Considerable recovery has taken place such that in 2008 there were 1 500 breeding ewes, 700 ewe lambs and 70 rams in 200 flocks. Thus, individual flocks have become smaller and the breed is now kept throughout England, Wales and southern Scotland, and breeding stock has been exported overseas.

Considered rare in the 1990s (Mason, 1996), the Greyface Dartmoor was among those breeds that had the highest proportion of their population "culled" in the UK 2001 FMD outbreak (Alderson, 2001). In 2009, however, and in part owing to many smaller flocks and their geographic dispersal, the Greyface is nonetheless not so seriously threatened as other Devon sheep and is on the RBST Watchlist as Category 5, Minority (RBST, 2009).

Figure 7. Fleece, shorn skin, rug and knitting wool of Greyface Dartmoor sheep.

White Face Dartmoor

The White Face Dartmoor is sometimes known as the Widecombe after the village of that name. Its descent is from native heath sheep that grazed Dartmoor in the seventeenth and eighteenth centuries. The modern White Face developed, however, from crossing Leicester Longwool on the original Dartmoor around 1900 (Mason, 1996). The breed was revived in 1950 when the White Face Dartmoor Sheep Association was set up after changing market demands had resulted in a marked decline in numbers during the 1940s. A *Flock Book* was established in 1951. Found over a wider area in the past, enclosure of open fields and commons resulted in the breed retreating to Dartmoor where it became firmly rooted but very localized (WFCSBA, 2009).

The breed is very hardy. It grazes heather in the summer and descends to the grassy valleys in the autumn and winter. Mature rams weigh 74 kg and ewes 54 kg. The White Face has a broad white head, although there is occasionally some speckling on the face. Previously, both sexes were horned, but most ewes are now polled (Figure 8). The coarse wool has a fairly strong crimp and is moderately greasy. Average ewe fleece weight is 5.0–7.0 kg although 9 kg is not unusual. Ewes have a strong mothering instinct and a naturally high milking ability. Lambing percentage is up to 150. Carcass value is high with good conformation, meat with little fat and a good flavour and texture and dressed weights of 14–18 kg (WFDSBA, 2009).

Figure 8. White Face Dartmoor ram and ewes at Devon County Show.

The breed is excellent for crossing in both sexes. White Face rams on the Welsh Mountain, for example, increase offspring carcass weight and quality and wool output while maintaining the vigour and hardiness of the dam line. The use of terminal sires such as the Suffolk on either pure or cross-bred White Face ewes produces a very attractive finished lamb that is lean and well muscled and ideal for the modern market.

The decline in wool prices during the 1980s and 1990s has contributed to a fall in numbers of breeding flocks. White Face Dartmoors are classed in Category 4, At Risk of the RBST, in terms of numbers but are Category 1, Critical, in terms of geographical concentration with more than 75 percent of their numbers being found within a radius of less than 12.5 km (RBST, 2010). Maintaining adequate blood lines is a problem and increased numbers of sheep and flocks would give more breeding options through increases in the gene pool. Breed characteristics meet, however, the "new" farming and environmental management needs being imposed on agriculture on Dartmoor through Environmental Sensitive Area legislation and EU Common Agriculture Policy reforms.

Devon Closewool

The Devon Closewool has existed for over 100 years and descends from the Devon Longwoolled and Exmoor Horn although it is a medium-wool polled breed (Mason, 1996). This very hardy breed is well adapted to the exposed uplands of its native heath partly as a result of its dense fleece, which does not part easily and keeps the skin dry even in heavy rain. Its heartland is Exmoor's southern slopes and around Barnstaple in North Devon, which gives rise to its alternative name of the Barnstaple (Figure 9). This is essentially an upland sheep that lives on grass and long fodder year round and thrives where many breeds would die. There are a very few in Cornwall, Somerset and parts of Wales.

The Devon Closewool Sheep Breeders Society was founded in 1923 and a *Flock Book* was established at the same time (Mason, 1996). The first registered flocks, however, date back to 1894. A dual-purpose meat and wool type, the Closewool, is a medium-sized (ewes 121–132 pounds [55–60 kg], rams 198 pounds [90 kg]) white-faced polled sheep, has good bone and stands on stout legs set apart giving it a very symmetrical appearance (Figure 10). The neck is short and thick and well set into the shoulders, and the ribs are well sprung with good depth. The back is well set up, big and wide and the leg of mutton is well let down. The dense white fleece is of medium length and staple and should contain no black fibres. Fleece weights of yearling ewes average 4 kg and those of yearling rams 6 kg with a staple length of 8–10 cm. The Bradford wool count is 48–53 (31–28 μm). The wool is popular with artisanal spinners and has a range of uses in modern manufacturing processes including hosiery, tweeds and fabrics.

The breed is ideal for crossing in both sexes. The Devon Closewool Halfbred section was formed in the early 1980s with the most popular cross being the Bluefaced Leicester to produce the Closewool mule. Continental and Down breeds are also used on the Closewool. Cross-bred ewes and lambs thrive in variable climates and terrain and produce first-rate easily finished prime lambs. These achieve carcasses of good conformation weighing about 18 kg at 12 weeks off grass. Closewool rams lend hardiness and "substance" to other white-faced breeds. As with the pure bred, halfbreds are popular for their ability to thrive in varied climates and farming systems as they are durable, prolific (160–200 percent lambing) and excellent mothers with good milking ability, which is reflected in early offtake.

The Devon Closewool is on the RBST Watchlist, in Category 4, At Risk (RBST, 2009, 2010), mainly because

Figure 9. Devon Closewool flock on marginal land on the slopes of Exmoor (photo courtesy of Devon Closewool Sheep Breeders' Society).

Figure 10. Devon Closewool mature ram Champion at Devon County Show 2009.

75 percent of the population is within a radius of 17.5–20.0 km. Provided epidemic disease can be avoided, the breed has a solid future as an easy care commercial sheep for harsh environments.

Exmoor Horn

Sometimes known as the Porlock, Exmoor Horns have been on Exmoor since time immemorial and have always been valued for their hardiness, ability to thrive and fleece and meat quality. This is a true dual-purpose hill breed that lives outside all year round. It has always been kept pure on the higher moorland and used for crossing on lower ground (Figure 11).

The Exmoor is a white-faced animal, with large horns in the male and smaller ones in the female, with cherry-coloured skin and a white fleece of medium length (Figure 12). In the 1850s, the Exmoor was small, weighing 60–75 pounds (27–34 kg) at 4–5 years of age and produced a long fleece of 4–5 pounds (1.8–2.3 kg) of good-quality wool valued, then, at 12–12½ pence per pound. The modern Exmoor is a much bigger animal with adult rams standing 77 cm at the withers and weighing 73 kg: Ewes are 65 cm at the shoulder and weigh 50 kg. The breed is prized for both lamb and mutton and continues to produce a fine quality fleece of excellent colour and good staple length with a Bradford wool count of about 40 (36–37 µm). Exmoors are among the most prolific of hill breeds (draft ewes on better ground produce even higher lambing percentages), are excellent mothers, very good milkers and produce a quality upland lamb. In performance relative to the standard Scottish Blackface, the Exmoor is superior in daily gain and equal in milk yield, percent fat, percent protein, muscularity, carcass leanness, litter size, length of mating season, lambing interval, age at sexual maturity, wool yield and wool quality.

The Exmoor Horn Sheep Breeders' Society was formed in 1906 and a *Flock Book* was established in 1907 (Mason, 1996). At the first registered sale and show in 1907, 1 200 ewes were sold by auction at an average price of 42 shillings. The 1908 *Flock Book* records 132 members and 25 000 pure Exmoors inspected and branded. The 2007 *Flock Book* includes 80 flocks with some 19 000 registered ewes.

Figure 11. Exmoor Horn ewes with Mule lamb on lower slopes of the native heath (pedigree registered Barton Town flock of Mr Philip Huxtable, Challacombe).

Figure 12. Exmoor Horn mature ram on culm grassland (pedigree registered Barton Town flock of Mr Phillip Huxtable, Challacombe).

In the mid-nineteenth century the Exmoor Horn, with the Devon Longwoolled, was the progenitor of the Devon Closewool. The breed is still excellent for crossing. The Bluefaced Leicester cross produces the Exmoor Mule, which is docile and prolific in lowland areas and recognized as one of Britain's finest mules (a mule is a cross between a lowland Bluefaced Leicester ram and a pure-bred upland or hill ewe). Mules retain many Exmoor Horn qualities while exhibiting the hybrid vigour of the cross-bred. Ewes are prolific, lambing at 160–200 percent, are very good and milky mothers, suffer very little from foot problems and are long lived and cheaply maintained. The Bluefaced Leicester influence produces a long animal of good conformation and excellent fat-to-weight ratio. Lambs achieve good weight gains from grass and finish easily at 18–22 kg deadweight of 2–3 litre fatness and U/R+ conformation. Exmoor rams are excellent terminal sires on a variety of crosses as they pass on their attributes of docility and the ability to produce finished lambs from low-input systems.

Though ancient in origin, the Exmoor Horn is well adapted to modern requirements. The breed's traditional values are as relevant as ever at the beginning of the twenty-first century. Renaissance in the market for mutton is a very positive step for the breed. Recent changes to farming policy have ensured a place for Exmoor Horns in the future plans of many farming businesses. An ability to fit into environmentally sensitive and conservation landscapes and the commercial value to produce pure-bred or cross-bred lamb with added-value and market potential means that Exmoor Horns continue to deliver good value to farmers.

In spite of its undoubted popularity in its home tract and its relatively large numbers, the Exmoor Horn is at serious risk and is listed by RBST as Category 1, Critical (RBST, 2009, 2010), because 75 percent of the breed falls within a radius of less than 12.5 km.

Equines

Most native equine breeds were traditionally used as working animals. Heavy breeds ploughed the rich lowlands, whereas ponies provided agricultural power on upland farms, and were used as transport (pack) animals and for shepherding, hunting and carrying the farmer to market. Ponies also worked in deep mines underground (Wilson, 2009).

Devon Pack Horse

Before the end of the seventeenth century, Britain had few roads and few wheeled vehicles. Roads began to be constructed in populated parts of the country, but in remoter areas and especially in hillier regions there was little development even by the end of the eighteenth century. It was noted "in Devon and Cornwall they have few wheel carriages by reason of the steep hills, but everything is carried either on hooks on each side of the horses, which are long or short according to the nature of the burden; they have drags for drawing up the side of steep fields, …" (Cartwright, 1889). The Devon Pack Horse was one of a group of similar regional equines (including the Norfolk Trotter or Roadster) developed to perform these functions. The characteristics of this literal "workhorse" were medium size (15 hands [60 inches, 152 cm] or slightly more at the withers), load-carrying capacity, an ability to walk and trot well, surefootedness, staying power, thriftiness and longevity (Staveley, 1910). A typical animal carried three sacks of corn, each of 220 pounds (100 kg), at a steady 5 mph (8 kph) for long periods. A string of six animals, carrying 1 800 kg in total, was controlled by one person. The person rode the horses turn about such that at some times a further 50–60 kg was added to the load of each animal (Staveley, 1910).

As roads became more widespread, two breeds of horse developed from Pack Horse stock. These were a heavy breed for slow goods traffic and a lighter faster type for carriages and coaches that included the Cleveland Bay and the Hackney. By the end of the nineteenth century, very few Devon Pack Horses remained. In 1910, there were but few aged mares in their original area and one 14-year-old stallion that had been exported to Australia (Staveley, 1910). The true breed is extinct (Mason, 1996).

Dartmoor

An early reference to ponies on Dartmoor is in the will of the Bishop of Crediton (in central Devon close to Dartmoor) who died in 1012. During the reign of Henry I (1100–1135) a stallion was taken from Dartmoor (which like Exmoor was a royal forest) to serve royal mares. Ponies have thus lived on the moor for a very long time and developed the metabolism to prosper in that tough and uncompromising environment. The Dartmoor "breed" began to emerge from the non-descript stock on and around the moor about 1800 (Palmer, 1912). It was to be another 100 years, however, before the modern type was established at the end of the nineteenth century and this following injections of Exmoor blood around 1860 (Palmer, 1912).

The Dartmoor pony is sturdily built – but perhaps not so much as the Exmoor – and has maintained much of its adaptation to its moorland environment (Figure 13). Its strength and ability to survive harsh conditions means it is suitable for both farm work and riding. Bay, brown and black are the commonest colours but there are some greys (piebald and skewbald animals are not recognized by the breed society). Males average 225 kg and females 212 kg with withers heights of 12.2 hands (50 inches, 127 cm) in both sexes. Despite their small frame, they are strong enough to carry a full-grown human all day. The potential as children's ponies has long been recognized as they make wonderful companions, give endless fun, and compete and succeed in all spheres of competition.

The Dartmoor Pony Society (DPS) was established in 1925 and in 2009 has about 700 members. Pedigrees were recorded in the *Polo Pony Stud Book* as early as 1899 but were later transferred to the National Pony Society. It was not until 1977 that DPS took over pedigree recording. This is now a primary role of the society. The Dartmoor Society Supporters Group acts mainly as a fund-raising body for the benefit of the society.

Registration by inspection of non-pedigree (but possibly pure-bred) animals was terminated in 1957, but an upgrading scheme has been reintroduced. Approved non-registered mares run with a registered licensed pure-bred stallion to achieve Supplementary Register 1 (SR1) status. Approved progeny become Supplementary Register 2 (SR2). Approved progeny of SR2 mares that foal to a licensed pure-bred stallion become fully registered and may be entered in the main *Stud Book*. Some unregistered true-to-type ponies have Heritage Trust List (HTL) status. These remain unregistered unless they enter the upgrading scheme. HTL status has been given to The Dartmoor Heritage Trust (not connected with DPS) to allow farmers

Figure 13. Dartmoor pony and foal on typical moorland ground.

on Dartmoor to obtain payments to assist them retain unregistered but true-to-type herds on the moor.

In the early twentieth century, the market for Dartmoors extended to Cornwall where about 300 animals went every year for use in mines, on farms and by hawkers; others went to northern England as pit ponies (Palmer, 1912). Dartmoor ponies have been exported to all parts of the world. Local groups formed as numbers of ponies increased and established their own *Stud Books*. In some countries, however, ponies are registered through central government or state agencies. In most cases, the DPS in the United Kingdom is regarded as the "Mother" society. "Daughter" societies – in Australia, Belgium, Germany, Holland, Norway and Sweden – ensure that all animals, wherever bred, conform to the requirements and criteria of the Mother society. Both the United States (The American Dartmoor Pony Association) and France (Association Francaise du Poney Dartmoor with a *Herd Book* established in 1969) are fully independent unities. In France, the Dartmoor is mainly found in the north but there are some on the island of Corsica.

Threats to survival of Dartmoor ponies go back several centuries. In 1535, Henry VIII passed legislation to eliminate "nags of small stature" as these were assumed incapable of carrying the weight of a knight and his armour. Fines were imposed on anyone using a stallion under 14 hands (56 inches, 142 cm). There have also been high points, however, as King Edward VII (1901–1910) valued Dartmoors for his polo teams and there was a huge comeback. In 1912, the outlook for the Dartmoor was "distinctly good" (Palmer, 1912). This ceased with the advent of First World War (1914–1918) and the breed was again severely threatened during the Second World War (1939–1945) when the moor was used – as was Exmoor – by the armed forces as a training area. Continuing mechanization throughout the later twentieth century forced the breed into another decline. In 2002, there were only 330 breeding females in the United Kingdom and 864 elsewhere in the world (Alderson, 2003). The breed is considered "endangered" in the Food and Agriculture Organization of the United Nations (FAO) World Watchlist with only 330 females and 61 males in the United Kingdom in 1999 (Scherf, 2000). On the RBST scale it is on Watchlist Category 3, Vulnerable (RBST, 2009).

Exmoor

The Exmoor pony is native to the hill country of the eponymous moor in northeast Devon and western Somerset. The breed is believed to be directly descended (as indeed are other species and breeds) from ponies that migrated from North America across the prehistoric land bridge between Alaska and Asia. Possible ancestors have been studied in fossilized remains in Alaska and these share a unique jaw type with the Exmoor together with seven molar teeth. Exmoors are the most primitive of northern European horse breeds, and their antiquity and genetic distance from other breeds have been well demonstrated (Baker, 2008). It is claimed that there has been very little cross-breeding, which makes the Exmoor probably the purest of all native pony breeds. Its natural environment and isolation have shaped its size, characteristic hardiness, independent spirit and native intelligence. Most Exmoor ponies are now bred in studs off the moor, but the herds of semiferal free-ranging ponies that survive on low-quality moorland grazing and stay out year round are essential to maintain the breed's true qualities. When Exmoor Royal Forest was sold by the Crown in 1818, Sir Richard Acland, the last royal warden, took 30 ponies and established the famous Anchor herd, which is still in existence. Local farmers also bought ponies and were able to keep the bloodlines pure.

The winter coat of the Exmoor has two layers: One is an insulating undercoat and the other an outer coat of greasy coarse hair that is almost waterproof. This insulation is so effective that snow collects on the coats – sometimes referred to as "snow thatching" – because not enough heat is being lost to melt it (Figure 14). The body hair grows in unique patterns that facilitate shedding of water and the plentiful mane, tail and forelock protect delicate parts of the body. The Exmoor has a very large nasal cavity that provides space to warm cold air and a raised rim around the eye protects it against water and debris. The deep girth and chest allow a large digestive capacity that is important for using a large amount of rough forage in the diet.

The Exmoor is extremely hardy and resistant to many equine diseases and has great powers of endurance. The small sturdy animal has ample bone and can carry heavy burdens in relation to its size. It is sure footed and has strong clean legs and feet with a smooth stride. The head is large with small ears. A "toad-eye" appearance is due to fleshy rims that serve to divert water. Bay or brown are the preferred colours although there are also duns. There are mealy patches around the eyes, on the muzzle,

Figure 14. A pure-bred Exmoor pony in her winter coat showing typical "snow thatching" (Bartridge Serenade, Registration Number 277/2).

on the belly and insides of the thighs. Because similar markings occur in equines other than horses they are considered to be a primitive trait. White hairs in the mane or tail are not accepted in the breed standard. Adult males and females weigh 227 kg. Withers height ranges from 11.0 hands (44 inches, 112 cm) to 13.1 hands (53 inches, 135 cm), but the commonest and preferred size is 11.3–12.2 hands (47–50 inches, 119–127 cm) (Figure 15). In spite of small numbers and little morphological differentiation two types of Exmoor are recognized. The first is the Acland (the family that acquired part of the Exmoor herd at the Crown Estate disposal in 1818), which is considered to bear the closest resemblance to the original type. The second is the Withypool, which is slightly larger and generally darker and has a straighter profile.

At the time of the *Domesday Book* in 1085 some 800 ponies roamed Exmoor. Estimates of moorland numbers over the next 900 years varied from 290 in 1819 to 970 in 1746. In 1921, there were an estimated 500 animals. The Second World War was disastrous as the moor became a training ground and ponies were shot and used for meat. By the end of the war only 50 ponies survived. Local people re-established herds but recovery was slow. A 1976 census showed only 99 ponies on the moor; there were 138 in 1990 and then 320 in 2006. Estimates of total numbers worldwide vary. By 1992, there were thought to be 800, all in the United Kingdom except for 35 in Europe (mainly Germany but also Sweden and Denmark) and 15 combined in the Falklands and Canada/United States. Of these, 270 were mares in "breeding situations" but only 100 foals were born and there were 170 geldings (EPS, 1992). In 1999, the World Watch List provided numbers of 390 breeding females and 63 males and put the Exmoor in the Endangered category (Scherf, 2000). The RBST has the breed in Category 2, Endangered (RBST, 2009). Canadian numbers increased from 3 in 1994 to 36 in 2004, and bloodlines of these were being shared with the United States (EPS, 2004) and total Exmoors overseas were estimated at 230. In the early twenty-first century, the Exmoor has – perhaps unfortunately –to some extent become a "lifestyle" breed. It is bred throughout Britain in small herds and as units of one or two animals. Numbers are now about 2 200 with about 160 foals born each year. Low foal numbers from the 1 000 or so mares are because less than 500 of these have foaled in the last 4 years and only about 100 have had more than two foals. Because of low numbers of stallions, a further concern is reduction in genetic diversity. The Exmoor is a truly "rare breed" with less than a third of the numbers of Scottish wildcats and only about one-seventh of the numbers of otters in the United Kingdom. Simple numbers do not, however, tell the whole story as the wild species do not have some 60 percent of their numbers as non-breeders (EPS, 2000).

The Exmoor Pony Society (EPS) was formed in 1921 to preserve and improve the traditional moorland type but a *Herd Book* was not established until 1961. EPS continues to be the leading proponent of the breed, and maintains information on the status of bloodlines and on overall numbers. All pedigree animals, after passing an inspection, are registered with the society and branded with the society's brand and a herd and an individual number. This applies equally to animals born off the moor and those living on it. The latter are rounded up in October of every year and the foals inspected. Colts classed as below standard are gelded.

In North America, the breed is registered in Canada by the Exmoor pony enthusiasts under the aegis of the American Livestock Breeds Conservancy. For effective global conservation, however, the North American registries must align their processes with the EPS so that animals and their genetic material may readily be exchanged. The status of Exmoors in North America is considered critical (ALBC, 2009). Exmoors were exported to Australia in the mid-nineteenth century where two sires, in particular Sir Thomas and Dennington Court, were instrumental in the formation of the Australian pony (APSB, 2009).

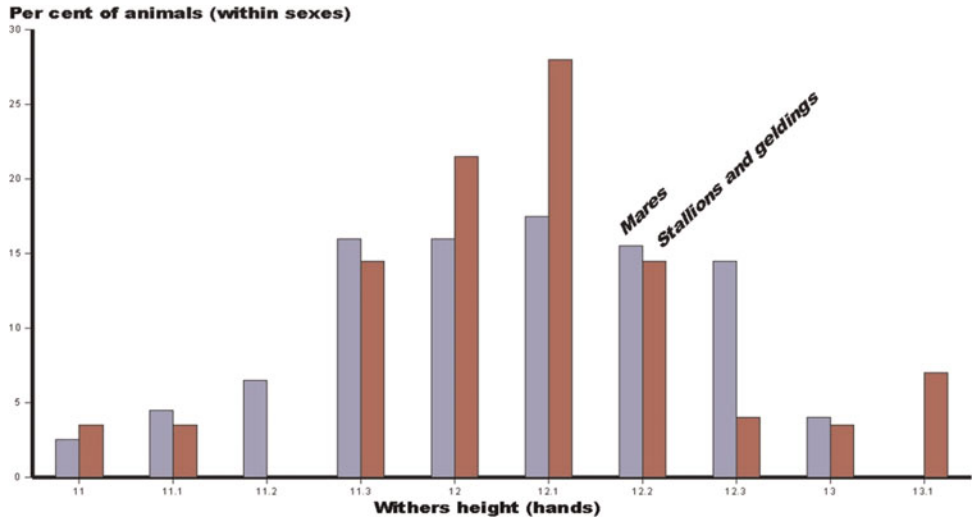

Figure 15. Frequency distribution if withers heights of female and male Exmoor ponies (Source: data from Baker, 2008).

Pure in itself, the Exmoor has been used to improve (or alter) both the Dartmoor (Mardon, 1912; Palmer, 1912) and the New Forest Pony (Mardon, 1912). In the early twenty-first century, the breed is used for a variety of activities including showing, jumping, long-distance riding and driving. Exmoors make good family ponies capable of carrying an adult but amenable enough to be handled by a child. Exmoor ponies are increasingly being used as native grazers in environmentally sensitive areas to maintain or increase plant diversity (Baker, 2008). The current roles of the Exmoor differ from its original ones but are sufficiently diverse to ensure its probable survival and its continued future use in both foreseen and unforeseen situations.

Pigs

One authority noted that it "was all so easy, and so cheap, compared with the expensive and lifelong task of merely improving a breed of cattle, to make a new breed of pigs". There thus appeared at royal shows in some years in the mid-nineteenth century the Molland and the Devon pig (Trow-Smith, 1959). These breeds apparently quickly disappeared into the obscurity whence they had arisen but they may have current relationships with the British Lop and Large Black (Mason, 1996).

Discussion

Extinction is forever – endangered means there is still time.

The wide variety of pastoral habitats of Devon's green and pleasant – if usually rather wet – land has led, over many centuries, to a concomitant variety in domestic livestock species and breeds. As was said of Robert Bakewell, the objective in animal breeding was to "find the best 'machine' for turning the products of the Land into products of higher money value as food for man" (Young, 1786).

Commonplace in eighteenth-century Britain was the inextricable mixture of genetic resources that developed in local environments with little exchange of material between one locality and another (Trow-Smith, 1959). In sheep especially, however, the dominance of the New or Dishley Leicester towards the end of the eighteenth century gradually reduced the number of local races by absorption or replacement. The peculiarly close relation of the sheep to its environment ensured, nonetheless, that many local breeds did survive and indeed developed through judicious within-breed selection into more productive stock. In remote Devon and its diverse environments, it was not the deep-pocketed and wide-landed gentry that developed these genetic resources, as they were more likely to use a fancy breed to grace their parks and lawns. It was, indeed, small tenant farmers who needed an animal that would help to pay the rent of the land they hired by producing those added-value products.

Developed for narrow ecological niches and a predominantly local market all Devon's breeds – bovine, ovine, equine and porcine – regressed as farming systems intensified and in the face of changing consumer demand. Devon cattle were overtaken by larger and leaner (but less thrifty and greedier feeding) continental breeds. Replacement of wool by human-induced fibres and the supply of frozen mutton and lamb from overseas made sheep farming a much less profitable enterprise. Four-wheel-drive vehicles and quad bikes made the small hardy pony breeds almost redundant and their slaughter in two world wars almost eliminated them altogether. Devon's nascent pig breeds were used as foundation stock and absorbed into modern breeds. All the cattle, sheep and pony breeds were able, however, to survive in limited numbers and usually in very circumscribed areas.

In recent years and especially since the mid-1990s and up to mid-2010, the British Government neglected and, was even disdainful of, agriculture. This is typified in the 2001 decision to abolish the Ministry of Agriculture and subsume it in the Department of the Environment, Food and Rural Affairs (DEFRA). Even this title is a misnomer: Ministers appointed were from the ruling political party and were conspicuous for their lack of experience or knowledge of any of the sectors in the department's title. The government clearly lacked concern for food security and frequently stated that the global economy and the market would ensure the availability of food. With especial regard to livestock, the government was even more negligent (or deliberately destructive) as witnessed by the 2001 foot and mouth disease outbreak: "The reduction in numbers of livestock coincided with government policy and may be permanent, and the damage to animal genetic resources has been significant" (Alderson, 2001). The government provided little moral or financial support for livestock, and there were no provisions of any kind for rare breed and the conservation of domestic animal genetic resources. A EU proposal to provide match funding (50/50 EU/government) for these rare breeds was rejected by the British Government.

The UK Biodiversity Action Plan (UKBAP; DEFRA, 2007) has no express provision for domestic livestock although they are expected to assist in conservation of some natural habitats. Even the action plan for an area such as Exmoor – which is hugely dependent on sheep and cattle grazing for its ability to act as a carbon sink and is home to three of Devon's native breeds – mentions domestic livestock, in passing, only three times (Exmoor National Park, 2005). Purple moor grass (*Molinia caerulia*) and Rush pastures are a priority habitat in the UKBAP: There are 400 sites of this Culm Grassland, as it is known in Devon, on Dartmoor covering 1 000 ha

(UKBAP, 2008) and these have depended for generations on sensitive grazing by Devon's locally adapted livestock, but again no special provision is made for conservation and use of this irreplaceable animal resource. Similarly, Moorland and Upland Heath with heather *Calluna vulgaris* and bell heather *Erica cinerea* are priority habitats in UKBAP. Concerted pressure from interest groups (they cannot be dignified as environmentalists or conservationists as they clearly know as little about the one as about the other) resulted in the government imposing restrictions on grazing by sheep, which led quickly to invasion by bracken and other weedy shrubs and concomitantly a reduction in quality habitat for birds, insects and other wildlife (Davies, 2008). The *status quo ante* was restored only when sheep grazing, as a crucial function of upland farming and of habitat conservation, was reinstated.

Conservation management is central to the reforms to the EU Common Agricultural Policy that encourages sustainable and environment-friendly farming. Participation in environmental and conservation schemes, and not production quota, is now the basis for public support (little as it may be) for agriculture. Devon's native breeds are well situated in this new "landscape" and are recognized by many organizations as preferred livestock for grazing areas of conservation value. These gentle and docile animals cause minimal damage to grassland and graze and thrive on marginal land and unimproved permanent pastures. Traditional breeds are recognized by Natural England and can attract some extra area payment as part of higher-level stewardship schemes. This support, together with that of other civic organizations such as the RBST, the individual breed societies and their charitable ancillaries together with that of interested commercial and hobby farmers, will probably ensure survival of Devon's ancient breeds, in the absence of devastating disease, for the foreseeable future.

Devon's ancient indigenous breeds are not historic curiosities. They are, as they have always been, practical weather-proof stock that require the minimum of husbandry and are capable of finding sustenance in distinctly inhospitable surroundings. These breeds have a proud and productive past that, it is to be hoped, will carry them over the next horizon.

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Methodology for morphological characterization of chicken and its application to compare Penedesenca and Empordanesa breeds

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Summary
The current study proposes a method for the morphological characterization of chicken. It involves the measurement of 25 variables, 12 from head measures and the other 13 from rest of the body. This method was used to compare two Catalonian autochthonous chicken breeds: partridge Penedesenca and blond Empordanesa with measurements of 30 hens each. Measurements were taken by two operators, each measured 15 hens per breed. Hens were 30 weeks old, and were bred under the same conditions. As a whole the results showed us that both breeds are very similar morphologically. Nevertheless, nine variables were different between the two breeds and six were different between the two operators, most of them were head measurements. So it is suggested that the measurements on head must be accurate. Only four variables, beak length and width, comb width and ear lobes length, showed interaction among the factors that do not allow us to address the differences between the breeds. The comparison results between Empordanesa and Penedesenca showed that Empordanesa had higher values in wattle length, wattle width and ear lobes width than Penedesenca. Regarding the corporal measures, Empordanesa had higher values of the folding wing and tarsus diameter than Penedesenca although Penedesenca had larger values in keel of sternum length and breast angle than Empordanesa. Empordanesa was a little heavier than Penedesenca.

Keywords: *poultry, zoometry, body measurements, head measurements*

Résumé
La présente étude propose une méthode pour la caractérization morphologique des poules. Elle prévoit la mensuration de 25 variables, dont 12 relatives aux mesures de la tête et les autres 13 relatives au reste du corps. Cette méthode a été utilisée pour comparer deux races de poules autochtones catalanes, Penedesenca Aperdizada et Empordanesa blonde, par le biais de la mensuration de 30 poules pour chaque race. Deux opérateurs, dont chacun a mesuré 15 poules par race, étaient responsables de cette opération. Les poules avaient 30 semaines et étaient élevées dans les mêmes conditions. Dans l'ensemble, les résultats nous ont indiqué que les deux races étaient très similaires du point de vue morphologique. Néanmoins, neuf variables étaient différentes entre les deux races et six étaient différentes entre les deux opérateurs. La plupart de ces différences étaient relatives aux mesures de la tête. Il est ainsi suggéré d'effectuer les mensurations de la tête avec beaucoup de précision. Quatre variables seulement, la longueur et la largeur du bec, la largeur de la crête et la longueur des lobes, ont montré une interaction avec les facteurs qui ne nous permettent pas d'aborder les différences entre les races. Selon les résultats de la comparaison entre ces deux races, l'Empordanesa possède des valeurs plus élevées que la Penedesenca pour ce qui est de la longueur et largeur de la caroncule, et de la largeur des lobes. Quant aux mesures corporelles, l'Empordanesa présente des valeurs plus élevées de pliage des ailes et de diamètre du tarse par rapport à la Penedesenca bien que cette dernière ait des valeurs plus élevées pour ce qui est de la longueur du bréchet et de l'angle de la poitrine par rapport à l'Empordanesa, cette dernière ayant par ailleurs un poids légèrement supérieur à celui de la Penedesenca.

Mots-clés: *volailles, zoométrie, mensuration corporelle, mensuration de la tête*

Resumen
En este trabajo se presenta un posible método de caracterización morfológica de gallinas. Éste método supone la medición de 25 variables, 12 medidas de la cabeza y otras 13 que se distribuyen por el resto del cuerpo. Dicho método se utilizó para comparar dos razas de gallinas autóctonas catalanas: Penedesenca aperdizada y Empordanesa rubia. Se tomaron medidas a 30 gallinas de cada raza. Las medidas fueron tomadas por dos operadores, cada uno midió 15 gallinas de cada raza. Las gallinas tenían 30 semanas de vida y fueron criadas bajo las mismas condiciones ambientales. Globalmente los resultados nos indican que ambas razas son muy parecidas morfológicamente. No obstante, nueve variables presentaron diferencias entre razas y por otra parte seis presentaron diferencias entre operadores, la mayoría de las cuáles fueron medidas de la cabeza, eso nos sugiere que se debería precisar más la toma de medidas en esta zona. Sólo las variables anchura de la cresta, longitud y anchura del pico y longitud de las orejillas presentaron interacción entre factores lo cual nos impide hablar de diferencias entre razas para estas variables. Los resultados de la comparación entre Empordanesa y Penedesenca mostraron que la raza Empordanesa presentó mayor longitud y anchura de barbillas y anchura de orejillas que la

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Penedesenca. Respecto a las medidas corporales, la Empordanesa obtuvo una mayor longitud del ala plegada y del diámetro del tarso aunque la raza Penedesenca obtuvo una mayor longitud de la quilla y del ángulo de pechuga. La Empordanesa resultó algo más pesada que la Penedesenca.

Palabras clave: *aves de corral, zoometría, medidas corporales, medidas en cabeza*

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Introduction

Many livestock species apply methodology for morphological characterization with the aim of comparing their various breeds. In fowls, not many measures have been taken from live birds; a few studies have been done on wild (undomesticated) fowls. Some measurements reported include: length or ornithological measurement, wingspan, beak length, comb length (Scott, 1982; Ceballos *et al.*, 1989), apparent size (Scott, 1982), folded wing length (Scott, 1982; Ceballos *et al.*, 1989; Ralph *et al.*, 1993; SEO, 2000), tarsus length (Scott, 1982; Ceballos *et al.*, 1989; SEO, 2000) and third primary length (SEO, 2000).

In this study, additional measurements have been defined in fowl species, based on parallelism with other animal species but taking ease of measurement into when measuring chickens. Also, some corporal indexes have been defined.

The study was carried out with Catalonian autochthonous chicken breeds (Figure 1), partridge Penedesenca (Figure 2, Francesch and Jordá, 1988) and blond Empordanesa (Figure 3; Francesch, 1994). These breeds are kept in a conservation program that was established in Mas de Bover Center of IRTA in 1982 (Francesch, 1997). The standards were presented by Francesch (2006).

The aim of this study was to propose a morphological characterization method of various chicken breeds by describing some zoometric measures and corporal indexes, and to validate it in two Catalonian autochthonous chicken breeds.

Figure 1. Geographical origin of Blond Empordanesa and Partridge Penedesenca hens in Catalonia (Spain).

Material and methods

Zoometric variables

There were 25 variables selected and divided into four categories depending on avian corporal region: head, neck, body, extremities and general characteristics. All of them are the parts described in a racial standard. All measurements of organ pairs were taken on the right-hand side of the birds.

General characteristics

1. *Weight:* The birds were weighed on the same day by the same operator.
2. *Ornithological measurement* (Scott, 1982): Measuring from the tip of the beak to the end of the tail when the bird was laid down on its back.
3. *Wingspan* (Pettingill, 1985): Distance between the ends of the longest primaries with wings stretched. On the work table, maintain the joints of the wings as stretched as possible.

Head (see Figure 4)

4. *Skull length*: Was measured as the distance between the occipital bone to the insertion of the beak into the skull (where the plumage starts).
5. *Skull width*: Measured at eyes level.

Figure 2. Partridge Pendesenca hen.

Figure 3. Blond Empordanesa hen.

6. *Comb length:* Distance between the insertion of the comb in the beak and the end of the comb's lobe.
7. *Comb width:* Distance from the tip of the central spike until insertion of the comb in the skull. If the number of spikes is even, the highest must be chosen.
8. *Ocular length:* Distance between eyelids corners.
9. *Ocular width:* Second ocular dimension, perpendicular to the length, including the folds of the eyelid.
10. *Beak length*: Length from the tip of the beak until insertion of the beak into the skull (Ceballos *et al.*, 1989).
11. *Beak width*: Measured from the insertion of the beak in the skull and perpendicular until the end of the inferior mandible.
12. *Ear lobes length:* Maximum length, keeping the head of the bird perpendicular to the neck. Person holding the bird should catch the bird's legs with one hand and with the other hand hold the neck on the middle height and with index finger keeping the bird's head perpendicular to the neck's line.
13. *Ear lobes width:* As in the previous measure, measured the second-largest dimension.
14. *Wattles length:* Length from insertion of the right wattle into the beak, holding the wattle with one hand and drawing a straight line to the end of the wattle.
15. *Wattles width:* Measurement of the second maximum dimension of the wattle perpendicular to the length.

Neck

16. *Neck length:* The bird had to be immobilized on its left-hand side on the work table by an operator, stretching legs with one hand and the neck with the other hand, another operator measured the distance between the nape and the insertion of the neck into the body.

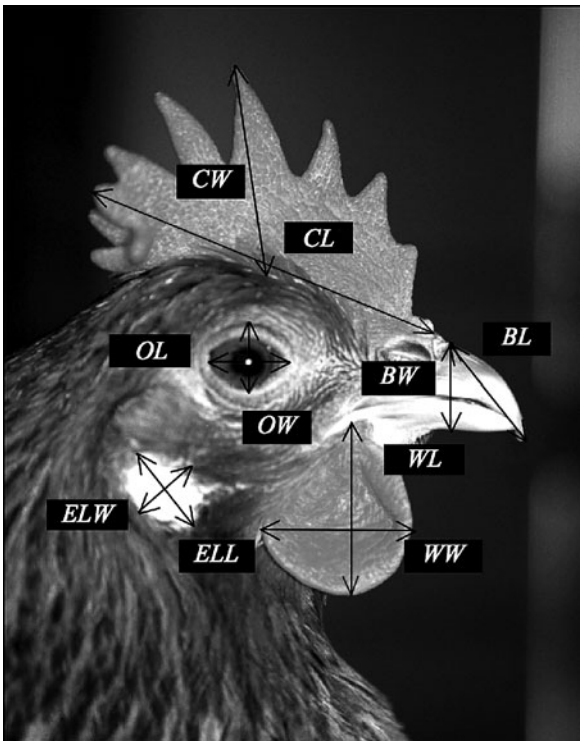

Figure 4. Details of a Patridge Penedesenca hen head with its corresponding measures. CL, comb length; CW, comb width; OL, ocular length; OW, ocular width; BL, beak length; BW, beak width; ELL, ear lobe length; ELW, ear lobe width; WL, wattle length; WW, wattle width.

Body

17. *Back length:* Length from insertion of the neck into the body to the saddle.
18. *Keel of sternum length:* Distance between both vertices of the sternum (*pocessus carinae* and *processus xiphoideus*) leaning the bird on its back.
19. *Tail length:* Length from the tip of a central rectrix to the point where it emerges from the skin (Pettingill, 1985).
20. *Breast angle:* A goniometer was placed at 1 cm from the extreme of the keel (*processus carinae*) of the sternum. The fixed arm of the tool had to be adjusted on the left breast and the mobile arm, on the right breast.

Extremities

21. *Thigh length*: Length from shinbone—femur joint, to shinbone–tarsus joint.
22. *Folding wing length*: The length was taken according to Pettingill's method (1985) along the wing chord. Wing had to be folded and closed to the body, and it corresponds to the length from carpal joint until the end of the longest primary.
23. *Tarsus length*: Length from the notch of the shinbone–tarsus joint until the other end, taking the toes forward 90° respect tarsus.
24. *Tarsus diameter*: Diameter from back to the front, on the middle of the metatarsus bone, without pressuring the skin.

Table 1. LSM means ± standard error of zoometric measurements of adult hens depending on race and operator, and significance of the average difference between both factors and their interaction.

Zoometric measures	Breed		Operator		Significance		
	A	S	I	L	B	O	B*O
Weight	1615 ± 32	1728 ± 32	–	–	*	–	–
Ornithological measure	581.3 ± 4	595.36 ± 4	588.65 ± 4	587.97 ± 4	ns	ns	ns
Wingspan	764.05 ± 5	758.4 ± 5	764.05 ± 5	759.2 ± 3	ns	ns	ns
Skull length	50.14 ± 0.93	49.46 ± 0.93	48.87 ± 1.07	50.73 ± 0.76	ns	ns	ns
Skull width	24.99 ± 0.30	27.25 ± 0.30	24.54 ± 0.35	27.69 ± 0.25	***	***	**
Comb length	62.05 ± 1.59	72.31 ± 1.59	67.21 ± 1.84	67.15 ± 1.30	***	ns	ns
Comb width	35.41 ± 1.59	39.56 ± 1.59	36.26 ± 1.83	38.71 ± 1.30	ns	ns	ns
Ocular length	14.32 ± 0.21	14.20 ± 0.21	15.38 ± 0.24	13.14 ± 0.17	ns	***	ns
Ocular width	11.35 ± 0.19	11.16 ± 0.19	11.10 ± 0.22	11.41 ± 0.15	ns	ns	ns
Beak length	20.16 ± 0.30	19.00 ± 0.30	20.53 ± 0.35	18.64 ± 0.25	**	***	*
Beak width	12.12 ± 0.14	12.79 ± 0.14	12.79 ± 0.16	12.12 ± 0.11	**	**	*
Ear lobes length	14.57 ± 0.54	16.26 ± 0.54	16.50 ± 0.63	14.33 ± 0.44	*	**	*
Ear lobes width	12.42 ± 0.36	14.67 ± 0.36	15.44 ± 0.42	11.66 ± 0.30	***	***	ns
Wattles length	27.16 ± 1.22	39.38 ± 1.22	34.59 ± 1.41	31.95 ± 0.10	***	ns	ns
Wattles width	21.44 ± 0.86	29.64 ± 0.86	24.86 ± 0.99	26.21 ± 0.70	***	ns	ns
Neck length	139.06 ± 2	142.98 ± 2	145.03 ± 2	137.01 ± 1	ns	**	ns
Back length	221.33 ± 3	220.03 ± 3	219.5 ± 3	221.85 ± 2	ns	ns	ns
Keel of sternum length	107.99 ± 1	104.39 ± 1	106.68 ± 1	105.7 ± 1	*	ns	ns
Tail length	159.97 ± 2.47	164.02 ± 2.47	160.50 ± 2.85	163.5 ± 2.02	ns	ns	ns
Breast angle	82.57 ± 1.01	78.90 ± 1.01	79.73 ± 1.01	81.73 ± 1.01	***	ns	ns
Thigh length	122.47 ± 1.48	125.67 ± 1.48	131.10 ± 1.51	117.05 ± 1.51	ns	*	ns
Folding wings length	231.13 ± 1	239.33 ± 1	236.8 ± 1	233.65 ± 1	***	ns	ns
Tarsus length	80.24 ± 1.19	80.36 ± 1.19	81.12 ± 1.38	79.48 ± 0.97	ns	ns	ns
Tarsus diameter	12.68 ± 0.13	13.04 ± 0.13	12.41 ± 0.15	13.31 ± 0.11	*	*	ns
Central toe's length	53.52 ± 0.57	54.17 ± 0.57	55.06 ± 0.65	52.63 ± 0.46	ns	**	ns

A, Penedesenca partridge; S, Empordanesa blond; B, breed; O, Operator; B*O, breed operator interaction; ns non significant.
*$0.05 > P > 0.01$, **$0.01 > P > 0.001$, ***$P < 0.001$

Table 2. LSM means ± standard error of the corporal indexes of hens depending on breed and operator and significance of the average difference between both factors and their interaction.

Corporal Index	Breed		Operator		Significance		
	A	S	I	L	B	O	B*O
Comb index	1.80 ± 0.05	1.87 ± 0.05	1.90 ± 0.05	1.77 ± 0.04	ns	ns	ns
Cephalic index	2.02 ± 0.03	1.82 ± 0.03	2.01 ± 0.04	1.83 ± 0.03	***	**	**
Ocular index	1.27 ± 0.02	1.28 ± 0.02	1.39 ± 0.03	1.16 ± 0.02	ns	***	ns
Ear lobes index	1.18 ± 0.05	1.14 ± 0.05	1.08 ± 0.05	1.24 ± 0.04	ns	*	*
Wattles index	1.28 ± 0.02	1.33 ± 0.02	1.38 ± 0.02	1.22 ± 0.02	ns	***	ns

A, Partridge Penedesenca; S, Blond Empordanesa; B, breed; O, operator; B*O, breed operator interaction; ns, non significant.
*$0.05 > P > 0.01$, **$0.01 > P > 0.001$, ***$P < 0.001$

25. *Central toe length*: Extending the toes on the table, length from the central toe – metatarsus joint until the insertion of the nail.

Corporal indexes

In the absence of indexes used previously and after achieving the linear measurements, we decided to test the relation between length and width of the structures of which both measurements were taken:

1. *Skull index* = skull length/skull width
2. *Ocular index* = ocular length/ocular width
3. *Comb index* = comb length/comb width
4. *Ear lobes index* = ear lobes length/ear lobes width
5. *Wattle index* = wattle length/wattle width

Biological material and maintenance

The data were collected using 60 adult hens, 30 belonging to partridge Penedesenca (A) and 30 belonging to blond Empordanesa (S), all of them were 30 weeks old.

Chickens were reared on the floor, combining natural and artificial light. At the beginning of the rearing there were 19 h of light and each week it was reduced in 15 min

until 14 h when hens started laying; at this moment they were housed in individual cages in the same room.

Until 8 weeks of age feeding consisted of a diet with 18 percent of protein and 2800 kcal/kg metabolizable energy (ME). Between 8 and 20 weeks feeding consisted of a diet with 15 percent of protein and 2700 kcal/kg (ME), and during laying 16 percent of protein and 2700 kcal/kg (ME).

Measuring instruments

Hens were weighed using an electronic scale (precision = 1 g), and the breast angle was measured with a goniometer. The ornithological measurement, wingspan, neck length, back length, tail length and folding wings length were measured with a tape measure (±1 mm). To measure skull length and width, comb width and length, thigh length, ocular width and length, beak width and length, ear lobes width and length, wattles width and length, keel of sternum length, tarsus diameter and central's toe length a calliper (±0.01 mm) was used.

Data collection

Measures were taken with the collaboration of two operators, one holding the bird and other one taking the measurement.

Measures were taken by two operators with the aim of checking differences between operators. Each operator measured 15 hens of each breed.

Statistical analysis

After checking the normality of data distribution and the equality of variances the 25 zoometric measurements were treated statistically like independent variables, breed factor, with two levels (A and S), operator with two levels (I and L) and the interaction between the two factors. The values of each variable and each corporal index were analysed using GLM procedures of SAS 9.1(SAS, 2002–2003).

The linear model for the response of independent variables was:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + e_{ijk},$$

where Y_{ijk} is the response expected in the dependent variable, μ is the average of population, α_i is the effect of breed factor for level i, β_j is the effect of operator factor for level j, $(\alpha\beta)_{ij}$ is the effect of interaction between two factors and e_{ijk} is the random error.

Results and discussion

Zoometric variables

Table 1 shows Least Squares Means (LSM)-means for the 25 zoometric variables that were measured on each bird. Although the Penedesenca and Empordanesa breeds are very similar morphologically, there were significant ($P \leq 0.05$) differences between the two breeds for nine of the variables. Empordanesa was heavier than Penedesenca. For the head variables, wattles length and width, ear lobes length and comb length, measures were higher in Empordanesa breed. For corporal measures, the folding wing length and tarsus diameter, they were higher in the Empordanesa compared with the Penedesenca, whereas Penedesenca breed had a longer length of the keel and a greater breast angle.

On the other hand, for six parameters, there were significant differences between operators: ocular length, ear lobes length, neck length, thigh length, tarsus diameter and central toe's length. Differences between operators indicated that these measurements are difficult and there is a need to improve the methodology.

In four variables, there was significant interaction between breed and operator. These included beak length and width, ear lobes length and neck width. Therefore, at present, we cannot inform about the differences between breeds for these variables. These results show that in these variables the operators have to take measures more carefully.

Corporal indexes

Five zoometric indexes were analysed with the aim of studying the ratio between the two principal dimensions of five structures and to learn about how the structure is. Its utility derived from an interpretation of the structure's shape or the relation between length and width.

Table 2 shows statistic analysis of the zoometric indexes. In the analysis, the significance of breed factor, operator factor and the interaction between them were studied.

We did not observe significant differences between the two breeds independently of the interaction with the operator factor. Significant differences (see Table 1) were found for the operator factor in two indexes: ocular index and wattles index. Interaction between the operator and breed was significant in the cephalic index and in the wattles index; these statistically significant interactions do not allow us to draw conclusions about the differences between the corporal indexes in the two breeds and probably it is because the interaction in the measures was already accounted for in the model.

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Comparison of four European endangered red sheep based on fleece characteristics

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Summary
Patterns of wool variations found in modern sheep breeds may shed some light on the history of circum-Mediterranean migrations, which at present are still largely unknown. In this study, the characteristics of wool from five different local European breeds were investigated. Wool samples were taken from the following sheep breeds: Aranese, Roussillon Red, Castillonnais, Levant Red and Majorcan Red. Specimens were collected from 88 animals in different herds for each breed. The following sheep fleece characteristics were investigated: length of long-coarse, short-fine and kemp (medullated) fibres; their proportion within the staple; yield after scouring with isoalcohol; and fibre diameter. The amount of short-fine fibres was lower in the Levant Red and Majorcan Red breeds, with an inversely proportional amount of kemp fibres. Clean yield with isoalcohol was about 80 percent in all these breeds. Fleece characteristics offer a glimpse of possible morphologic relationships between the Levant Red and Majorcan Red that moreover exhibit a similarity in colour and a geographical proximity. Because very little is still known about the nature of the patterns of the fleece of Atlantic West and North African sheep, the importance of the African influence on existing European Mediterranean red sheep breeds remains to be clarified. A plausible hypothesis is that different influences would have left different traces, with a lesser impact on Pyrenean breeds.

Keywords: *Aranese, Castillonnais, Levantina Red, Majorcan Red, Roussillon Red*

Résumé
Les modèles des variations de la laine découverts dans les races modernes de moutons pourraient apporter quelques éclaircissements sur l'histoire des migrations autour de la Méditerranée qui sont à présent encore largement inconnues. Dans cette étude, on a examiné les caractéristiques de la laine de cinq différentes races locales européennes. On a pris des échantillons de laine des races suivantes de moutons: Aranesa, Rouge du Roussillon, Castillonnaise, Levantina Red et Roja Mallorquina. Pour chaque race, on a collecté les spécimens de 88 animaux de différents troupeaux. Les caractéristiques de la toison des moutons ayant été analysées ont été les suivantes: la longueur des fibres longues et grossières, courtes et fines et de jarre (médullaires), leur proportion dans le bouquet, le rendement après le dégraissage avec l'alcool isopropylique et le diamètre des fibres. La quantité de fibres courtes et fines était inférieure dans les races Levantina Red et Roja Mallorquina, avec une quantité inversement proportionnelle de fibres de jarre. Le rendement de la laine lavée à fond avec l'alcool isopropylique était d'environ 80 pour cent dans toutes les races. Les caractéristiques de la toison donnent un aperçu des relations morphologiques possibles entre les races Levantina Red et Roja Mallorquina qui présentent en outre une similitude de couleur et une proximité géographique. En raison des connaissances très limitées sur la nature des types de toison des moutons de l'Atlantique occidental et de l'Afrique du Nord, l'importance de l'influence africaine sur les races européennes existantes de moutons rouges de la Méditerranée n'a pas encore été précisée. Une hypothèse plausible est que les différentes influences ont laissé des traces différentes, avec un impact moindre sur les races des Pyrénées.

Mots-clés: *Aranesa, Castillonnaise, Levantina Red, Roja Mallorquina, Rouge du Roussillon*

Resumen
Los modelos de variación en la lana que pueden hallarse en las razas ovinas modernas pueden arrojar cierta luz sobre la historia de las migraciones circun-mediterráneas, que aún en la actualidad están poco estudiadas. En este estudio, se investigaron las características de la lana de cinco razas locales europeas diferentes. Se obtuvieron muestras de lana de las razas Aranesa, Roja del Rossellón, Castillonesa, Guirra y Roja Mallorquina, agrupando un total de 88 animales de rebaños diferentes. Fueron investigadas las siguientes características del vellón: longitud de fibras largas-bastas, cortas-finas y kemp, su proporción en la mecha, rendimiento isoalcohólico, y diámetro de las fibras. Las razas Guirra y Roja Mallorquina presentaron la menor cantidad de fibras cortas-finas, y ello en proporción inversa respecto de las fibras kemp. El desengrasado con isoalcohol apareció entorno el 80% para todas las razas. Las características del vellón reflejan posibles relaciones morfológicas entre la Guirra y la Roja Mallorquina, que además exhiben una similitud en su color y proximidad geográfica. Puesto que existe poca información de los patrones del vellón de los ovinos del Atlántico Occidental y del

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Norte de África, la importancia de la influencia africana sobre las razas rojas mediterráneas europeas está aún por dilucidar. Una hipótesis plausible es que diferentes influencias hayan dejado señales diferentes en esas razas, con un menor impacto en las pirenaicas.

Palabras clave: *Aranesa, Castillonesa, Guirra, Roja Mallorquina, Roja del Rrossellón*

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Introduction

Patterns of wool variations found in modern sheep breeds may shed some light on the history of circum-Mediterranean migrations, which at present are largely unknown. But there are not many reports in the literature regarding the relationships among Mediterranean sheep. For instance, Álvarez *et al.* (2004) sampled from six Spanish sheep breeds included in the ancestral Iberian Churra sheep group, Gaouar *et al.* (2005) sampled from two Algerian breeds, El Nahas *et al.* (2008) sampled only from Egyptian breeds and Ali *et al.* (2009) also sampled from Egyptian sheep. They all analysed microsatellites or structural genes.

Moreover, there is very little information about fleece characteristics for the Mediterranean breeds. The few existing studies on comparative fleece characteristics for some of these breeds have been done by Parés (2008) and Perezgrovas *et al.* (2010). Among the authors' drawbacks is that the fleece analysis can be used not only to describe single isolated breeds, but also to contribute to the study of phenotypical groups.

Taking into account rapid genetic erosion (Scherf, 2000) and the importance of animal genetic resources for the future (Notter, 1999), it may not be possible to wait for specific and detailed information on some of the less studied Mediterranean breeds and ecotypes. In this study, we concentrate on a preliminary comparative analysis of fibre and staple characteristics for the red Mediterranean breeds with the aim of establishing fibre morphologic relationships. One of our hypotheses is that differentiation between these red breeds is clearly due to more than colour pattern alone. The approach to apply conventional multivariate analysis remains valuable as these red breeds can be viewed as relatively closely related.

Materials and methods

Breeds studied

Samples were taken from five different local European breeds (Figure 1): Aranese (ARA), Castillonnais (CAST), Levant Red (GUIR), Roussillon Red (BERB) and Majorcan Red (ROJM), the last two being funnel tailed. Except for the ARA, they yield red wool. The ARA, which is also a medium-woolled type (Parés, 2008), was taken as a comparative group, its coat generally being white in colour (other phenotypes are allowed, but none is red).

The ARA thrives in the Aran Valley, in the Central Pyrenees. Husbandry is similar to that for the CAST, i.e. during winter each flock is pastured at the owner's farm in the valley, with feed provided in the stall, and for four months during the summer, the flocks of sheep graze normally in the sub-Alpine and Alpine grasslands. Although it is quite possible that the origin of the Aran breed may include some elements of the Merino, it is necessary to look for the presence of other stock in its formation (Parés, 2008).

The BERB (in Spain known as the Berberina) is a semifine woolled breed from the lowlands of southwestern France, especially concentrated between Narbonne and Perpignan (Babo, 2000). The 2 percent of the breed that are black are not accepted as pure BERB (Brooke and Ryder, 1977). Head, legs and belly are bare of fleece and reddish-brown (Brooke and Ryder, 1977). The origin of the breed is unknown. Pujol (1974) accepts as valid the traditional belief that the BERB is of North African origin, introduced into France via Spain. Sánchez Belda (1976a, 1976b) postulates that both the BERB and the ROJM have Barbary ancestry, and he also rejects the suggestion that the BERB and the

Figure 1. Origin of studied breeds: 1, ARA; 2, BERB; 3, CAST; 4, GUIR; 5, ROJM.

GUIR are closely related. Babo (2000) puts forward the possibility of Solognote or Cobourg influence. In France, the breed has been declining for many years: From more than 50 000 in 1900 (Pujol, 1974) to 3 000 in 1963 (Ministere de l'Agriculture, 1963), but its survival is not at critical levels in Spain, where many pure flocks exist, mainly in the eastern Pyrenees of Catalonia.

The CAST (formerly Saint Gironnaise and locally known as Castelhonesa or Tête Rouge), a breed (like the ARA) from the Central Pyrenees, is found in the Lez valley, southwest of St Geronç (Ariège) (Babo, 2000). The main breeding area is near the villages of Castillon-en-Couserans and Bordes (Brooke and Ryder, 1978). The Castillon breed is described by Quittet (1965), Mason (1967) and Babo (2000): Coat is white; the head, legs, and belly are reddish-brown or partly reddish-brown; the shade varies from dark to light. Lambs are born entirely reddish-brown, and mature animals are not considered pure-bred unless the head is at least partly red, a recessive characteristic (Brooke and Ryder, 1978). It has received influences from the Southdown breed (Babo, 2000). With a count of about 1 000 animals, its survival is critical (Babo, 2000).

The GUIR (also known as Guirra and Sudat) sheep is an autochthonous breed distributed throughout southeast Spain. The GUIR is characterized by a reddish coat colour and very oily wool (Sánchez Belda, 1976a, 1976b; Esteban, 2003) ("Guirra" is the word for "reddish" in the Valencian dialect; "Sudat" means "greasy", in reference to the oily condition of the uncleaned wool – Sánchez Belda, 1976a, 1976b; Brooke and Ryder, 1977). Its numbers have been decreasing in recent years (Esteban, 2003). The colour of the fleece of the animals varies from reddish-brown to yellow-white (Sánchez Belda, 1976a, 1976b; Brooke and Ryder, 1977). The colour of newborn lambs is dark reddish-brown (Sánchez Belda, 1976a, 1976b; Esteban, 2003). With age, the coat lightens, becoming a dirty cream colour at full maturity (Sánchez Belda, 1976a, 1976b; Brooke and Ryder, 1977). Both sexes lack horns (Sánchez Belda, 1976a, 1976b). Years ago it was believed that the GUIR breed was a pigmented variety of the Segureña breed or a similar breed to the Manchega variety (Sánchez Belda, 1976a, 1976b), but nowadays it is considered ethnically independent with African ancestry, consistent with the close ties between the Spanish central Mediterranean coast and the Maghreb (Sánchez Belda, 1976a, 1976b). Specifically, it would have originated on the Atlantic coast of Morocco from the Beni Ahsen breed, which has exactly the same colour and wool characteristics (Sánchez Belda, 1976a, 1976b; Esteban, 2003).

The ROJM (also known as Coete) is a breed found on the island of Majorca. In recent decades, the breed has steadily declined to such an extent that its survival is uncertain (Esteban, 2003). The ROJM developed from crossing the island animals with funnel-tailed and chestnut North African breeds (Sánchez Belda, 1976a, 1976b; Esteban, 2003). Both sexes lack horns (Sánchez Belda, 1976a, 1976b). The tail is funnel shaped and the wool has hairy fibres (Esteban, 2003).

Additional breed descriptions are available from Esteban (2003) for Spanish breeds and Babo (2000) for French ones.

Meat and/or milk production are the unique traits for these sheep, with wool production being unimportant. Farmers shear their flocks once a year between late April and June.

Sampling

Adult animals were randomly chosen (a herd for each breed). Staples were taken before sharing from the shoulder and stored in plastic bags for further analysis. Subsamples were taken to measure fibre length and diameter. A total of 88 animals were sampled.

To identify differences between fibres, macroscopic and microscopic features were analysed using the method as described in Rojas *et al.* (2005).

Traits studied

The following traits were considered in the study: length of long-coarse, short-fine and kemp fibres; percentage of long-coarse, short-fine and kemp fibres (staple composition); percentage of clean yield using isoalcohol; fibre: kemp ratio; average fibre diameter; and F30 (fibres with diameter >30 μm). Formal statistical requirements, such as covariance homogeneity between samples and multivariate normality of distribution, are assumed to be met.

A more precise view of relationships can be gleaned from the similarity coefficients. So to compare differences between breeds, a principal coordinate (PCO) scatter diagram and a paired cluster analysis were done based on the Gower distance matrix, considering each breed as a group. F30 was not considered in this case. Used data from ARA, CAST and BERB were previously compiled by Parés (2008) and data from GUIR and ROJM by Perezgrovas *et al.* (2010). All crude values are available from the first author upon request. Data were analysed using PAST® v. 1.94b (http://palaeo-electronica.org/2001_1/past/issue1_01.html).

Results and discussion

The descriptive statistics obtained are shown in Tables 1 and 2. Statistical differences for some of the studied traits were detected. The results for the breeds studied showed an overall fibre diameter of 29.5 ± 10.65 μm. The rather symmetrical diameter distribution makes them a short, fine wool type. The histograms for frequency of diameter distribution (not presented here) confirm the macroscopic findings, with a lower proportion of long-coarse fibres, although ROJM also shows the highest percentage of long-coarse fibres, indicating a slight tendency towards the

Table 1. Descriptive statistics obtained from fleece analysis (mean ± SE) (breed abbreviations in the text).

	ARA	BERB	CAST	GUIR	ROJM
No. of samples	18	15	28	15	12
Long-coarse fibres length	4.17 ± 0.43^{a}	2.56 ± 1.40^{b}	4.33 ± 1.75^{c}	7.55 ± 0.75^{d}	12.04 ± 2.2^{e}
Short-fine fibres length	4.10 ± 1.12^{a}	2.94 ± 0.55^{b}	4.64 ± 1.06^{c}	6.30 ± 0.95^{ac}	9.54 ± 1.48^{d}
Kemp length	1.28 ± 0.49^{a}	0.88 ± 0.28^{B}	0.85 ± 0.46^{c}	2.40 ± 1.00^{d}	2.92 ± 0.97^{d}
% long coarse	5.85 ± 13.91^{ab}	0.75 ± 2.40^{b}	1.78 ± 6.20^{b}	3.94 ± 3.50^{ab}	10.33 ± 5.12^{a}
% short fine	93.17 ± 13.97^{a}	98.35 ± 2.60^{a}	97.01 ± 6.07^{a}	92.36 ± 4.85^{a}	83.42 ± 7.95^{b}
% kemp	0.96 ± 1.33^{a}	0.88 ± 0.85^{a}	1.19 ± 1.05^{a}	3.69 ± 2.65^{b}	6.23 ± 5.00^{c}
Isoalcoholic yielding (%)	84.29 ± 9.48^{ac}	81.19 ± 10.06^{bc}	80.59 ± 7.71^{bc}	74.71 ± 5.92^{b}	76.50 ± 5.88^{bc}
Fibres:kemp	102.30 ± 17.01^{ab}	121.06 ± 27.13^{a}	117.67 ± 27.30^{a}	42.62 ± 9.44^{ab}	30.54 ± 7.93^{b}

Fibre lengths in cm.
Different letters in the same row indicate significant differences ANOVA ($P < 0.05$) among each breed.

double coat (important percentages of both long-coarse and short-fine fibres). It is also surprising that the ROJM, with the highest percentages of long-coarse and kemp fibres, has a more uniform fleece in terms of SD of fibre diameter than the CAST and GUIR and a more desirable value for F30 than the CAST. All can be classified as "entrefine" wool (medium quality, fibre diameter from 24 to 36 μm) according to the Spanish classification, with the CAST wool being the coarsest (as described by Quittet, 1965; Mason, 1967) and with kemp, and ARA being the finest with nearly no kemp. GUIR and ROJM show the lowest yield after clean yielding with isoalcohol (74.7 and 76.5percent, respectively), thus confirming the "oily wool" that characterizes these breeds (Perezgrovas *et al.*, 2010). The fleece of GUIR is also the least uniform among the studied breeds in fibre diameter. Its fibre lengths appeared slightly longer than those reported by Esteban (2003), which are of 5–6 cm. Obtained fibre lengths for ROJM appeared too longer than those reported by Esteban (2003), which are of 8–9 cm.

Table 3 shows the Gower distances between breeds. Figure 2 presents the PCO scatter diagram. The results of the PCO analysis are eminently interpretable in terms of function of all analysed traits. The first PCO accounts for about three-quarters of the total variance. The first component variate explains the majority of the variance (79.5percent) and acts to separate the two Iberian red breeds (GUIR and ROJM) from the French ones (CAST and BERB).

Figure 3 displays the paired clustering obtained ($\rho = 0.941$). Iberian and French breeds are widely separated from each other, GUIR and ROJM having a low fibre-to-kemp ratio (high percentage of kemp and low percentage of short-fine fibres). Their fibre diameter also tends to be lower; the wool is markedly greasy and the staple longer. GUIR and ROJM could be grouped as "hairy and high-greasy medium-wool" breeds. BERB and CAST could be defined as "low-greasy medium-wool" breeds with the CAST having very coarse fibres.

The results of the clustering analysis here are similar to one of those done by Parés (2008) with ARA and French breeds, but differ slightly from Parés (2010) who investigated 31 Iberoamerican breeds (that include the studied breeds in this research). One reason that the results of this study differ is that the resulting dendrogram may strongly vary according to the selected clustering methods.

Table 2. Some descriptive traits obtained from fibre diameter analysis (breed abbreviations in the text).

	ARA	BERB	CAST	GUIR	ROJM
No. of fibres	2 184	1 248	1 380	1 560	1 248
Min (μm)	9	10	11	12	14
Max (μm)	135	93	145	175	80
Mean (μm)	29.5^{b}	26.7^{a}	35.3^{c}	27.7^{ae}	27.9^{de}
Std. error	0.175	0.175	0.287	0.372	0.267
Variance	67.56	38.50	113.71	216.40	89.43
Stand. dev	8.22	6.21	10.66	14.71	9.46
CV (%)	27.77	23.21	30.18	53.04	33.82
Median (μm)	29	26	34	25	26
25 percentile	24.00	23.00	28.00	22.00	22.00
75 percentile	34.00	30.00	41.00	29.00	31.75
Skewness	2.734	2.178	2.014	5.294	2.078
Kurtosis	154.421	19.355	−29.254	−287.537	6.196
Geom. mean	28.58	26.07	33.91	25.91	26.72
F30	39.42	23.48	66.81	19.49	27.40

All fibre types are included.
Different letters in the row indicate significant differences ANOVA ($P < 0.05$) between means among each breed.

Table 3. Matrix of Gower distances (abbreviations in the text).

	ARA	BERB	CAST	GUIR	ROJM
ARA	0.000				
BERB	0.254	0.000			
CAST	0.251	0.201	0.000		
GUIR	0.429	0.521	0.518	0.000	
ROJM	0.704	0.847	0.838	0.368	0.000

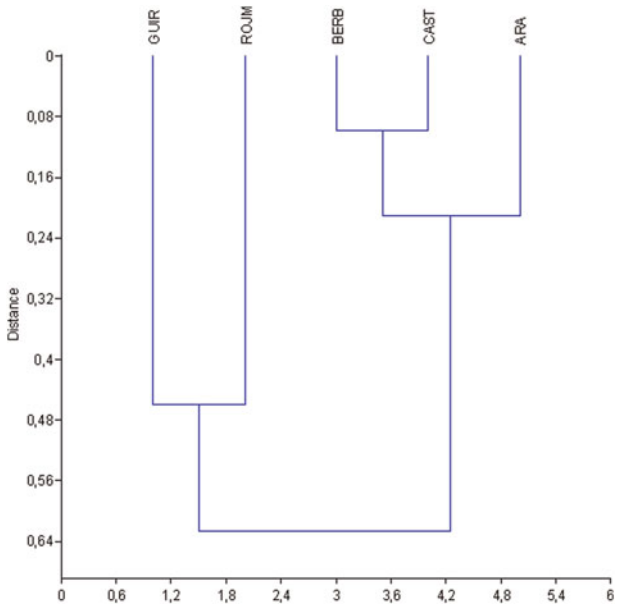

Figure 3. Paired cluster analysis based on the Gower distance matrix depicting the results of the cluster analysis described in the text. Each breed is considered as a group (breed abbreviations in the text). Note the initial bifurcation between Iberian red breeds (GUIR and ROJM) and French ones (CAST and BERB). Note also that GUIR and ROJM are in a cluster of long branches. $\rho = 0.941$.

Discussion

The very early breeds of sheep had two coats: an outer coat of kemp and an under coat of fine wool or down that is shed in the spring (McManus, Rezende and Olegário de Araújo, 2010). The kemp has been gradually bred out of most sheep so that they have coats that are all wool (McManus, Rezende and Olegário de Araújo, 2010). Fleece characteristics offer a glimpse of possible historic relationships among the breeds studied beyond their similarity in colour and geographical proximity.

The geographic location of the Iberian Peninsula makes it a natural link between Europe and North Africa. However, it is a matter of debate to what extent African influences via the Strait of Gibraltar affected Iberia's prehistoric development. Because early African pastoralist communities were dedicated to sheep breeding, a possible means of detecting prehistoric African–Iberian contacts might be to analyse the origin of ovine breeds on the Iberian Peninsula. But because we still know very little about the nature of the fleece patterns of Atlantic West and North African breeds, the importance of the African influence on modern European red sheep remains to be clarified.

Evidence from the Cairo Genizah indicates quite clearly that in the eleventh and twelfth centuries the Mediterranean world was a kind of medieval common

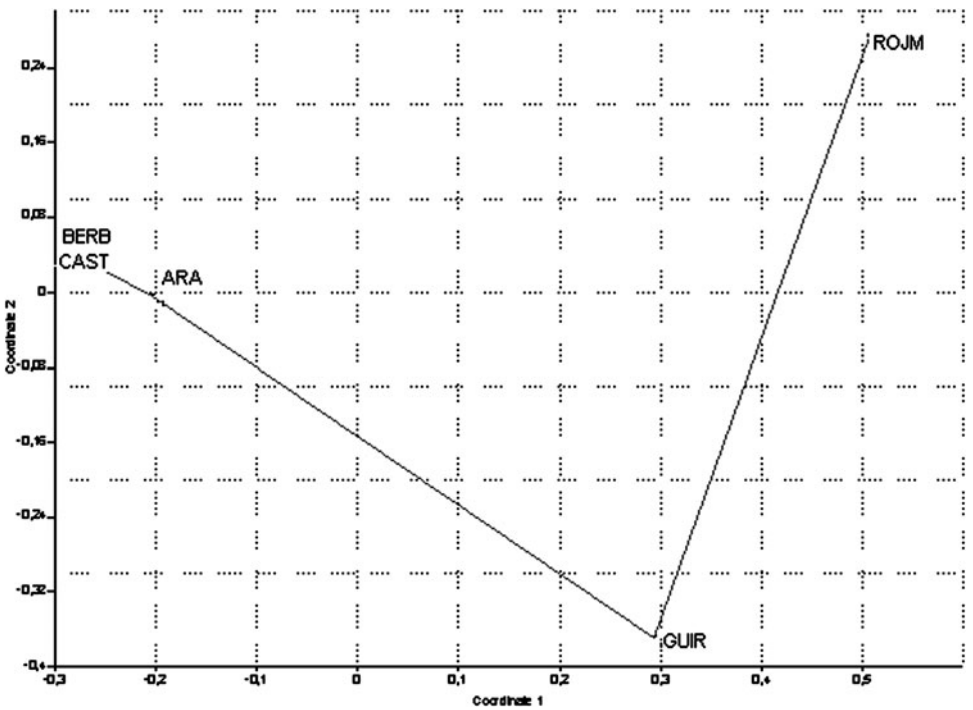

Figure 2. PCO scatter diagram of the first two PCOs based on the Gower distance matrix, considering each breed as a group (breed abbreviations in the text). Note that on the 1 coordinate (explaining the majority of the total variance) the two Iberian red breeds (GUIR and ROJM) are very far separated from the French ones (CAST and BERB) and ARA.

market, forming a free trade area (Goitein, 1967). This communications network, shared by Christians, Jews and Moslems, expressed the notion that there was blessing in movement "fi'l-haraka baraka" (Glick, 1979). In addition, the Atlantic maritime trade between Spain, Portugal and the Maghreb at this time is well documented by Picard (1997). All these influences would have left different traces, with a less frequent influence on Pyrenean breeds. It seems possible that different breeds, as they spread northward, were the origin of different European breeds. Subsequent selective breeding for desirable traits such as wool, milk and meat production as well as environmental tolerance was responsible for the development of more differentiated sheep populations. A loss of wool improvement can be assumed, at least in recent decades. The influx of stocks through different pathways is compatible with this hypothesis as the southernmost breeds (GUIR and ROJM) displaying a high degree of interbreed Gower distances. Moreover, it seems difficult to suppose that the funnel-tailed ROJM and the thin-tailed GUIR, which appear in the same cluster, are closely related. Because very little is still known about the nature of the patterns of the fleece of Atlantic West and North African sheep, the importance of the African influence on existing European red sheep breeds remains to be clarified. A plausible hypothesis is that different African influences would have left different traces, with a lesser impact on Pyrenean breeds. DNAmt finds could further clarify the links between African and Iberian cultures.

More red sheep breeds from the Mediterranean basin and Atlantic African coast had to be included in further studies to achieve a good general study of red sheep breeds: Beni Ahsen breed (Atlantic Morocco); Anatolian Red and Red Karaman breeds (Turkey); Tunisia, Libya, Lebanon and Algeria sheep, etc.

Conclusions

A shortcoming of the methodology used here is that the sampling scheme did not include all the red sheep breeds in the geographical area under study (Mediterranean basin). Nevertheless, the characterization of wool in these five sheep breeds will allow comparison with other breeds as done by Parés (2008) and Parés (2010).

Other traits as staple colour, as used by Perezgrovas *et al.* (2010), would be tested as discriminative parameters in view of comparing breeds.

Acknowledgements

Very special thanks are extended to the Spanish and French farmers who allowed us to collect samples from their herds. Special thanks are offered to the staff at CEAGA in Castielfabib (Rincón de Ademuz, Valencia) for providing the superior facilities for sampling their GUIR animals and to Guillem Riera from the Universitat de Lleida, who kindly supplied us with ROJM samples.

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El ovino criollo Chilote y su potencial productivo

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Resumen
Con este artículo se trata de resaltar las características distintivas del ovino criollo Chilote (OCH) para su conocimiento y utilización como recurso genético animal de gran adaptación a las condiciones del archipiélago de Chiloé, ubicado en la zona sur de Chile. Se describen las características geomórficas del archipiélago, el origen histórico y cultural que rodea este recurso animal, su estructura genética, sus características morfológicas y productivas, así como los sistemas de producción en los cuales se utiliza.

Palabras clave: *ovinos, recursos genéticos, producción animal*

Summary
This article describes the characteristics of the Chilote breed of sheep (OCH) as a genetic animal resource which is highly adapted to the conditions of the Chiloé archipelago in the south of Chile. The article describes the geomorphological features of the archipelago, the historical and cultural origins of the Chilote breed, its genetic structure, its morphological and productive characteristics, and the systems of production in which it is used.

Keywords: *Sheep, genetic resources, animal production*

Résumé
Avec cet article on a essayé de souligner les caractéristiques distinctives de l'ovin créole Chilote (OCH) pour sa connaissance et utilisation comme ressource génétique animale de grande adaptation aux conditions de l'archipel de Chiloé, situé dans la zone sud du Chili. On décrit les caractéristiques géomorphologiques de l'archipel, l'origine historique et culturelle qui entoure cette ressource animale, sa structure génétique, ses caractéristiques morphologiques et productives, ainsi que les systèmes de production dans lesquels elle est utilisée.

Mots-clés: *ovins, ressources génétiques, production animale*

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Introducción

La oveja criolla Chilota (OCH) se ha desarrollado como grupo racial en el archipiélago de Chiloé, formación insular ubicada en el sur de Chile, entre 41°44' y 43°17' de latitud sur (Figura 1). Las condiciones geomórficas y climáticas del archipiélago de Chiloé, así como el manejo antrópico ancestral del pueblo Williche, han tenido una significativa influencia sobre la conformación particular y diferenciación de los ovinos Chilotes, desde los ovinos ibéricos originarios hasta la población ovina adaptada y particular que ha llegado hasta nuestros días, y que conocemos como ovinos Chilotes.

Contexto de desarrollo de la raza ovina Chilota

Los ovinos llegan a Chiloé en 1568, durante la fundación de la Ciudad-Puerto de Castro, que servirá de abastecedora a la ruta marítima que conecta el océano Pacífico y el Atlántico a través del Cabo de Hornos (Montiel, 2006).

Los ovinos que ingresan a Chiloé se originan en las primeras dotaciones traídas desde el Perú por Francisco de Castañeda en 1568. Estos ovinos, a su vez, provenían de animales reproducidos previamente en las Antillas, a partir de los primeros ejemplares ovinos que llegaron de España (Gratacos, 1998). Es posible que pequeños efectivos llegaran posteriormente en los barcos españoles que se avituallaban en Chiloé, después de pasar el estrecho de Magallanes (Montiel, 2003).

Los primeros animales llegados a Sudamérica, con un objetivo reproductivo, fueron del tronco ibérico-churro, debido a la mala adaptación inicial del Merino en las zonas de clima tropical (Miller, 1986; Sánchez, 1986; Sánchez y Sánchez, 1986).

La geomorfología del archipiélago es producto de la acción glacial que conformó los canales y fiordos que en la actualidad separan este territorio de la zona continental del cono sur americano. La geomorfología post-glacial implica un paisaje accidentado, de pendientes variables y acumulaciones irregulares de material rocoso. Sobre este

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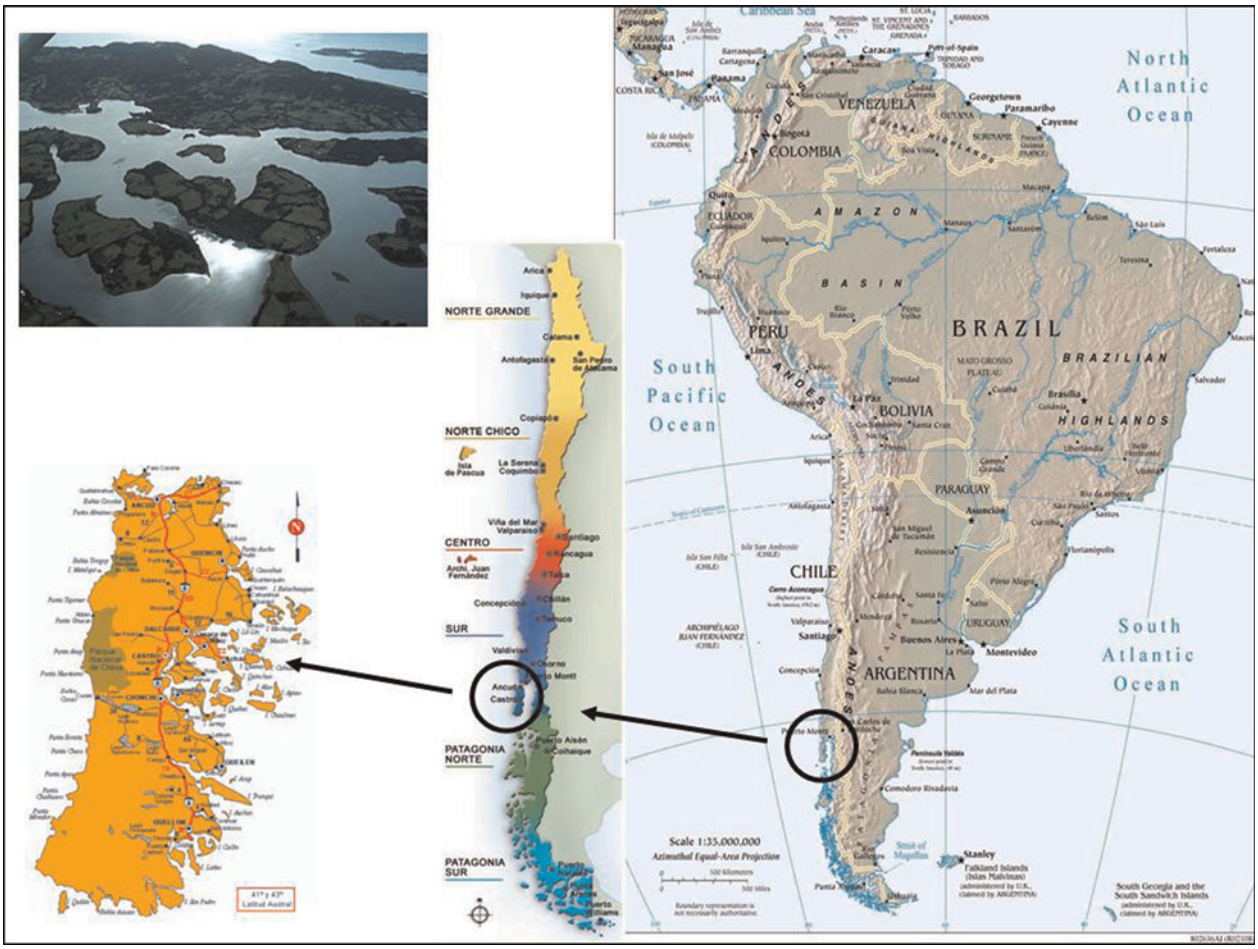

Figura 1. Ubicación del archipiélago de Chiloé, Chile.

material se acumularon grandes capas de ceniza volcánica, muy porosa y que corresponde al material generador de los suelos Andisoles característicos de esta zona (Montiel, 2003; Vera, 2003).

La génesis particular de los suelos ha determinado bajos niveles de pH, altos niveles de saturación de aluminio, altos contenidos de materia orgánica, así como bajo contenido de bases y de elementos como fósforo, nitrógeno y potasio, lo que repercute en una deficiente nutrición de las plantas y ha definido una cobertura vegetal de lento desarrollo y bajo valor alimenticio para el ganado (IREN, 1964; Bernier, 1982; INIA, 1997).

El clima del archipiélago es del tipo templado marítimo-lluvioso. Las precipitaciones oscilan entre los 1.800 y los 3.000 milímetros anuales, con un promedio de 2.070 mm al año. La temperatura media anual es de 10,7°C, con máximas absolutas comunes en verano de 26°C y con mínimas absolutas en invierno cercanas a 0° C, siendo poco frecuentes las heladas (Montiel, 2003).

Se presentan agrupaciones vegetales pluviales siempreverdes, donde predomina el bosque perennifolio de *Nothofagus dombeyi*, tanto en estado puro como acompañado principalmente de Mirtáceas. El borde costero de la isla presenta franjas de *Aextoxicon punctatum*, con *Drimys winteri*, *Eucryphia cordifolia* y *Weinmannia trichosperma*. Los sectores de humedales y pantanos sustentan agrupaciones arbustivas de Ericáceas como *Pernettya spp.* y *Tepualia stipularis*, acompañadas por Juncáceas y Ciperáceas. Es probable, también, que en estos ambientes haya estado presente *Pilgerodendron uviferum* (Quintanilla y Matute, 2005).

Respecto a la comunidad vegetal de las praderas naturalizadas, varía según el nivel de intervención y manejo. Así, existen praderas naturalizas mientras que otras han sido mejoradas por fertilización o drenaje y están principalmente compuestas por gramíneas y leguminosas. Las praderas naturalizadas existentes poseen un importante componente matorral y de especies herbáceas de bajo valor forrajero y se han originado principalmente por la eliminación de las áreas boscosas mediante tala, para transformar estos terrenos en suelos de uso agrícola y pecuario. En ellas se encuentran especies muy comunes como *Holcus lanatus*, *Trifolium repens* y *Cynosurus echinatus*. Las praderas expuestas a mayor pluviosidad, cobijan especies como *Acaena ovalifolia*, *Agrostis capillaris*, *Leontodon taraxacoides* y *Leucanthemum vulgare* (INIA, 1989; Ramirez *et al.*, 1991; Quintanilla y Matute, 2005).

El desarrollo adaptativo del ovino responde por un lado a las condiciones ambientales, especialmente la alta humedad ambiente y la escasa calidad del alimento natural; y por otro, al precario manejo antrópico, basado en un sistema extensivo puramente intuitivo, tradicionalmente utilizado bajo estrategias de subsistencia de los campesinos y las comunidades indígenas. Por último, un factor significativo en el desarrollo racial de esta población ovina ha sido el aislamiento reproductivo, incluso entre los animales situados en diferentes islas del archipiélago, generando una población animal con marcadas características locales.

Censo y distribuciòn

En la actualidad, en el archipiélago existe una masa ganadera ovina de 142.000 cabezas, de las cuales alrededor de un tercio son ovinos Chilotes, el resto corresponde a animales híbridos en distintas intensidades, con razas exóticas introducidas en el último siglo (De la Barra y Bravo, 2006a; Mujica, 2006).

Los ovinos Chilotes constituyen uno de los reservorios más abundantes de animales de origen ibérico existentes actualmente en Chile (Figura 2). Sin embargo, hasta mediados del siglo XX el archipiélago de Chiloé llegó a poseer cerca de 250.000 cabezas ovinas de este tipo. La reducción ha obedecido, primero a una generalizada disminución del ganado ovino en el país y, en segundo lugar, a la introducción en los últimos 20 años de ganado ovino de razas exóticas de mayor rendimiento carnicero como Suffolk Down y Romney Marsh (De la Barra y Bravo, 2006b; Mujica, 2006; De la Barra, 2008).

El ovino Chilote se encuentra diseminado por todo el archipiélago, con mayor concentración en zonas marginales, dentro de la isla mayor o en algunas de las islas más alejadas. En las zonas mas centrales de la isla mayor y donde se concentran los mejores pastos, este tipo de ovino criollo ha sido desplazado por razas introducidas recientemente (Fundación Radio Estrella del Mar, 2002).

La recuperación de este recurso genético se inició en 2004, por parte del Instituto de Investigaciones Agropecuarias (INIA), con apoyo de fundaciones locales y organizaciones de productores (Figura 3). En la actualidad se ha constituido un núcleo genético de 150 vientres y 30 machos, que ha permitido realizar los primeros estudios genéticos, etnológicos y productivos de esta población animal.

Genética poblacional

Desde el punto de vista genético, el ovino Chilote muestra una estructura poblacional que no difiere, sensiblemente, de la que presentan las principales agrupaciones raciales ibéricas relacionadas en origen, aún cuando es claramente diferenciable de ellas (Figura 2) (De la Barra, 2008; De la Barra y San Primitivo, 2009). Como grupo poblacional, el ovino Chilote presenta una gran proximidad con diferentes agrupaciones raciales ovinas ibéricas, pero con cercanía significativa con las razas Castellana y Churra (Figura 4), igual en magnitud que la existente entre estas dos razas, permitiendo considerarla como una raza en desarrollo (De La Barra, 2008).

A la fecha se ha podido describir las frecuencias para los distintos alelos de 21 marcadores tipo microsatélites, lo que ha permitido develar en parte las características de su estructura genética poblacional, además de su proximidad y a la vez su diferenciación con las poblaciones relacionadas en origen. La riqueza alélica del ovino criollo Chilote (Figura 5) se circunscribe al rango encontrado

Figura 2. Ovinos Chilotes en típico sistema de producción pastoril.

Figura 3. Pastor de Chiloé aportando ejemplares al Núcleo genético de recuperación del ganado ovino Chilote.

entre poblaciones raciales ibéricas de distintos troncos étnicos.

En cuanto a su diferenciación a partir de su separación y desarrollo aislado, el ovino Chilote presenta 6 alelos que no están presentes en otras poblaciones raciales ibéricas (Tabla 1). En el mismo sentido, se ha detectado la ausencia de 3 alelos, es decir alelos que estando presentes en todas las poblaciones ibéricas estudiadas no lo están en el ovino Chilote.

Respecto a la estructura genética, en la Tabla 2 se presenta la heterocigosidad observada y esperada junto al índice de fijación (Fis) para el ovino Chilote y poblaciones raciales relacionadas en origen. El estudio genético evidencia la existencia simultánea de una alta variabilidad genética y de una elevada endogamia en la población (Tabla 1). Esta estructura genética es muy probablemente causada

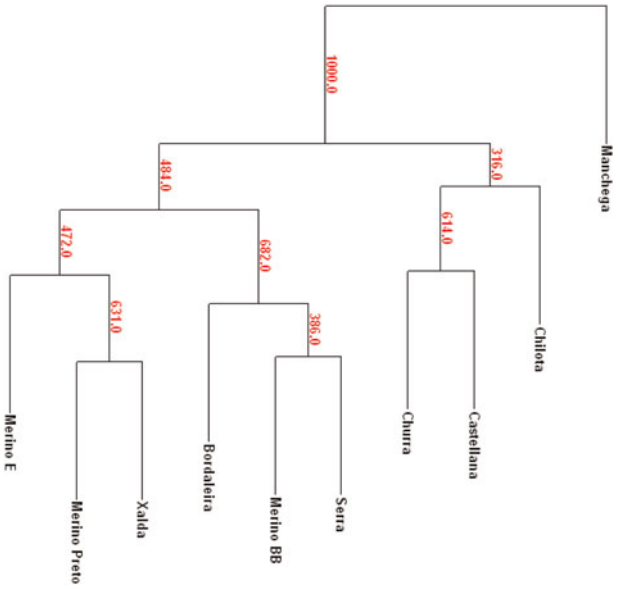

Figura 4. Distancia de Reynold entre el ovino Chilote (OCH) y poblaciones ovinas ibéricas (De la Barra *et al.*, 2008a).

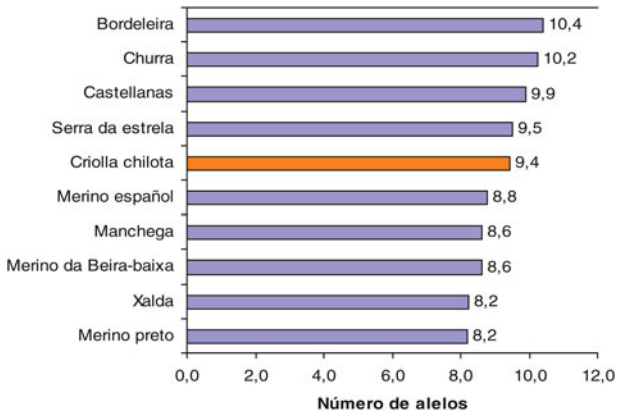

Figura 5. Número de alelos promedio por locus del ovino Chilote (De la Barra *et al.*, 2008a).

por la existencia de subpoblaciones debido a un intenso aislamiento reproductivo, consecuencia de su ubicación en islas diferentes o en regiones aisladas dentro de la isla grande (De la Barra *et al.*, 2008a).

En la Tabla 3 se presentan los resultados de una simulación realizada con el programa STRUCTURE estudiando las frecuencias alélicas del ovino Chilote y de poblaciones raciales relacionadas en origen. En esta simulación se construyen agrupamientos (*clusters*) iterativamente, para determinar si las poblaciones estudiadas se descomponen a su vez en subpoblaciones y con que probabilidad. Existe una gran consistencia interna en cada una de las poblaciones estudiadas, no habiendo diferencias entre la constitución y consistencia interna de razas ibéricas reconocidas como tales y este grupo racial en etapa de caracterización.

En la Figura 6 se representan las distancias de parentesco entre poblaciones relacionadas en origen con el ovino Chilote y éste, apreciándose que la población Chilota es una de las que presenta un mayor grado de diferenciación desde un origen teórico común.

Características morfológicas

La población ovina Chilota presenta faneros y marcas exteriores comparables a las de actuales razas ibéricas como Churra y Castellana, con las cuales posee una probada proximidad genética (De la Barra *et al.*, 2008a; De la Barra *et al.*, 2008b). El formato general del animal es ortoide o recto, con una tendencia muy leve a subceloide o subcóncavo y la grupa caída como parte de un formato muy proporcionado (Figura 7). Es un animal mediolíneo a brevilíneo (49,82 ± 0,39 kg de peso medio en los machos y 46,28 ± 0,86 en las hembras), caracterizándose como un animal compacto, de corporalidad menuda y con huesos gruesos, aún cuando hay una alta variabilidad individual de morfotipo (De la Barra, 2008; De la Barra, 2009).

La cabeza presenta una predominancia del largo sobre el ancho, con un perfil fronto-nasal recto, con una tendencia

Tabla 1. Presencias y ausencias únicas de alelos en el ovino Chilote (De la Barra *et al.*, 2008a).

Marcador	Tamaño (pb)	Frecuencia (%)
RM006	115	1,25
RM006	119	1,25
CSSM31	129	2,5
OARAE0129	130	1,25
OARFCB0304	166	2,5
SPS113	249	1,32
CSRD0247	231	0
MAF0065	138	0
OARCP0049	82	0

muy leve a subcóncava. La cara es estrecha, con orejas de pequeño tamaño, móviles y proyectadas horizontalmente. Machos y hembras carecen de cuernos. El cuello es fino, alargado, sin papada y no presenta mamellas. El tronco es ligero, con costillares arqueados, grupa cuadrada e inclinada y nacimiento de la cola bajo. Las extremidades son de longitud media, con pezuñas fuertes y simétricas. Las mamas se presentan bien desarrolladas y con buena implantación. La piel es fina y sin pliegues. El vellón presenta colores como negro, roya y gris, existiendo también ejemplares blancos. La lana tiende al tipo Churro a entrefino. El vellón se puede extender por el tronco, cuello, cabeza, vientre y extremidades. Con frecuencia aparecen pigmentaciones en forma de grandes manchas en la punta de la cola, frente y cara (De la Barra, 2009).

Exhibe un bajo nivel de dimorfismo sexual, así, en la Tabla 4 se aprecia que las hembras presentan una mayor armonía morfoestructural que los machos, en un contexto general de armonía aceptable; y en que las hembras tienen proyecciones levemente mayores que los machos, presentándose por lo tanto como animales mas afinados y con mayor volumen torácico (De la Barra, 2008; De la Barra *et al.*, 2008a).

El análisis de la faneróptica a través de un test de Twinspan (Figura 8) indica que existe un grupo de 15 variables presentes individualmente en el 90,1% de los animales analizados. A su vez estas variables se presentan como conjunto descriptor del 68,4% de los animales estudiados, por lo cual se puede afirmar que se constituyen en el conjunto de variables principales en la descripción cualitativa del ovino criollo Chilote.

Características productivas

El ganado ovino Chilote (OCH) evidencia una gran rusticidad, alta resistencia a parásitos gastrointestinales y enfermedades podales, especial habilidad para aprovechar forrajes de bajo valor nutritivo, una buena prolificidad y

Tabla 2. Heterocigosidad e índice de fijación (Fis) en el ovino Chilote y poblaciones raciales relacionadas en origen (De la Barra *et al.*, 2008a).

Población estudiada	Heterocigosidad esperada (He)	Heterocigosidad observada (Ho)	Indice de fijación (Fis)
Castellanas	0,758	0,723	0,046
Merino da Beira-baixa	0,747	0,722	0,033
Manchega	0,768	0,689	0,103
Serra da estrela	0,773	0,677	0,124
Bordeleira	0,788	0,674	0,145
Merino español	0,755	0,673	0,109
Churra	0,761	0,673	0,116
Criolla Chilota	0,772	0,652	0,155
Xalda	0,743	0,636	0,144
Merino preto	0,708	0,626	0,116

Tabla 3. Proporción de cada población adscrita a cada uno de diez *clusters* inferidos por el programa STRUCTURE (De la Barra, 2008).

Población	1	2	3	4	5	6	7	8	9	10
Castellana	0,978	0,005	0,002	0,001	0,001	0,001	0,001	0,004	0,001	0,006
Churra	0,030	0,961	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001
Merino da Beira-baixa	0,002	0,001	0,945	0,000	0,002	0,001	0,001	0,039	0,002	0,006
Manchega	0,001	0,001	0,001	0,993	0,001	0,000	0,001	0,001	0,000	0,002
Xalda	0,001	0,001	0,002	0,001	0,989	0,003	0,001	0,001	0,001	0,002
Merino preto	0,000	0,001	0,001	0,001	0,010	0,986	0,001	0,001	0,000	0,000
Serra da estrela	0,001	0,001	0,004	0,001	0,001	0,001	0,969	0,003	0,004	0,015
Merino español	0,001	0,008	0,001	0,001	0,001	0,001	0,001	0,981	0,001	0,003
Bordeleira	0,001	0,002	0,008	0,001	0,001	0,001	0,002	0,001	0,982	0,001
Criolla Chilota	0,016	0,001	0,001	0,002	0,001	0,001	0,001	0,005	0,001	0,971

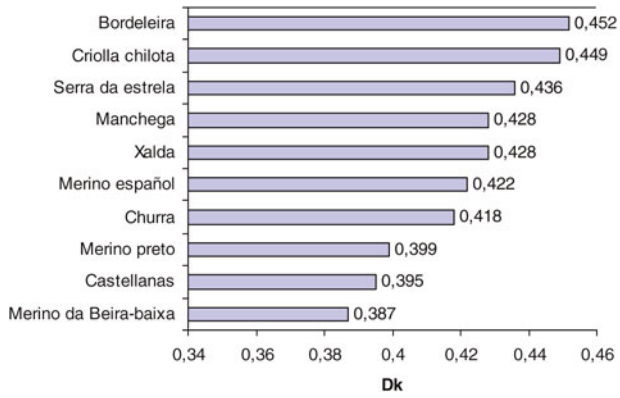

Figura 6. Distancia de parentesco (Dk) entre las poblaciones estudiadas (De la Barra *et al.*, 2008a).

Figura 7. Ideotipo de oveja de raza Chilota.

Tabla 4. Comparación de valores morfométricos medios en ovinos Chilotes de 2 años (De la Barra *et al.*, 2008c).

Variables	Hembras (cm)	Machos (cm)	Diferencia M–H (cm)
Peso	46,28	49,82	*3,54
Perímetros			
de la caña	8,72	9,00	0,28
torácico	82,04	76,91	*–5,13
Longitudes			
de grupa	15,86	15,86	0,00
del muslo	27,42	25,41	*2,01
del lomo	32,64	31,82	–0,82
Anchuras			
del pecho	18,26	17,64	–0,56
ant. grupa	15,31	14,77	–0,54
Alzadas			
de la cruz	58,21	56,09	*–2,12
pelvis	59,63	57,86	–1,77
nac.cola	55,75	54,23	–1,52
Diámetros			
bicostal	27,13	26,91	–0,22
longitudinal	62,81	60,50	*–2,31
dorsoesternal	34,33	33,00	–1,33

*Significancia estadística de 95% con prueba de t.

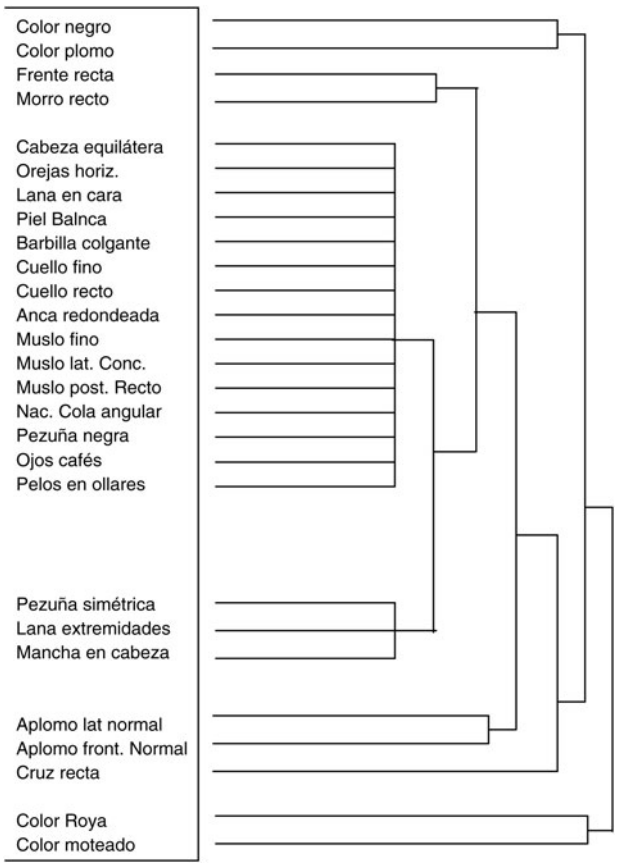

Figura 8. Dendrograma de atributos cualitativos según análisis TWINSPAN (De la Barra *et al.*, 2008d).

habilidad materna. Todo ello lo ha convertido en un animal exitoso en las especiales condiciones de este archipiélago para producir carne (De la Barra, 2008). Posee una aptitud productiva no especializada, aún cuando su orientación fundamental es la producción de carne. Las ovejas no se ordeñan. El vellón de un animal adulto alcanza una media de 2,5 kg. La lana es vasta y presenta una alta policromía, habiéndose identificado siete coloraciones distintas, entre las cuales el blanco es el color más escaso.

Bajo las condiciones agroecológicas del archipiélago de Chiloé, las hembras adultas alcanzan una fertilidad en torno al 98% y una prolificidad que oscila entre un 125% y 140%. El peso al nacimiento de las crías de parto simple oscila entre 3,5 y 4,5 kg y en las de parto doble entre 3,1 y 3,8 kg. Se aprecia en las hembras una gran habilidad materna, con un instinto de protección que se proyecta hasta una edad avanzada del cordero. De igual manera, se estima una buena producción láctea, dada su habilidad para permitir una alta sobrevivencia de los mellizos.

Es un animal de gran rusticidad, muy adaptado a recursos forrajeros de baja calidad nutricional, muy apto para el "ramoneo" de matorral e incluso adaptado al consumo de algas disponibles en la costa durante la marea baja. Este ganado evidencia una gran fortaleza podal a enfermedades como el *foot-rot* o Pietín. De igual manera, resiste

bastante bien la alta carga parasitaria existente en las condiciones de alta pluviometría de las praderas del archipiélago.

Conclusiones

El ovino Chilote desciende de los primeros ejemplares de ganado ovino introducidos por los conquistadores españoles en el archipiélago de Chiloé. El intenso proceso adaptativo y el tiempo transcurrido derivaron en una marcada diferenciación del tipo animal generando particularidades morfológicas y genéticas que permiten considerarlo como una raza local de alta significancia productiva. De esta forma, sus habilidades adaptativas, unidas a su utilización ancestral por parte del habitante de Chiloé en la gastronomía y en la vestimenta, así como los modos de producción específicos usados en su manejo, lo han transformado en un valor patrimonial del archipiélago y en un pilar del turismo y de la actividad económica para sus habitantes.

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El ganado criollo colombiano Costeño con Cuernos (CCC)

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Resumen
Este artículo describe el origen del ganado criollo colombiano en general y en particular la formación de una de dichas razas, el bovino Costeño con Cuernos (CCC), el nicho ecológico donde ha prosperado y la historia de la creación del hato de conservación que el Estado colombiano mantiene, desde 1936, en uno de sus centros de investigación, Turipaná, localizado en el municipio de Cereté, Córdoba, Colombia. Igualmente, se detallan las principales características externas, fisiológicas, genéticas y productivas de la raza, con especial énfasis en los resultados de investigación en rasgos de crecimiento y producción de leche. Se concluye que el CCC, por su adaptación al trópico húmedo, es un recurso genético valioso para producir en forma sostenible, competitiva y limpia, especialmente en sistemas extensivos de uso limitado de insumos externos.

Palabras clave: *Colombia, bovinos criollos, Costeño con Cuernos*

Summary
This paper describes the origin of the Colombian Creole breeds, in particular the formation of one of these, the Horned Coastal Creole (CCC) cattle. It outlines the ecological environment where it has flourished, and the history of the foundation of the conservation herd that the Colombian government has maintained since 1936 in one of its research stations, Turipaná, located at the town of Cereté in Córdoba department. Additionally we detail the breed's principal external, physiological and genetic characteristics, with special emphasis on the research results as regards growth and milk production traits. We conclude that the CCC, because of its adaptation to the humid tropic environment, is an important genetic resource to produce in a sustainable, competitive and 'green' way, especially in extensive systems with low external inputs.

Keywords: *Colombia, cattle creole, Costeño con Cuernos*

Résumé
Le présent article décrit l'origine des races créoles colombiennes et, en particulier, la structure d'une de ces races, les bovins Costeño con Cuernos (CCC). Il décrit également le milieu écologique où cette race a prospéré et l'histoire de la création du troupeau de conservation que le Gouvernement colombien entretient depuis 1936 dans un de ses centres de recherche, celui de Turipaná, qui se trouve dans la ville de Cereté, Córdoba, en Colombie. L'article expose en outre en détail les principales caractéristiques externes, physiologiques et génétiques, en mettant un accent particulier sur les résultats de la recherche relatifs aux caractères de la croissance et de la production de lait. Il conclut que la race CCC, en raison de son adaptation au milieu humide tropical, est une ressource génétique importante à produire de façon durable, compétitive et écologique, en particulier dans le cadre des systèmes extensifs à faible apport d'intrant.

Mots-clés: *Colombie, bovins Créoles, Costeño con Cuernos*

Presentado: 10 Octubre 2009; aceptado: 5 Enero 2011

Introducción

El ganado criollo colombiano conocido como Costeño con Cuernos (CCC) debe su nombre a la región de origen, la Costa Atlántica, y a la presencia de cuernos, que lo diferencian de otro bovino criollo colombiano oriundo de la misma región, denominado Romosinuano, el cual también deriva su nombre de la región de origen, Valle del río Sinú, y de la ausencia de cuernos, 'romos' o 'topos' (Pinzón, 1981; Martínez, 1998). Se adapta bien a las variadas condiciones de la Costa Norte de Colombia, desde las muy fértiles, húmedas y planas del valle del río Sinú o las pobres, áridas y onduladas de las sabanas de Bolívar, a las anegadizas del valle del río Magdalena o las fértiles y secas de las llanuras de Valledupar.

Desde su origen a comienzos del siglo XVI y hasta comienzos del siglo XX, cuando se inició el cruzamiento absorbente e indiscriminado de los bovinos de origen *taurus* introducidos por los conquistadores españoles con otros genotipos exóticos, estos fueron la base de la economía pecuaria del país; sin embargo, actualmente,

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todas las razas criollas colombianas se encuentran en estado vulnerable o en peligro de extinción, tomando como base los indicadores establecidos por la FAO (1992).

La población de ganado criollo CCC, detectada en el censo llevado a cabo en 1999 (Martínez, 1999), fue de escasos 416 animales, de los cuales 395, es decir, el 95% del total de la población, se encontró en un solo hato, que corresponde al Banco de Germoplasma de conservación de la raza, ubicado en el Centro de Investigación Turipaná (ICA–CORPOICA), lo que significa que, conforme a los parámetros de FAO (menos de 1.000 vientres, 20 machos y tendencia al descenso) es una raza en inminente peligro de extinción y que, por tanto, requiere de una política especial de manejo, utilización y protección por parte del Estado colombiano. La existencia del hato de conservación (*in vivo)* de la raza no es garantía absoluta de la supervivencia, por tanto se requiere de la participación decidida de los productores, para garantizar la sobrevivencia de la raza.

Todas las razas de bovinos criollos colombianos conocidas en el país, siete en total (Martínez, 1995), fueron el producto de la selección natural que operó en los bovinos introducidos por los colonizadores a la Costa Norte de Colombia: Rodrigo de Bastidas en 1525, Pedro de Heredia en 1533 y Alonso Luís de Lugo en 1542; al sur del país, vía océano Pacífico por la ruta de Balboa, Panamá y Ecuador y por el oriente, por la vía de Venezuela. Todas las importaciones provenían de los ganados existentes en la península ibérica, introducidos desde África y Asia por los invasores árabes, y desde allí a la Española (hoy Santo Domingo) en el segundo viaje de Cristóbal Colón (Pinzón, 1991; Rouse, 1977).

Las razas criollas colombianas obtuvieron su nombre de la región de origen y/o de sus características externas más sobresalientes, así: Blanco Orejinegro (también conocido como ganado antioqueño), por sus principales rasgos fenotípicos: color blanco de la capa y orejas negras (Martínez, 1992, 1995); Romosinuano, ya mencionado, oriundo del Sinú y por la ausencia de cuernos, 'romo' o 'topo'; Chino Santandereano, por su pelo muy corto (lampiño, chino) y por la región de origen, departamento de Santander. En los Andes occidentales se encuentra el Hartón del Valle o Caucano; su nombre deriva de la región de origen (Valle del Cauca) y del parecido de sus cuernos con un tipo de plátano denominado 'hartón', y finalmente el Costeño con Cuernos (CCC), ya mencionado y del cual nos ocuparemos en este escrito. Los ganados criollos del oriente del país (Orinoquia colombiana) Casanareño y Sanmartinero, derivan sus nombres de las subregiones de origen, departamento de Casanare y ciudad de San Martín (Meta) respectivamente (Sastre, 2004; Martínez y González, 2000).

Existen, además, dos razas compuestas, Lucerna y Velásquez, las cuales fueron formadas con base en cruzamientos de Hartón, Holstein y Shorthorn, la primera y con Romosinuano, Red Poll y Brahman Rojo, la segunda.

Finalmente, en la región del Amazonas, se ha identificado un nuevo biotipo, ganado criollo Caqueteño, probablemente producto del cruzamiento al azar entre las razas criollas Sanmartinera, Romosinuano y Hartón del Valle, las cuales se considera como las que dieron origen a la ganadería del departamento del Caquetá (Pinzón, 1981).

Formación del núcleo de conservación del bovino CCC

En el año 1936, el gobierno colombiano, consciente del valor económico que los animales criollos tenían para la producción, estableció, en el Valle del río Sinú, noroeste de la Costa Atlántica, Granja de Montería, el primer grupo de conservación de bovinos criollos. Se adquirieron en las mejores ganaderías de la Costa, 366 animales de ganado 'costeño', especialmente 'romo', para confinarlo en la Granja, con el objetivo de estudiarlo y seleccionarlo; de los 366 animales iniciales 256 eran romos y 110 astados. En el año de 1937 se dividió el hato en dos grupos; los animales con astas (Costeño con Cuernos, CCC) fueron trasladados a la Estación Pecuaria de Valledupar, ubicada en el noreste de la Región Caribe. Posteriormente, en 1955, el CCC fue trasladado de Valledupar a la Granja Experimental de Tolúviejo, departamento de Sucre, perteneciente al Departamento de Investigaciones Agropecuarias (DIA), del Ministerio de Agricultura, y finalmente, en 1962 fue trasladado al sitio actual de conservación y estudio, el Centro de Investigaciones Turipaná, Cereté, Córdoba, bajo el cuidado inicial del Instituto Colombiano Agropecuario (ICA) y actualmente de la Corporación Colombiana de Investigación Agropecuaria (CORPOICA) del Ministerio de Agricultura de Colombia (Pinzón, 1991, Martínez, 1998).

El Centro de Investigación (CI) Turipaná está situado en el Valle del río Sinú (Cereté, Córdoba), a 8° 31' 16" de latitud norte y 75º 58' 11'' de longitud oeste del meridiano de Greenwich. El valle, en su parte baja, corresponde a la zona climatológica de Bosque Seco Tropical (BST), con

una temperatura media de 27,5°C, 83% de humedad relativa y 1200 milímetros (mm) de precipitación anual, distribuidos en dos épocas: una de baja precipitación entre los meses de diciembre a marzo y otra de alta precipitación entre abril y noviembre (Ossa, 2004).

En el año de 1960 se inició el control lechero en la Granja Experimental de Tolúviejo, con el objeto de evaluar la capacidad productiva de la raza, bajo dos sistemas de ordeño, con y sin ternero; los trabajos se continuaron en el CI Turipaná, donde se pudo constatar que el sistema de ordeño con ternero genera mayor producción de leche, posiblemente debido al estímulo del ternero; en el sistema de ordeño sin ternero las producciones fueron muy bajas y el sistema tuvo que ser suspendido debido a que las vacas cesaron su producción, indicando una excelente habilidad o instinto materno (Rubio, 1976). Paralelamente se hicieron estudios de producción de leche bajo diferentes esquemas de cruzamientos con las razas Holstein y Pardo Suizo y en el año 1986, por recomendaciones de consultores externos, se suspendió el ordeño y el ganado pasó al sistema de cría libre (sistema de producción de ganado de carne).

Reseña histórica

Las razas criollas americanas fueron conformadas a partir de las poblaciones de animales de la península ibérica que se introdujeron en la época de la colonización; el bovino criollo americano desciende, por tanto, en forma directa de los animales que llegaron a la isla La Española en el segundo viaje de Colón en el año 1493 y expediciones posteriores. Sevilla, según las crónicas de la época, era la ciudad de España que tenia la exclusividad para organizar los embarques oficiales a América; sin embargo, hay autores que afirman que también salieron barcos para América desde Galicia en el norte de España. Tampoco se sabe si todo el ganado provenía de las regiones cercanas a Sevilla o si algunos embarques se hicieron en las Islas Canarias, ruta de escala habitual en los viajes a América (Rouse, 1977).

Los ganados *taurus* ibéricos de la época del descubrimiento de América (siglo XV), que dieron principio a las razas criollas americanas, son los mismos que originaron las que posteriormente se conocieron en España como 'razas autóctonas españolas'. Por el parecido fenotípico entre ellas, debido a su ancestro común, muchos historiadores las relacionan, erróneamente, como descendientes directas de las 'razas autóctonas españolas', entre las que se cuentan Gallega, Andaluza Negra, Berrenda Andaluza, Pirenaica, Tudanca, Cacereña y Murciana entre otras. Por derivarse de un ancestro común, es normal que en los caracteres externos del CCC y de otras criollas de América se descubran rasgos fenotípicos de las razas ibéricas actuales, incluidas las portuguesas (Martínez, 2007).

Características externas del ganado costeño con cuernos

Apariencia general

El ganado CCC es llamado así, como ya se mencionó, por estar dotado de cuernos, este ganado es de tamaño mediano: la alzada a la cruz, en los machos, varía entre 129 a 139 cm., con un valor medio de 137.8 cm. y en las hembras entre 123 a 127 cm., con media de 126.7 cm. Los pesos adultos varían, entre 532 y 690 y entre 380 y 450 Kg, en machos y hembras, respectivamente (Rubio, 1976).

La cabeza es fina y mediana, con perfil cóncavo, los cuernos son delgados en forma de lira, las orejas son pequeñas y ovaladas. El dorso es recto y fuerte en los machos, aunque un poco débil en las hembras. El tren posterior es un poco estrecho, la inserción de la cola es alta lo cual, en las hembras, compensa la relativa estrechez de la pelvis, aspecto que favorece la no presencia de partos distócicos. Los miembros poseen hueso fino y fuerte; poseen pezuñas sólidas y de color negro muy resistentes a los terrenos fangosos propios de la región de origen.

conformación de las vacas revela aptitud para la producción de leche, con ubre glandular de apariencia colgante, pezones medianos y con venas mamarias bien desarrolladas. Los toros son vigorosos y activos sexualmente; poseen extremidades fuertes y con buenos aplomos; testículos de tamaño proporcionado y prepucio corto, muy adherido al cuerpo (Rubio, 1976).

El color del pelo, como en la mayoría de las razas criollas colombianas, con excepción del Blanco Orejinegro, es amarilla con tres tonalidades: bayo, colorado y hosco. La tonalidad baya casi siempre presenta coloración clara en las mucosas del hocico, halo de los ojos, borla de la cola, pelo de las orejas, cascos y cuernos. Los animales colorados tienen pelaje amarillo rojizo ('monos'); presentan mucosas, borla y cascos de color negro. La tonalidad hosca, presenta una capa de pelos amarillos claros con pelos negros en la región de los flancos, tabla del cuello, paletas, cara y piernas. El tinte de las mucosas, borla y cascos es invariablemente negro. La piel es gruesa y bien adherida, con escaso pelo, corto, brillante y grasoso; todas estas características indican adaptación a las condiciones cálidas y húmedas propias de la Región Caribe (Rubio, 1976).

Características fisiológicas

Las condiciones climáticas que han tenido que afrontar los animales Costeño con Cuernos, por años y centurias, desde cuando llegaron por primera vez a nuestro medio, modelaron una raza perfectamente adaptada a las condiciones ecológicas de la Costa Norte de Colombia. La adaptación es el resultado de la acción conjunta de carácteres morfológicos, anatómicos, fisiológicos, bioquímicos y de comportamiento, en el sentido de promover bienestar y favorecer la supervivencia de un organismo en un ambiente específico. Un aspecto importante de su adaptación a zonas húmedas es, según Pinzón (1981), la calidad de las pezuñas, que lo habilitan para soportar el fango de las inundaciones en la época de invierno en la Costa Atlántica.

Resultados experimentales

Los trabajos experimentales con la raza Costeño con Cuernos comenzaron en la Granja Tolúviejo en el año 1954; en 1967 fueron trasladados al C.I. Turipaná, en donde continúan hasta el presente.

Reproducción y supervivencia

Rubio (1976), en 18 años de observaciones en Turipaná, indicó un porcentaje de natalidad de 74,57%. El mismo autor señala que la edad al primer parto (EPP) entre los años 1950 a 1974 en las Granjas de Tolúviejo y Turipaná, en 1.431 observaciones, fue de 37,6 meses, resultado semejante al reportado por Pérez y Moreno (2000), $37{,}83 \pm 7{,}0$ meses, entre los años 1995 y 1999 en 130 observaciones en el CI Turipaná. El intervalo entre partos (IEP), en un periodo de 23 años y 3.554 observaciones, en la Granja Tolúviejo, arrojó un promedio de 441,8 días (14.7 meses). En un sistema de monta estacional de tres meses, en cría libre con ternero al pie, en el CI Turipaná, entre 1995 y 1999, Pérez y Moreno (2000) reportaron $422{,}71 \pm 136{,}6$ días (14.1 meses). Los anteriores índices reproductivos son muy superiores a los reportados para el país: edad al primer parto, 41 meses e intervalos entre partos que oscilan entre los 18 y 24 meses en diferentes regiones del país (FEDEGAN, 2006). Adicionalmente, Rubio (1976) señala que, en un período de 14 años, la mortalidad en terneros y animales adultos fue solamente del 5,6%.

Producción de leche

La raza Costeño con Cuernos ha sido utilizada, en ordeño con ternero, como productora de leche y carne, en el sistema conocido en Colombia como 'doble propósito'; pero ha ido perdiendo su importancia en los cruzamientos con otras razas cebuinas y europeas, por la falta de reconocimiento de sus bondades adaptativas, representadas en sus adecuados índices reproductivos, de rusticidad (resistencia) y longevidad.

En el año 1960 se inició en la Granja Experimental de Tolúviejo, con el objeto de evaluar la capacidad productiva de la raza, el control lechero bajo dos sistemas de ordeño, con y sin ternero. En el sistema de ordeño con ternero, la producción total y diaria de leche reportadas por Rubio (1976), en 376 observaciones fueron, en lactancias de 266 días, de 1.202,3 y 3,7 Kg, respectivamente.

En el cuadro 1 se presentan los resultados de producción de leche del CCC, en ordeño sin ternero, y de las razas puras Holstein y Pardo Suizo y de cruces de toros de estas razas con vacas CCC, en las condiciones de Turipaná.

Los datos muestran que el CCC, en ordeño sin ternero, reduce en forma drástica la duración de la lactancia (177 d.) y por ende la producción de leche por lactancia que fue de 396 Kg, es decir, 2.2 Kg/d; comparado con el Holstein (6,6 Kg/d); los híbridos, con excepción del ½ PS × ½ CCC, superaron la producción del Holstein y tuvieron un comportamiento similar al Pardo Suizo puro. Los trabajos con los ganados puros Holstein y Pardo Suizo tuvieron que ser suspendidos debido a su pobre comportamiento reproductivo y de resistencia al medio; la hibridación con toros puros también fue suspendida para no incidir en la reducción de la población de la raza (Rubio, 1976).

Cuadro 1. Producción de leche de la raza Costeño con Cuernos y sus cruces con las razas Holstein y Pardo Suizo.

Raza o cruce	No. obs.	*Duración (días)*	Leche (Kg)	Kg/vaca/ día	Relación
CCC	652	177	396	2,2	33
Holstein	162	294	1.950	6,6	***100***
½ H × ½ CCC	187	275	2.000	7,3	111
¾ H × ½ CCC	35	258	1.832	7,1	108
Pardo Suizo	60	315	2.282	7,2	109
½ PS × ½ CCC	53	230	1.318	5,7	86

Fuente: Rubio, 1976.

Crecimiento pre y posdestete de ganado CCC

Los promedios, el número de observaciones y coeficiente de variación de los pesos al nacer (PN), peso al destete (PD), (peso ajustado a 240 días), posdestete (peso ajustado a los 480 días) de machos y hembras CCC bajo el sistema de cría libre se presentan en el cuadro 2.

El promedio general de peso al nacimiento de machos y hembras (PN) de terneros CCC, hallado por Ossa y Pérez (2002), fue de 29,3 Kg. El escaso PN es una de las características de las crías de las diferentes razas criollas; este rasgo se considera muy importante, ya que implica menor dificultad de la vaca al parto, aspecto que redunda en una rápida involución uterina y, en consecuencia, una más pronta reconcepción y por tanto menor intervalo entre partos IEP.

El promedio general de PD, a los 8 meses de edad, fue de 173,27 Kg, lo que implica que la ganancia de peso en el periodo predestete fue de 0,609 Kg/día. El peso al destete es un indicativo de la producción de leche de la vaca, de su habilidad para criar un ternero y, en menor escala, las diferencias en las capacidades de desarrollo de terneros, cuando son manejados bajo el sistema de producción de carne (cría al pie) hasta el destete.

El promedio general de peso a los 16 meses fue de 228,36 Kg, con ganancias diarias de peso de 0,229 Kg/día, entre los 8 y 16 meses. Después del destete el ternero deja la protección materna y debe, usar sus propios medios para proveer su alimento; en estas condiciones los pesos individuales de los animales indican su propio mérito genético. Los PN y PD se encuentran dentro del rango de valores reportados para otras razas criollas (Hernández, 1981; Martínez, 1992, 1998; Martínez y González, 2000; Ossa y Pérez, 2002).

El peso promedio a los 16 meses de los terneros CCC fue de 228,36 ± 27,64 Kg; aunque no hay mayor diferencia con las demás razas criollas utilizadas en el país, los pesos de ellas oscilan entre 210 y 240 Kg, según los reportes de Hernández (1981); Martínez (1992, 1998); Martínez y González (2000) y Ossa y Pérez (2002).

Cuadro 2. Caracterización de los pesos al nacer, destete y a los 16 meses de edad de terneros Costeño con Cuernos en el CI Turipaná.

Carácter	No. de datos	Media Kg	Desviación estándar	CV
Peso al nacer	1.303	29,3	3,6	12,71%
Peso al destete	1.108	173,27	23,71	13,68%
Peso 16 meses	841	228,36	27,64	12,10%

Fuente: Ossa y Pérez, 2002.

Parámetros genéticos

Los valores de los parámetros genéticos, heredabilidad, repetibilidad y de correlación genética entre los PN, PD y peso a los 16 meses se resumen en el cuadro 3. Se obtuvieron directamente a partir de los componentes de varianzas y covarianza del programa MTDFREML (Multiple Trait Derivative Free Restricted Maximum Likelihood) según el método REML (Restricted Maximum Likelihood, Maxima Verosimitud Restringida) de Bolman et al. (1995).

El cálculo de los parámetros genéticos es de gran importancia en los programas de mejoramiento genético animal. El coeficiente de heredabilidad es de gran importancia en la valoración del mérito genético de los reproductores y en la predicción de la respuesta a la selección; así mismo, los valores de repetibilidad nos permiten, cuando son de alta magnitud, (>50%) hacer una selección más pronta y reducir el intervalo entre generaciones. Las correlaciones genéticas igualmente, cuando son positivas y de elevada magnitud, (>60%) permiten una selección más efectiva por rasgos positivamente correlacionados.

Conclusiones

Por sus extraordinarias propiedades de adaptación a las condiciones ambientales de la zona húmeda del país, dada por su eficiencia reproductiva (edad al primer parto e intervalo entre partos) y por su gran habilidad combinatoria con las razas Holstein y Pardo Suizo, asociada a factores productivos y reproductivos, consideramos que los ganaderos del país no deberían ahorrar esfuerzos en la utilización de la raza CCC. Por otro lado si el propósito es producir leche de excelente calidad, económica y sostenible, los resultados relacionados en este trabajo resaltan la importancia del ganado CCC para tal propósito. Con el fin de proteger la raza de su extinción e indirectamente estimular a los escasos criadores, es importante que se estudien los mecanismos para promover programas encaminados a la comercialización de la leche y sus derivados como productos con 'sellos de origen'.

Cuadro 3. Coeficientes de heredabilidad (h^2) repetibilidad (t), correlación genética (rg) y su error estándar (EP), de terneros Costeño con Cuernos en el CI Turipaná

Carácter	h^2	EP	t	EP	rg
Peso al nacer PN × PD	0,082	0,04	0,05	0,02	0,19
Peso al destete PD × P 16 m	0,26	0,08	0,08	0,03	0,045
Peso 16 meses	0,22	0,08			

Fuente: Ossa y Pérez, 2002.

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Conservación del bovino Curraleiro: cuantificación del censo y caracterización de los criadores

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Resumen
El bovino de raza local brasileiro Curraleiro se encuentra en situación de riesgo. Esto ha motivado a un grupo de investigadores a desarrollar acciones relacionadas con la conservación y utilización de estos animales. Son descendientes de bovinos traídos por los colonos ibéricos, que se han adaptado a los pastos de baja calidad, altas temperaturas, clima seco y otros factores adversos que son característicos en el interior de Brasil. Se realizó un censo poblacional con el objetivo de identificar las características de los criadores de bovinos Curraleiro, en los estados de Goiás y Tocantins: fueron entrevistados 28 ganaderos que respondieron a un cuestionario semiestructurado, con información sobre el ganado, las propiedades y los animales. Se estableció el tipo de sistema productivo utilizado y el nivel de tecnología aplicada en las ganaderías. Fueron localizadas 49 ganaderías en los estados de Goiás, Tocantins, Bahía, Pará y Piauí con un número de 3.692 animales. El sistema de producción de las ganaderías de Curraleiro es extensivo, con un nivel medio de tecnología, bajos costos de producción y poco beneficio económico. El riesgo de la endogamia es evidente pero hay un gran interés de los ganaderos en conservar la raza. El censo nacional es bajo y la raza debe ser considerada vulnerable con riesgo de extinción.

Palabras clave: *Desarrollo sostenible, Pé-Duro, criollos, raza local, sertão brasileño*

Summary
The local Brazilian breed of cattle known as Curraleiro is at risk of extinction. As a result a group of researchers have taken action to conserve and utilize these animals. The Curraleiro breed is descended from cattle brought to Brazil by Iberian colonizers. These animals have adapted to pasture of low quality, very low humidity conditions, heat and other adverse factors characteristic of the Brazilian savannah. A population census was conducted and, in order to identify the characteristics of Curraleiro breeders, 28 farmers in the states of Goiás and Tocantins were interviewed using a semi-structured questionnaire, eliciting information about them, their farms and their animals. The type of production system and the level of technology applied in the farms were determined in each case. Forty-nine herds, with a a total of 3,692 animals, were located in the states of Goiás, Tocantins, Bahia, Pará and Piaui. The production system applied to Curraleiro livestock herds is extensive, with a medium level of technology, low production costs and low economic returns. The risk of inbreeding is evident and there is great concern and interest on the part of producers in conserving this breed. Because the national census of these cattle is low, this breed can be considered vulnerable and at risk of extinction.

Keywords: *Brazilian savannah,* criollo *cattle, local breed, Pé-Duro, sustainable development*

Résumé
Les bovins de la race locale bresilienne Curraleiro sont à risque, ce qui a motivé un groupe de chercheurs de développer des actions liées à la conservation et l'utilisation de ces animaux. Ils sont les descendants de bovins introduits par les colons ibériques, qui ont adapté au pâturage de faible qualité, des hautes temperatures, la sécheresse et d'autres facteurs défavorables qui sont caractéristiques de l'intérieur du Brésil. Nous avons effectué un recensement de la population afin d'identifier les caractéristiques des éleveurs Curraleiro dans les États de Goiás et Tocantins. Nous allons demandès á 28 agriculteurs agriculteurs qui ont répondu à un questionnaire semi-structuré, avec des informations sur le bétail, les biens et animaux. I'l a eté identifié un type de système de production utilisées et le niveau de technologie appliquée. 49 troupeaux ont été situées dans les États de Goiás, Tocantins, Bahia, Pará et Piauí, avec un nombre de 3.692 animaux. Le système de production des troupeaux de Curraleiro est vaste, avec un niveau moyen de la technologie, faibles coûts de production et de profit sont faibles. Le risque de consanguinité est évidente mais il ya un grand intérêt des agriculteurs de préserver la race. Le recensement national est faible et la course doit être considérée comme vulnérable à l'extinction.

Mots-clés: *développement durable, Pé-Duro, créoles, race locale, sertão-brésilienne*

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Introducción

Hace más de 10.000 años, los agricultores han criado bovinos, ovejas y cabras de manera sostenible, manteniendo los animales adaptados a las condiciones locales. Hace 200 años, la situación comenzó a cambiar drásticamente, con el surgimiento del concepto raza. Todos los animales de la misma raza pasaron a ser seleccionados por características fenotípicas y el cruzamiento entre razas fue seriamente reducido. Hace algunas décadas, la presión de selección volvió a aumentar, con el fin de mejorar la productividad, pero sin suficiente énfasis en la conservación de la diversidad genética global.

La eficiencia de los métodos modernos de selección, al mismo tiempo que la producción aumentó, condujo a una dramática pérdida de variabilidad genética. Con el desarrollo de las llamadas razas industriales de alta productividad, la presión económica sobre los agricultores les llevó a abandonar la explotación de razas locales tradicionales, con tanta intensidad que algunas razas ya se han extinguido. Esto significa que los recursos genéticos animales están altamente amenazados. Por lo tanto, es importante establecer medidas para promover la gestión sostenible de los recursos genéticos: en primer lugar, la preservación de las razas en peligro de extinción, y en segundo lugar, utilizar programas de selección para restaurar la diversidad genética de las razas industriales y, finalmente, la protección de colaterales salvajes que pueden proporcionar, en el futuro, recursos genéticos útiles (Taberlet et al., 2007).

Concretamente, no se sabe el origen del ganado llevado a América por los conquistadores. Probablemente descienden directamente del *Bos taurus primigenius*, domesticado en la zona pirenaica desde la época paleolítica. Ya que había una amplia distribución geográfica es el ancestro único de todo el bovino doméstico. Para el año 1178, y en el período 1580–1640, España y Portugal fueron un solo territorio. Así que, probablemente, los bovinos ibéricos son los ancestros de los bovinos criollos de las Américas, y su desplazamiento por las distintas regiones, han determinado un proceso de selección natural en poblaciones diferentes y adaptadas a las circunstancias locales (Primo, 1993).

En Brasil, la primera entrada de ganado bovino de origen portugués se produjo entre 1533 y 1534, por orden de Dª Ana Pimentel, esposa de Martim Alfonso de Sousa, donatario de la Capitanía de São Vicente (São Paulo), que tenía la orden de traer a está capitanía hereditaria, el primer lote de ganado bovino desde la Isla de Madeira. En 1535, Duarte Coelho llevó el segundo lote a la provincia de Pernambuco, y desde 1550, Tomé de Souza desembarcó bovinos provenientes de la Isla de Cabo Verde (Primo, 2004).

Por lo tanto, los animales que dieron origen a las razas locales brasileñas fueron originarios de España y Portugal, y su traslado por las diferentes regiones llevó a un proceso de selección natural en distintas poblaciones adaptadas a las condiciones locales. Cada raza y población es producto de la evolución y adaptación a través de los siglos, con diferentes presiones de selección impuestas por el clima, enfermedades, la disponibilidad de alimento y los criterios determinados por el hombre. La formación de una raza es probablemente asociada a la pérdida de diversidad genética en las primeras etapas, así como la concentración y, ocasionalmente, la fijación de algunas características específicas (Mariante y Egito, 2002).

El ganado bovino es conocido en algunos estados como Pé-Duro (Piauí y Maranhão) o Curraleiro (Goiás y Tocantins); descendientes de las diferentes razas traídas por los colonos, fueron adaptándose poco a poco a los pastos de baja calidad, clima caliente y seco, así como otros factores adversos. El resultado de la selección natural fue la supervivencia de los animales (Figuras 1 y 2) adaptados a estas condiciones desfavorables del sertão de Brasil (Carvalho y Girão, 1999). El término genérico del sertão comprende dos ecosistemas brasileños, el Cerrado (sabana tropical brasileña) y la Caatinga (zona de clima subdesértico). El Cerrado ocupa el área central de Brasil, con una superficie equivalente al 22% del territorio nacional, distribuido entre los estados de Minas Gerais, São Paulo, Bahía, Piauí, Maranhão y en la parte septentrional

Figura 1. Bovinos de la raza Curraleiro.

Figura 2. Bovino de la raza Curraleiro.

de la región norte. La Caatinga ocupa alrededor del 10% del territorio nacional; se extiende por los estados de Maranhão, Piauí, Ceará, Río Grande do Norte, Paraíba, Pernambuco, Sergipe, Alagoas, Bahía y el norte de Minas Gerais.

En América Latina, las razas bovinas locales fueron la base pecuaria durante casi cinco siglos y hoy se encuentran en el punto de ser totalmente absorbidas por las razas exóticas. La expectativa de que las razas introducidas resolviesen los problemas de producción y aquellos relacionados con la sanidad y nutrición de las poblaciones locales, los llevó a cruzarlos con las líneas exóticas sin una planificación sistemática de cruzamiento o mejoramiento genético. Este modelo productivo, que aun persiste en muchas regiones ha provocado el descenso o desaparición de diversas razas. En Brasil en el siglo XXI sólo existen cinco razas bovinas localmente adaptadas, cuatro de ellas encontrándose en riesgo de extinción (Curraleiro, Pantaneiro, Crioulo Lageano y Mocho Nacional) y una considerada ya de fomento (Caracu). Para evitar la extinción de la raza Curraleiro, un grupo de investigadores están desarrollando un programa de conservación y diversos estudios para obtener información sobre las características morfológicas, fisiológicas, inmunológicas, de comportamiento, genotípicas, fenotípicas y sanitarias, entre otras.

La etapa inicial de cualquier proyecto de conservación es la realización de un censo de la población, por lo tanto el objetivo del presente estudio fue cuantificar las ganaderías de bovino Curraleiro y, en los estados de Goiás y Tocantins, caracterizar el sistema productivo y perfil de los ganaderos.

Material y métodos

La encuesta de los bovinos Curraleiro comenzó con la Asociación Brasileña de Criadores de Curraleiro (ABCCurraleiro) en 1998 y se terminó en el año 2003. Del 2005 a 2008, la Escuela de Veterinaria de la Universidad Federal de Goiás (EV/UFG) promovió el incremento y expansión de esta encuesta, a través del contacto con los ganaderos por medio de llamadas telefónicas, envió de correos y visitas a las explotaciones.

La información que se evaluó a partir de los propietarios y explotaciones de ganado Curraleiro, en los estados de Goiás y Tocantins, fueron obtenidos por medio de la aplicación de un cuestionario semiestructurado, siguiendo la metodología propuesta por Thrusfield (1995), realizada por miembros del grupo de investigación de la EV/UFG, con la colaboración del veterinario (Demerval da Silva Torres) perteneciente al órgano oficial de salud veterinaria, de la ciudad de Lizarda, Tocantins. Ocho encuestas fueron recogidas en el estado de Goiás y veinte en el estado de Tocantins (Figura 3). Para realizar el análisis de los resultados se aplicó una estadística descriptiva.

La encuesta se dividió en cuatro segmentos. En la primera parte se encontraban los datos generales, que describían la localización de la propiedad e identificación del propietario. El segundo segmento fue la caracterización de la ganadería, que estaba constituido por 29 preguntas relacionadas con la gestión de la producción y la nutrición y sanidad de los bovinos. El tercer segmento, la caracterización de la propiedad, estuvo compuesto por 16 preguntas relacionados con el suelo, las características climáticas, la sanidad y la asistencia técnica. En el cuarto segmento, la caracterización de los ganaderos, se utilizó 22 preguntas relacionadas con el nivel de educación, los ingresos, el lugar de residencia, su opinión sobre la raza Curraleiro y el desarrollo de la industria ganadera.

Para determinar el nivel tecnológico de las ganaderías, se consideró la utilización de las siguientes técnicas de manejo:

1 – identificación de los animales;
2 – registro de los parámetros zootécnicos;
3 – utilización de sistemas intensivos de producción;
4 – suplemento alimenticio;
5 – mineralización;
6 – aplicación de vacunas obligatorias;
7 – control de endoparásitos;
8 – control de ectoparásitos;
9 – desinfección del ombligo en terneros;
10 – uso de la época de monta;
11 – manejo adecuado de cadáveres; y
12 – asistencia técnica.

Las explotaciones que tenían de cero a cuatro técnicas de manejo fueron clasificadas con bajo nivel tecnológico, aquellas con cinco a ocho técnicas de manejo fueron consideraron de nivel tecnológico medio, y por encima de nueve técnicas de manejo con alto nivel tecnológico.

Resultados y discusión

Fueron identificadas y registradas 49 ganaderías, en cinco estados brasileños: Goiás, Tocantins, Bahía, Pará y Piauí (Figura 4). Se obtuvo información adicional de que los estados de Maranhão, Paraíba y Minas Gerais, aún poseen ganaderías de Curraleiro, pero estos todavía no han sido confirmados y contabilizados. El total efectivo identificado fue de 3.692 bovinos (Cuadro 1).

La FAO (Hodges, 1992) establece algunos parámetros para determinar el nivel de amenaza de una población, y uno de ellos es el número de hembras en reproducción. Siguiendo este criterio, puede considerarse a la raza Curraleiro como vulnerable a la extinción (1.000–5.000 hembras en reproducción). Sin embargo, se recomienda un análisis de la dinámica de la población, tasa reproductiva, nivel de endogamia, introducción del cruzamiento con otras razas, ubicación geográfica, características del sistema de producción y ganaderías involucradas en la conservación de recursos genéticos de animales domésticos. Estos parámetros no han sido aún evaluados, pero son

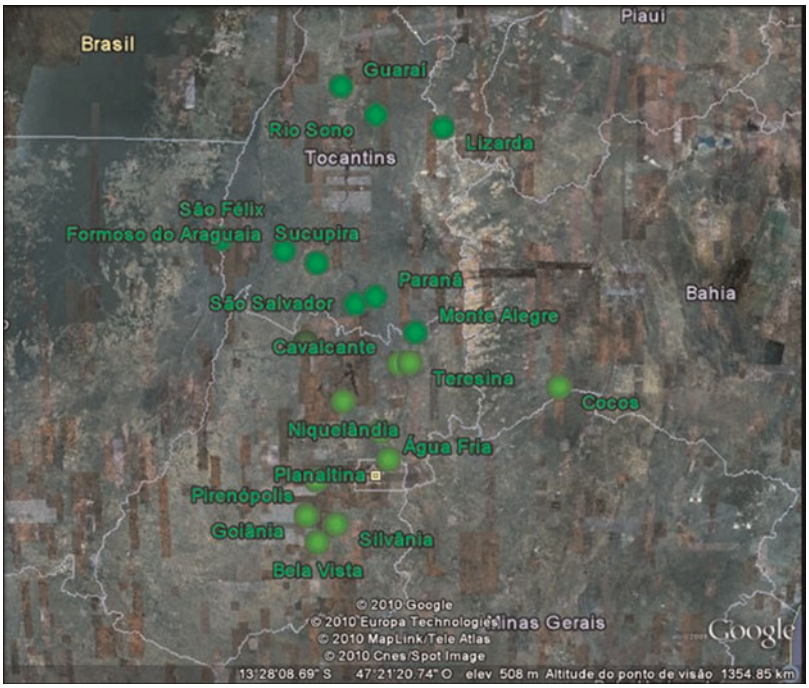

Figura 3. Municipios recorridos (marcas verdes) por el equipo de la UFG para la ubicación y recogida de información sobre las ganaderías de la raza Curraleiro.

fundamentales para la implantación de un programa de conservación en esta raza, así como para determinar las estrategias específicas para las diferentes regiones dónde están siendo criados los bovinos Curraleiros.

Teniendo en cuenta las 28 ganaderías donde se aplicaron las encuestas, 15 (53,6%) tenían un nivel tecnológico medio y 13 (46,4%) un bajo nivel tecnológico. La mayoría de las explotaciones no reunían cinco de las doce técnicas de manejo evaluadas: uso de la época de monta (n = 0), sistema intensivo de producción (n = 0), asistencia técnica (n = 2), suplemento alimenticio (n = 2) e identificación de los animales (n = 5).

Figura 4. Censos de bovinos de raza Curraleiro por estados. Brasil, 2008.

Cuadro 1. Censo nacional de ganaderías de Curraleiro estratificado por estados y municipio, Brasil, 2008.

Estado	Municipio	Número de rebaños	Efectivo poblacional
Bahia	Coribe	1	33
	Cocos	1	11
	Subtotal	**2**	**44**
Goiás	Água Fria	1	83
	Bela Vista	1	40
	Cavalcante	3	134
	Cocalzinho de Goiás	1	55
	Faina	1	273
	Flores de Goiás	1	55
	Goiânia	1	83
	Hidrolina	1	18
	Mimoso de Goiás	1	71
	Minaçu	1	10
	Monte Alegre de Goiás	1	102
	Mutunópolis	1	82
	Niquelândia	1	153
	Pilar de Goiás	1	72
	Pirenópolis	1	92
	Planaltina	1	37
	Porangatú	1	72
	Silvânia	1	88
	Teresina de Goiás	1	143
	Subtotal	**21**	**1.663**
Pará	Irituia	1	158
	Subtotal	**1**	**158**
Piauí	São João do Piauí	1	377
	Altos	1	10
	Batalha	1	69
	Subtotal	**3**	**456**
Tocantins	Formoso do Araguaia	1	18
	Guaraí	1	201
	Itapiratins	1	91
	Lizarda (región de Jalapão)	12	492
	Paranã	1	54
	Porto Nacional	2	215
	Rio Sono	1	150
	São Félix do Tocantins	1	26
	São Salvador do Tocantins	1	81
	Sucupira	1	40
	Subtotal	**22**	**1.368**
TOTAL		**49**	**3.692**

Todos los ganaderos utilizaban un sistema de producción extensivo, la gran mayoría con pasto natural y en bosques del Cerrado (Figura 5). Este resultado es fácil de entender cuando se observa la información disponible en el censo agropecuario nacional. Las regiones dónde se están criando los Curraleiros disponen de grandes extensiones de pasto natural. El estado de Tocantins dispone de 34,6% de zonas agrícolas compuestas por pastos naturales y en la región de Jalapão (al este del estado) el porcentaje es mayor con el 55%. En el estado de Goiás este valor fue de 18,7%. En el nordeste del estado, en el municipio de Cavalcante el porcentaje de pastos naturales llega a 57% y en el municipio de Teresina de Goiás a 61,2% (Brasil, 1998).

El número medio de animales por ganadería en Goiás fue de 77,5, mientras que en Tocantins fue de 66,5. Estos

Figura 5. Pastizales nativos típicos de la región de Jalapão, Estado de Tocantins.

resultados estuvieron por debajo de la media descrita en 153,7 y 142,2 para los estados de Goiás y Tocantins, respectivamente (Brasil, 2006). La baja densidad fue más evidente en las ganaderías de la región Jalapão (Tocantins), dónde fueron identificadas 12 fincas (42,8% del total muestreado). Estas ganaderías eran pequeñas (entre 10 a 30 animales) y algunas criaban a los Curraleiros en una misma área de pastoreo sin división de las mismas. La baja densidad de bovinos encontrada en este estudio concuerda con el Instituto Brasileño de Geografía y Estadística (IBGE) (Brasil, 2006), que informa que el número de animales en la región de Jalapão es bajo, representando solo el 4,8% del total del ganado bovino del estado de Tocantins. Probablemente este hecho se asocia con las condiciones menos favorables para la explotación de los animales, por causa de un suelo muy arenoso y escasa vegetación, resultado de la sequía. Adicionalmente, algunos ganaderos tienen la práctica de realizar pequeños incendios controlados, que se producen durante la estación lluviosa y tienen como objetivo proporcionar pastos verdes a los animales (Figura 6), y que acelera la degradación del suelo.

Los sistemas extensivos de producción de carne de vacuno ecológico tienen un atractivo indiscutible, ya que cuando

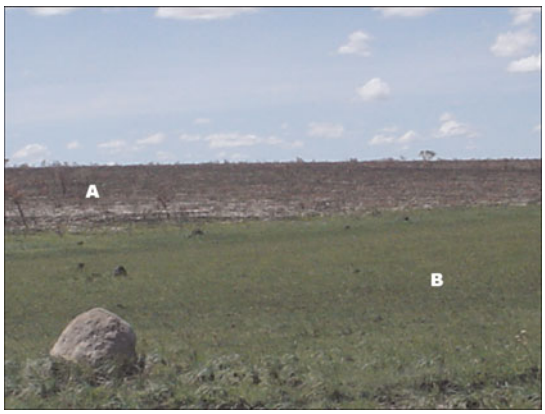

Figura 6. Pastos de la región de Jalapão, Tocantins (A – área quemada; B – área de rebrote).

su uso es adecuado tienden a equilibrar la oferta y la utilización de los recursos naturales, logrando el equilibrio entre la producción y conservación, lo que permite la convivencia de estos animales con la flora y fauna autóctona. El sistema de pastoralismo aplicado en regiones de vegetación nativa, puede ser eficaz en la prevención de incendios, desempeñando un papel importante para mantener la población en las zonas rurales, donde las actividades económicas están limitadas por la distancia y la falta de infraestructura. Esta actividad puede ser una alternativa en el fortalecimiento del turismo rural y otros servicios que mantienen el sector primario (Bellido et al., 2001, Nogales y Baena, 2007).

El sistema silvopastoril con razas locales podría ser desarrollado en Brasil, por la menor exigencia de estos animales de pastos de alta calidad, junto con un pastoreo controlado y la carga animal baja; sería una herramienta para disminuir la biomasa, que es el principal combustible para los incendios, y un modelo adecuado capaz de mitigar los posibles impactos negativos de esta actividad en el suelo y la flora local. El desarrollo de la investigación con este enfoque es esencial, considerando la legislación brasileña actual, según la cual, criar cualquier animal doméstico en los Parques Nacionales, Reservas del Estado y Patrimonio Natural está estrictamente prohibido.

No existe manejo nutricional en las ganaderías de Goiás. En Tocantins está práctica fue observada en dos ganaderías (7,1%) durante la sequía, mediante el uso de la caña o yuca triturada. La administración de suplemento mineral ocurrió en 26 ganaderías (92,9%), siendo suministrada continuamente, pero la mayoría de ellos no se ajustan a criterios técnicos (Figura 7). La producción de bovino de ciclo completo, fue observada en 51,7% de las ganaderías, el 44,8% realizaban solamente cría, y apenas una propiedad realizaba el ciclo combinado de recría y engorde (3,5%). El engorde de los animales castrados para la comercialización de la carne se presenta en dos ganaderías de Goiás (25%) y diez ganaderías de Tocantins (52,6%); sin embargo, estos animales a menudo son sacrificados para el consumo local.

Figura 7. Comedero para el suministro de sal mineral al ganado, Lizarda, Tocantins.

El sistema de producción del ganado Curraleiro, incluso hoy en día, es característico del estado de Goiás desde la época de los 60. Borges (2000) informo que la mayoría de explotaciones de ganado vacuno era organizada de forma precaria, con baja inversión y los animales criados en un sistema de explotación superextensivo. Casi no existían cercas que dividían las ganaderías y pastos, ya que la adquisición del alambre era difícil. Hubo falta de sal para la alimentación del ganado, principalmente en la región norte del estado, donde el producto era poco común en las ganaderías. El capital necesario para desarrollar la actividad pastoril era mínimo. Las construcciones eran fincas rústicas y los métodos de producción rutinarios. El ganado que prevalecía en Goiás era conocido como Curraleiro o Pé-Duro, una raza muy rústica, adaptada a la explotación extensiva en el Cerrado, donde el pastizal natural favorecía la reducción de costos de esta actividad.

Algunas ganaderías seleccionaban animales muy pequeños, para venderlos como mini-bueyes ó mini-vacas, un nicho de mercado muy rentable, pero presenta una selección negativa y degeneración genética de estos animales.

La venta de novillos y reproductores era muy pequeña y sólo se producía en el 36,6% de las explotaciones de Curraleiro. Este hecho se asocia a un problema serio, el aumento de la consanguinidad con la perdida de variabilidad genética, que puede ser confirmado por la información de que el 70% de las explotaciones hacen reposición de reproductores con animales de la propia ganadería o de la región (30%). De acuerdo con Egito (2007), la raza Curraleiro, en comparación con otras razas autóctonas brasileñas, fue la que mostró valores más altos en los valores F y menores niveles de heterocigosis en un estudio molecular. La reducción significativa de la heterocigosis en esta población refleja que el apareamiento no se produce al azar, donde la relación entre macho y hembras es pequeña. La proporción de alelos compartidos entre los animales estudiados fue de 34,37%, siendo inferior apenas en los observados en la raza Caracu (38,39%), en la cual los trabajos de mejoramiento genético son frecuentes y pueden conducir a la acumulación ó fijación de determinados alelos.

Este resultado es bastante preocupante y exige una modificación en el manejo reproductivo. Wiggans et al. (1995) verificaron en bovinos una disminución de las características productivas, asociada con el aumento de la endogamia. Este resultado concuerda con las directrices de los programas de conservación de recursos genéticos animales, donde se da prioridad a mantener la máxima diversidad genética de cada especie, inclusive previendo imprevistos para el desarrollo de sistemas de producción sostenible, ya que las características que pueden ser necesarias en el futuro son indeterminadas (Egito et al., 2002).

La información sobre los parámetros de producción y reproducción fueron observacionales, y por tanto inexactas. Segundo Barbosa y Vilela (2006), la falta de registros

precisos de estos parámetros dificulta evaluar el potencial productivo y económico de la producción pecuaria.

La reproducción se realizaba con monta natural, permaneciendo juntos machos y hembras durante todo el año. La primera cubrición se producía entre 2 y 2,5 años de edad y el primer parto entre los 3 y 3,5 años. Por la información de los propietarios y empleados que manejaban los animales 'es poco posible que la vaca no se quede preñada, excepto en el año que hay falta de pasto'. En condiciones adecuadas paren una vez al año terneros con pesos entre 17 y 21 Kg. La desinfección del ombligo se practica en el 50% de las ganaderías. Las vacas producían suficiente leche para la lactancia (2 a 4 litros/día), y en algunas ganaderías utilizaban la leche de las más productivas para el consumo local y también para la producción de derivados. El peso estimado al sacrificio fue 300 a 330 kilos con una edad media de 3,5 a 4 años, reportando buenos rendimientos a la canal. Los valores informados por los ganaderos son similares a los descritos por Barbosa y Vilela (2006), para sistemas de producción con poca aplicación de tecnología.

Es común la venta de bueyes para la tracción de vehículos, una tradición viva en las fiestas religiosas y eventos culturales del estado de Goiás. Según Maia y Coelho (2006), la Fiesta del Divino, en el municipio de Trindade, Goiás, reúne cientos de carretas de bueyes que acompañan las romerías de peregrinos procedentes de diferentes regiones del estado, llevando sus pertenencias y alimentos. Muchos peregrinos informan que las carretas también son utilizadas en pequeñas propiedades para transportar leña y el maíz cosechado en los campos.

A pesar de no haber rentabilidad con el ganado Curraleiro, los ganaderos han expresado su entusiasmo con la raza que obtuvo un grado de satisfacción de 9,4 a 9,6 (escala 0–10), destacando como principales ventajas la rusticidad y los bajos costos de producción de estos animales. Cuando los comparamos con otras razas bovinas criadas por estos ganaderos, éstos ganaron más de ocho puntos sobre las características, tales como: resistencia, temperamento dócil, poca necesidad de cuidados, productividad y bajos costes de mantenimiento. Estas cualidades innatas de los Curraleiros, han dirigido el trabajo de los investigadores a verificar con exactitud dichas características y sus aplicaciones prácticas en el desarrollo pecuario. El potencial de está raza ha sido conocido durante mucho tiempo, Vianna (1927) afirmaba que los Curraleiros tienen cualidades que deben ser desarrolladas y mejoradas, destacando su resistencia, fácil manejo, calidad de la carne y leche rica en grasa. Aunque su producción fuese pequeña el manejo zootécnico podría mejorarse.

Los criadores de ganado Curraleiro están extremadamente relacionados con el ambiente rural: sólo el 30% han realizado estudios superiores, 44% viven en las ganaderías y el 51,9% viven exclusivamente de la actividad agrícola. Considerando el tiempo de dedicación en esta actividad, el 70,3% son ganaderos por más de 20 años y la gran mayoría poseen bovinos Curraleiro, también por más de 20 años. Cuándo se les preguntó sobre las razones que les hizo criar estos animales, respondieron en unanimidad, es la tradición, el sabor y calidad de la carne. Es evidente el carácter cultural y familiar, como la creencia que la actividad permanecerá en las generaciones futuras.

El Curraleiro, al ser un *Bos taurus*, tiene una carne sabrosa, suave y con un contenido de grasa adecuado. Además, su robustez y mayor resistencia a ciertas enfermedades y parásitos, minimizan el uso de insumos químicos como los medicamentos y acaricidas, lo que permite el uso de la raza en sistemas de producción ecológica (Carvalho, 1997). Estas características pueden ser aprovechadas como un diferencial en el mercado que ha crecido considerablemente: como es el consumo de productos saludables como el ecológico. Actualmente, el mercado consumidor de carne de vacuno en el mundo se enfoca en un nuevo patrón de demanda, poniendo énfasis en la calidad y seguridad alimentaria, más allá de la percepción de los problemas ambientales derivados del sistema de producción tradicional y la exigencias de sistemas de producción que son al mismo tiempo socialmente justos, económicamente viables y ambientalmente sostenibles (Ramos Filho, 2006).

En comparación con el sistema de producción desarrollado en el suroeste de la región mediterránea de España (dehesas), se pueden observar algunas similitudes en el número de animales, la extensión de las explotaciones, la carga animal y la calidad de los suelos y pastos. Por el contrario, estas explotaciones españolas presentan mayores tasas de mortalidad y un alto nivel de comercialización y rentabilidad. El modelo utilizado en las dehesas cumple estratégicamente con los requisitos del mercado europeo, que valora más los productos ecológicos libres de aditivos, y que da prioridad a la conservación de la biodiversidad, el bienestar animal, la calidad y seguridad alimentaria (Bellido et al., 2001; Perea et al., 2007). El establecimiento de un modelo adaptado a las condiciones del Cerrado podría ser una alternativa viable para la conservación del ecosistema como del bovino Curraleiro.

Costa et al. (2008) analizaron los indicadores de sostenibilidad económica, ambiental y social de los sistemas agrícolas que utilizan el bovino Maronés, una raza autóctona criada en la región de Vila Real, Portugal. Algunos indicadores económicos son difíciles de evaluar en explotaciones de Curraleiro, porque los animales no poseen un valor de mercado y raramente son comercializados; además, los productores no están dispuestos a dar información contable y financiera a quienes los consulten. En cambio, los indicadores ambientales y sociales evaluados, como los sistemas de producción son muy similares a los obtenidos en Portugal. Las diferencias se encuentran en la extensión de la propiedad y el valor del producto comercializado debido a los subsidios del gobierno. En la crianza de la raza Maronesa predominan las explotaciones minifundistas, la certificación de la carne aporta un valor añadido al producto final, y el apoyo financiero otorgado

por el gobierno ayuda en gran medida la sostenibilidad económica del sistema productivo.

La política agrícola de Unión Europea se ha centrado principalmente en medidas que promueven sistemas de explotación sostenibles, menos intensivos, con el objetivo de proteger el medio ambiente y preservar el ecosistema rural. Las subvenciones y el apoyo financiero a los ganaderos de razas autóctonas les da la posibilidad de comercializar productos de alta calidad y denominación de origen, y han promovido un aumento del interés en criar estas especies autóctonas, debido principalmente a sus características adaptativas a las condiciones ambientales de cada región (Matos, 2000). Esto puede ser un punto de partida para las negociaciones entre los ganaderos de razas locales y gobierno brasileño, creando mecanismos de compensación que estimulen el crecimiento de estás poblaciones.

Conclusiones

El censo de los bovinos Curraleiros es bajo y la raza debe ser considerada en peligro de extinción. Los sistemas de producción aplicados en estas ganaderías se caracterizan por tener un nivel medio de tecnología, con bajos costos de producción, poco retorno económico y riesgo de endogamia. Como existe un gran interés entre los ganaderos en preservar la raza, la investigación y difusión de las tecnologías, pueden ser una herramienta importante en la utilización del potencial de este recurso genético y establecer modelos sostenibles que se han aplicado con relativo éxito en otros países.

Agradecimientos

- La Asociación Brasileña de Criadores de Curraleiro (ABCCurraleiro) y los ganaderos por la valiosa información proporcionada;
- El Ministerio de Integración Nacional, por la financiación para este trabajo;
- El Consejo Nacional de Desarrollo Científico y Tecnológico (CNPq) por la concesión de una beca de doctorado.

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Animal Genetic Resources, 2011, 48, 117. © Food and Agriculture Organization of the United Nations, 2011

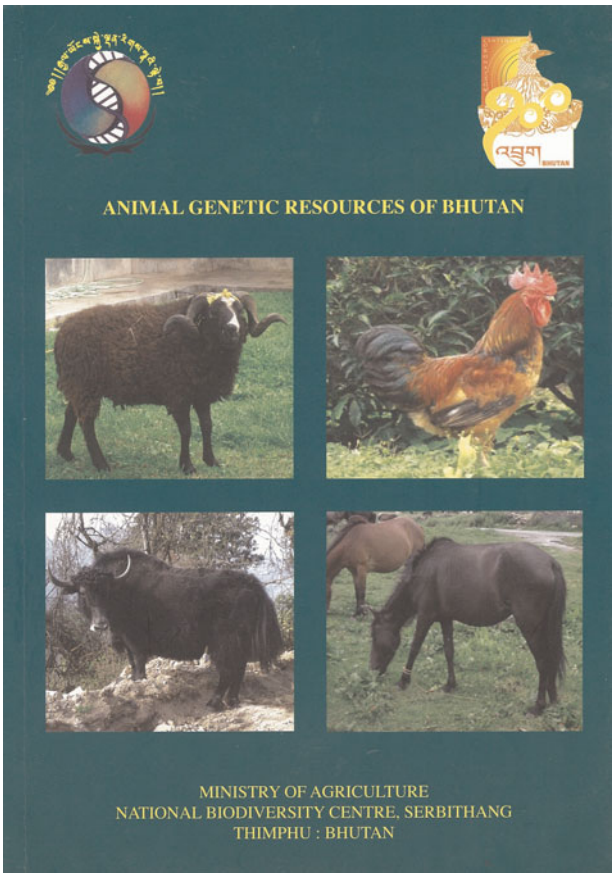
Recent Publication

Animal genetic resources of Bhutan

National Biodiversity Centre, Serbithang. Published in 2008, pp. 51
Available at http://www.nbc.gov.bt/publications

doi:10.1017/S2078633611000117

This publication provides an overview of the animal genetic resources of Bhutan targeted at researchers, extension agents, farmers, students and the general public, with the aim of increasing awareness of livestock biodiversity and conservation. It is divided into seven chapters, each devoted to a particular species: nublang (traditional cattle breed of Bhutan); yak; sheep; goat; poultry (chickens); pig and horse. Each chapter has a standard format for easy reference: a short introduction is followed by the local and scientific names of species and breeds, photographs, descriptions of origin and population size, geographic distribution (map), utility, distinguishing features, physical parameters, genetic variation/diversity. management system, production performance, socio-cultural/religious and economic importance, selection environment, breeding structure, population trends and threats, conservation initiatives and conclusions. The book is intended as a precursor to more detailed documentation of the country's animal genetic resources, which will be presented in future publications.

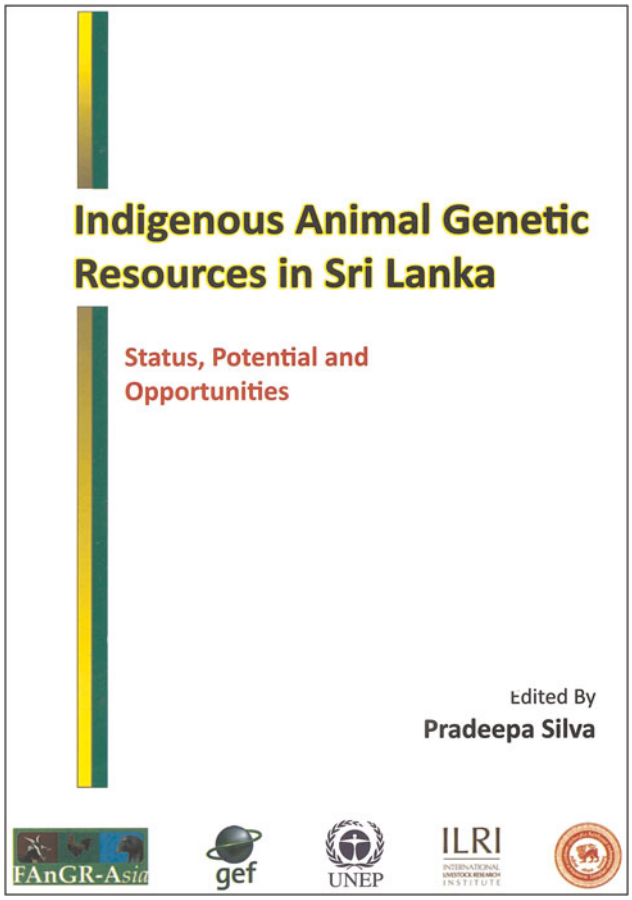


Recent Publication

Indigenous animal genetic resources of Sri Lanka. Status, potential and opportunities

Edited by Pradeepa Silva. A publication of the UNEP/GEF/ILRI – FAnGR Asia Project of Sri Lanka implemented by the University of Peradeniya, Sri Lanka. Published in 2010, 168 pp.
ISBN: 976-955-589-120-2

doi:10.1017/S2078633611000129



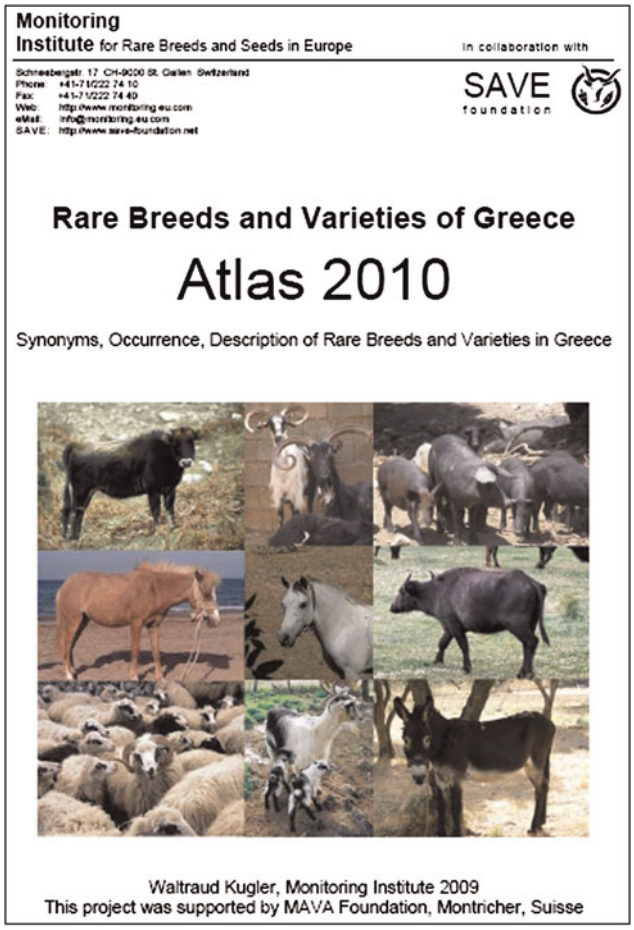
This publication sets out to evaluate the potential and prospects for utilizing Sri Lanka's indigenous animal genetic resources by describing them in the context of their physical, socio-economic, legal and policy contexts. The first chapter provides an introduction to the country's animal genetic resources, providing an overview of their origins and distribution, production systems, population trends and risks. This is followed by a description of the country's agro-ecology, focusing on climate, natural resources and land use. The next chapter reviews the potential for marketing products from indigenous animals as a basis for sustainable use, considering both marketing structures an consumer demand for various types of product. Chapter 5 describes national policy and legal frameworks affecting the management of animal genetic resources and provides a list of recommendations on how these frameworks could be improved. Chapter 6 describes the state of capacity to manage Sri Lanka's animal genetic resources and indicates where capacity-building efforts are required.

Recent Publication

Rare breeds and varieties of Greece Atlas 2010. Synonyms, occurrence, description of rare breeds and varieties in Greece

W. Kugler
Monitoring Institute for Rare Breeds and Seeds in Europe, Switzerland
Published in 2010, pp. 129
Available at http://www.agrobiodiversity.net/greece/PDF/Breedatlas_Greece_FINAL.pdf

doi:10.1017/S2078633611000130



The objective of this publication is to serve as a basis for further conservation work at national and private levels and to raise awareness among all stakeholders. In a country like Greece, with varied topography and climate, one expects great diversity in livestock as a result of their adaptation to these conditions. The book documents information available on one breed/variety of buffalo, 37 of cattle, 13 of chickens, 4 of donkeys, 39 of goats, 20 of horses, 6 of pigs and 46 of sheep, mostly with photos. It lists breeds' risk statuses, based on the following six categories: not at risk, vulnerable, critical, endangered, unknown or extinct. Generally, the category with highest frequency is "unknown" (37%) followed by "endangered" and "critical" (17% each). The proportion of extinct breeds/varieties is highest in cattle (41% of all listed cattle breeds/varieties) while the highest percentages of "unknown" breeds are in chickens (69% of all listed chicken breeds) and goats (68% of all listed goat breeds/varieties). Other information includes official acceptance, population size, colour and other phenotypic traits, performance traits, and area of distribution. Species and breeds within species are arranged in alphabetical order for easy reference. Not all breeds/varieties documented are rare, however. The Karagouniko sheep, for example, has a population of 220 000.

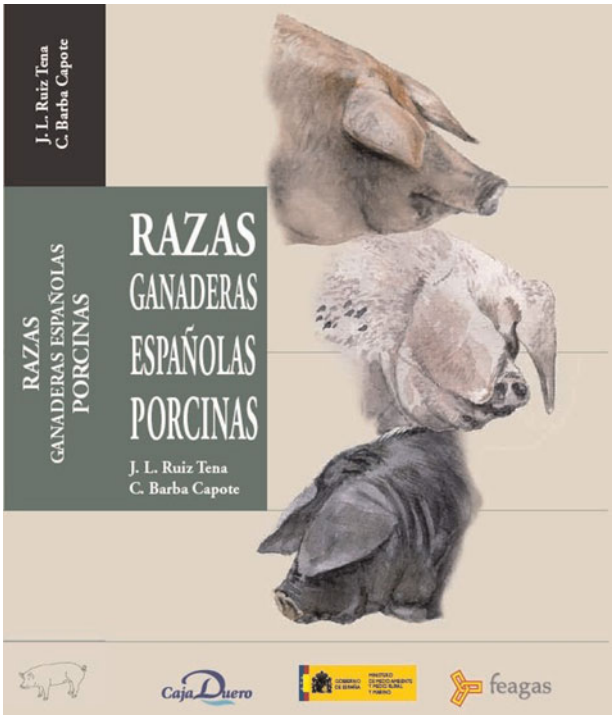
Animal Genetic Resources, 2011, 48, 120. © Food and Agriculture Organization of the United Nations, 2011

Recent Publication

Razas Ganaderas Españolas Porcinas (Spanish pig breeds)

J.L. Ruiz Tena and C. Barba Capote, FEAGAS,
Ministerio de Medio Ambiente, y Medio Rural y Marino (Eds.)
(In Spanish)
Published in 2010,
ISBN 978-84-491-0882-2
pp.171

doi:10.1017/S2078633611000142



En la década de los ochenta el Ministerio de Agricultura editó los catálogos de las razas autóctonas españolas de la especie bovina, ovina y caprina. Estas publicaciones tuvieron un gran éxito entre los profesionales relacionados con la producción ganadera. Después de 30 años, la Federación Española de Asociaciones de Ganado Selecto (FEAGAS), junto con el Ministerio de Medio Ambiente y Medio Rural y Marino, ha editado, en la línea de lo desarrollado para estas otras especie, una obra centrada en la especie porcina que también ha tenido una excelente acogida en el sector.

Esta publicación, en tapa dura, con 125 fotografías a color, 16 mapas, dibujos, gráficos y tablas, describe la situación tanto de las razas porcinas autóctonas como de las razas que se introdujeron y explotaron en España durante más de 40 años, y que ahora son partes de nuestro patrimonio genético.

El objetivo de esta publicación es describir la situación actual de cada raza en el contexto de su propio entorno y el sistema de producción. Incluyendo datos sobre características morfológicas y productivas, así como del origen, los sistemas de producción, la distribución en el país y los programas de cría aplicados.

Es necesario subrayar el importante papel que las razas autóctonas tradicionalmente han desempeñado en España, y el todavía mayor que pueden desempeñar hoy en día, tanto desde el punto de vista económico como social y medioambiental, dando lugar a una gran variedad de productos de calidad, contribuyendo al desarrollo rural de una manera sostenible.

FEAGAS, con la publicación de este nuevo tratado de zootecnia, en el que ha contado con la colaboración de las diferentes Asociaciones de Criadores, continua cumpliendo con el compromiso adquirido de editar una colección de libros de las diferentes especies de interés, presentes en la Cabaña Ganadera Española.

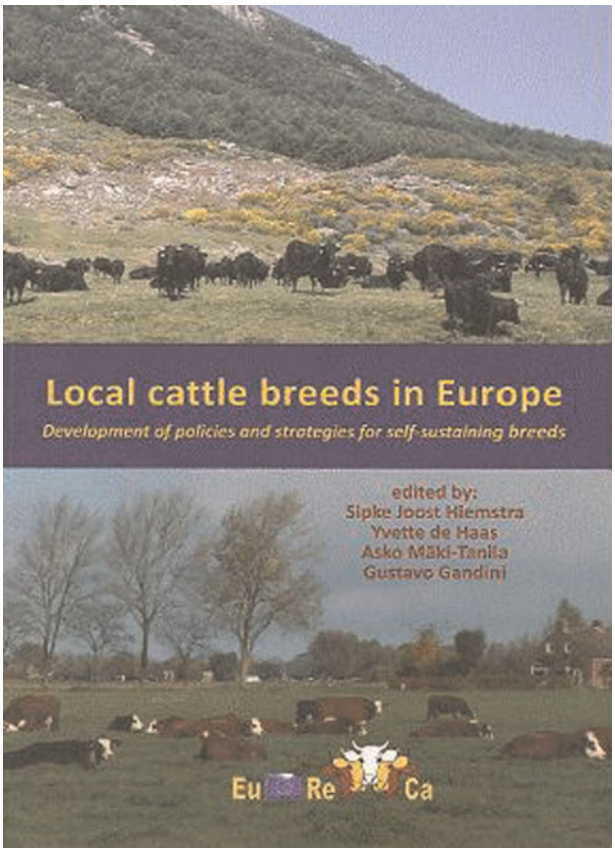
Se trata del cuarto libro de esta serie, precedido de otras tres publicaciones, una centrada en la especie bovina, otra en la ovina y otra en la caprina, que continuará con el proyecto, ya puesto en marcha, sobre la especie equina.

Recent Publication

Local cattle breeds in Europe. Development of policies and strategies for self-sustaining breeds

Edited by S.J. Hiemstra, Y. de Haas, A. MäKi-Tanila & G. Gandini
Wageningen Academic Publishers
Published in 2010, pp. 154.
ISBN: 978-90-8686-144-6
e-ISBN: 978-90-8686-697-7

doi:10.1017/S2078633611000154



This publication is an outcome of the EURECA project – "Towards self-sustainability of EUropean, REgional, CAttle breeds" – undertaken by a consortium of 10 European partners (10 countries) between 2007 and 2010. The project sought to answer the question: "How can we positively influence the future of our local cattle breeds in Europe?" The approach taken involved collecting fifteen breed cases studies – history, status and development – across eight European countries. Sources of information included farmer interviews and the perceptions of other stakeholders and experts including National Coordinators for the Management of Animal Genetic Resources. Strengths, weaknesses, opportunities and threats (SWOT) were analysed for each breed. For some breeds, strategic opportunities were identified and the project partners interacted with relevant stakeholders in order to develop or strengthen the future prospects of the breeds in question. The project also studied similarities and differences among national cryoconservation programmes, and reviewed available methodologies and software for assessing the management of genetic variation within populations. The book's eight chapters cover: an introduction to the project and its methods; trends in cattle diversity and production in Europe; the state of local cattle breeds in Europe – covering risk status and the state of management; differences and similarities across local cattle farming in Europe – including farm characteristics, farmer profiles and SWOT analyses; the role and state of cryoconservation in local cattle breeds – including organizational aspects, sampling strategies and factors affecting management decisions; assessment and management of genetic variation; decision-making tools for the development of breeding strategies; and recommendations for the management of local cattle breeds in Europe. Text boxes present short descriptions of the history and management of the breeds studied and the outcomes of the respective SWOT analyses.

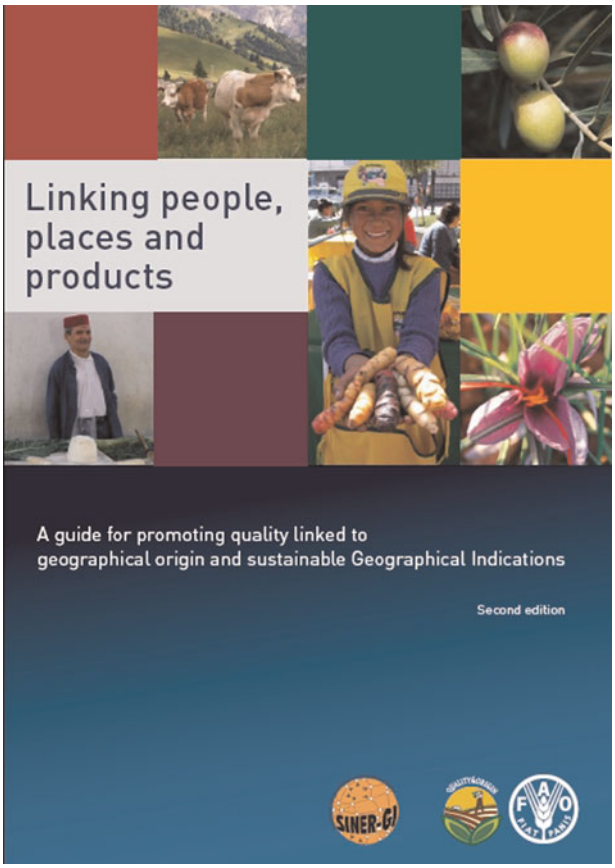
Animal Genetic Resources, 2011, 48, 122. © Food and Agriculture Organization of the United Nations, 2011

Recent Publication

Linking people, places and products. A guide for promoting quality linked to geographical origin and sustainable Geographical Indications

E. Vandecandelaere, F. Arfini, G. Belletti and A. Marescotti
FAO/SINER-GI
Published in 2009, pp. 194
ISBN 978-92-106374-3
Available at http://www.fao.org/docrep/012/i1057e/i1057e00.htm

doi:10.1017/S2078633611000166



This publication focuses on the use of geographical indications (GI) as a means of promoting links between people places and agrifood products in support of sustainable rural development. Specific objectives are to explain the GI concept, raise awareness regarding the potential of origin-linked products in rural development, and facilitate implementation of GI schemes at local level. The guide provides a conceptual framework, concrete examples and methodologies for use by those interested in implementing such schemes. The main target audience includes practitioners, rural development specialists from the public or private sectors, representatives of value chains, policy makers, rural community leaders and trainers. It is argued that an origin-linked product can become the pivotal point of a virtuous circle in which identification of the product is followed by qualification (means of distinguishing the product) and remuneration (marketing or public support for non-marketable benefits) lead to reproduction of the local resources that underpin production, and preservation of the agrifood system and related social networks – thus contributing to economic, sociocultural and environmental sustainability. At each phase of the virtuous circle, local actions need to be reinforced by appropriate public policies that provide an enabling institutional framework. The guide is structured around these five elements (identification, qualification, remuneration, reproduction and public policies) with a chapter dedicated to each. More than 40 case studies are presented. Several examples involving animal products are featured: Chivito Criollo del Norte goat meat (Argentina); Livno cheese (Bosnia-Herzegovina); Chontaleño cheese (Nicaragua); Cotija cheese (Mexico); Pampa Gaúcho da Campanha Meridional meat (Brazil); Turrialba cheese (Costa Rica); Lardo di Colonnata pork fat (Italy); Jinhua ham (China); Comté cheese (France); Gruyère cheese (Switzerland); Parmigiano Reggiano cheese (Italy); Parma ham (Italy) and ham of Uzice/Zlatibor (Serbia).

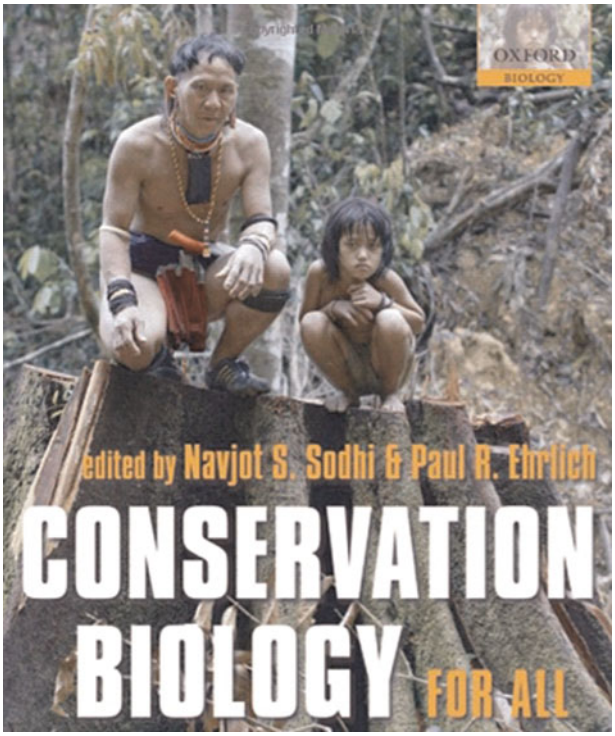
Animal Genetic Resources, 2011, 48, 123. © Food and Agriculture Organization of the United Nations, 2011

Recent Publication

Conservation biology for all

N.S. Sodhi and P.R. Ehrlich (eds.)
Oxford University Press
Published in 2011, pp. 344
ISBN 978-0-19-955423-2 (hardback.)
ISBN 978-0-19-955424-9 (paperback.)
Available at http://www.mongabay.com/conservation-biology-for-all.html

doi:10.1017/S2078633611000178



This publication helps meet the obvious need for a book that deals with conservation biology as a science in its own right. The book deals with conservation generically, covering ecosystems, species, landscape, etc., but for instance it mentions little or nothing about gene banks, *in situ* or *ex situ* conservation. It contains 16 chapters written by 26 authors covering a wide range of related topics including historical background, theoretical aspects of conservation, factors leading to the decay of biodiversity, country experiences and advice on how to develop conservation actions. The book is relevant and quite useful to both undergraduate and graduate students as well as scientists, managers and personnel in non-governmental organizations. The book is freely available on the web.

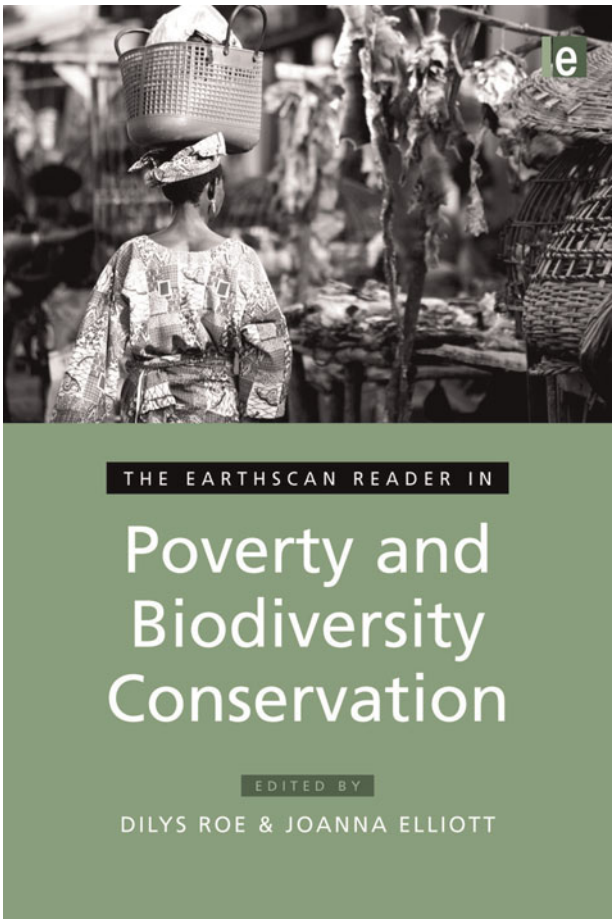
Animal Genetic Resources, 2011, 48, 124. © Food and Agriculture Organization of the United Nations, 2011

Recent Publication

Poverty and Biodiversity Conservation

Edited by Dilys Roe & Joanna Elliott. 2010.
Earthscan, London. 396pp.
ISBN 978-1-84407-842-4/1

doi:10.1017/S207863361100018X



The editors have drawn together a galaxy of authors who bring expertise on all aspects of biodiversity loss, conservation, poverty and its alleviation. In fact the book may be regarded as a manual on these two subjects with a wealth of references, experiences and perspectives. The main thesis of the book is that both biodiversity and poverty are global problems that are regarded as separate topics and addressed by policies and programmes operated by people and institutes that do not have contact with each other. The editors argue that the loss in biodiversity and the obscene existence of extensive poverty are major global problems for which better solutions can be found if they are integrated. In fact some of the causes of biodiversity loss are the same as some of those causing poverty. They derive from the mono-lithic, mono-cultural and mono-selfish system that drives the use of biodiversity in the interests of a small capital rich section of the world. This model gains more for those who are already rich by the use of minimal diversity in natural resources and by replacing labour with capital. Large-scale, uniform production and use of limited, patented biological diversity is more profitable than coping with great diversity. The scope of the book as a review of the two topics is enormous. There are chapters on biodiversity and poverty, conservation policy and practice; NGO's and governments, ecosystems and adaptation, indigenous people and those who exploit them, anthropology and social science, forests and protected areas, international conventions and world trade, livestock and fisheries, landscapes, people and power. In addition the issue of climate change is seen as a complicating factor that cannot be ignored and may well be helped by a new vital partnership between programmes of biodiversity conservation and poverty alleviation. The book thrusts towards the proposed marriage of Conservation-Poverty Partnerships in order to find mutual benefits and solutions that otherwise either ignore or conflict with each other. The book is perhaps stronger on description and diagnosis than on specific ways of such partnerships but the argument is so well supported by the facts that it merits serious consideration and new dialogue between partners. The proposal is of specific interest to livestock and animal genetic resources since indigenous breeds that are often owned by the poor are under threat and need conservation. It has long been recognized that well-organized situ conservation of indigenous livestock breeds can bring economic benefits to poor livestock keepers.

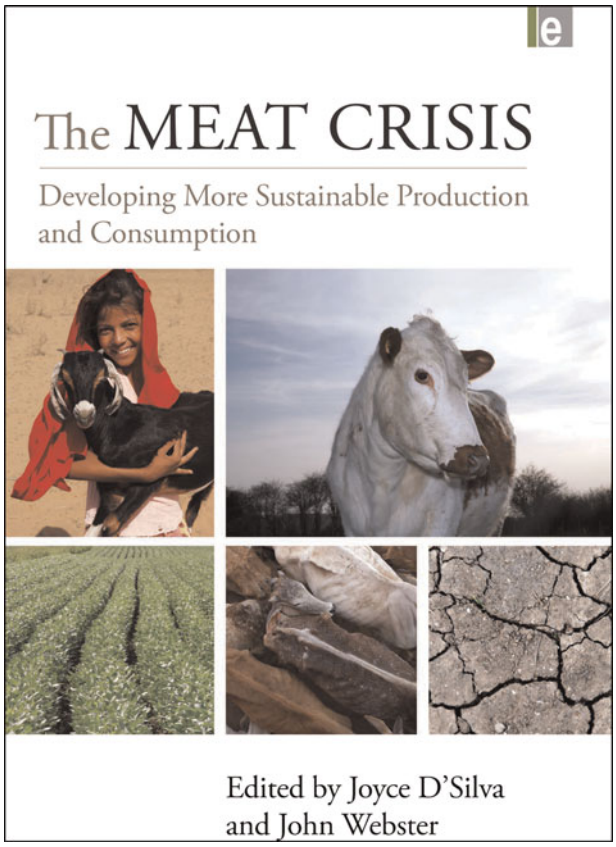
Animal Genetic Resources, 2011, 48, 125. © Food and Agriculture Organization of the United Nations, 2011

Recent Publication

The meat crisis: developing more sustainable production and consumption

Edited by J. D'Silva and J. Webster
Earthscan
Published in 2010, pp. 328
eBook ISBN 13: 9781849776561
Print ISBN 13: 9781844079025

doi:10.1017/S2078633611000191



The book comes in 17 chapters in five parts covering: the impacts of animal farming on the environment; farming practices and animal welfare; the implications of meat production for human health; ethical and religious approaches to animal foods; and devising farming and food policies for a sustainable suture. Chapters are contributed by 25 authors well versed in agriculture, human and animal health, environment, socio-economics and related topics. The book propounds its pivotal thesis that natural recourses are not unlimited and that with current increases in world population and per capita average consumption of animal products, both production and consumption of animal products, including poultry and fish, are becoming unsustainable. Over and again, the book points out that the overconsumption of animal products negatively impacts human health, animal health and the health of the earth. A main culprit for this trend, the book argues, is the domination of corporate farming (factory farms) and the disappearance of "family farming" leading to industrialization and production intensification (*unsustainable*, reviewer). It is justly pointed out that corporate agriculture has been a main factor in shrinking diversity in genetic resources and ecosystems. It explores the complex interplay between economic, social, cultural and moral issues (e.g. animal welfare). It highlights the disparity between per capita consumption of animal products in the high-income countries (200–300grams/day) and low-income countries (e.g. 20–40 grams/day in sub-Saharan Africa). The book advises that "In order to substantially reduce greenhouse gas emission from food production and to preserve natural and agricultural biodiversity, policies that separately address the demand and the supply sides of food system will be required. Taxes on animal food, and other policies that shift consumption patterns towards less greenhouse gas and land-demanding food will be crucial for reducing agricultural greenhouse gas emission as well as mitigating biodiversity losses related to the expansion of agriculture into natural ecosystem". In some places in the book it is admitted that animal proteins are required for healthy human diet, but in some other places it enthusiastically states otherwise: "Industrial livestock policies are invariably playing on the widespread but incorrect belief that we need animal protein for healthy diet". The motto of the book could be summarized as "If you eat less meat you would be healthier as would our planet" but a significant distinction must be made between these who overeat and those who cannot get enough.

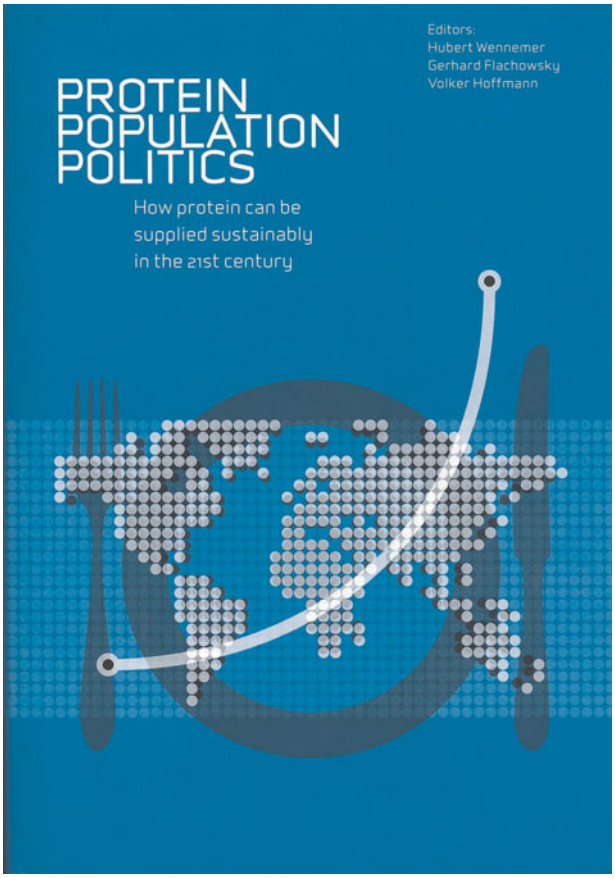
Animal Genetic Resources, 2011, 48, 126. © Food and Agriculture Organization of the United Nations, 2011

Recent Publication

Protein, population, politics. How protein can be supplied sustainably in the 21st century

Edited by Hubert Wennemer, Gerhard Flachowsky and Volker Hoffmann
Degussa AG, German Federal Agriculture Research Center (FAL), Council for Tropical and Subtropical Agriculture (ATSAF)
Published in 2006, 160 pp

doi:10.1017/S2078633611000208



This book brings together a series of ten essays on the theme of protein supply for human consumption. Its origins lie in a symposium – "Protein, population politics" – organized in Berlin in 2002 by the German Federal Agriculture Research Center, Council for Tropical and Subtropical Agriculture and Degussa AG (a supplier of feed additives). All written in popular-science style, the catchily titled essays span the millennia from the evolutionary origins of the human species to the twenty-first century with its high-tech livestock and feed industries. The first essay – on the part played by meat in the transition from ape to human – is followed by a discussion of human population growth in relation to food supply and the maintenance of biodiversity. The focus then moves to a discussion of how livestock have shaped the world, from the earliest domestications of wild species, via the role of livestock in conquest and colonization, disease epidemiology and transformation of landscapes, to concerns about the environmental effects of livestock production; the essay ends with a discussion of the current use of livestock genetic diversity and the potential for future species domestications. This is followed by a look at how concerns about animal welfare have affected the livestock industry and a discussion of the concept of sustainable agriculture. Attention then shifts to international trade flows of live animals, meat and livestock feed and to the issue of whether supplying feed for the world's livestock contributes to the problem of hunger among the world's poor. Next come discussions of fisheries and aquaculture and of non-meat protein sources such fungi and algae. The final essay addresses the overall task of ensuring a sustainable supply of protein in the coming decades; attention is paid to social and policy developments as well as to the potential of technology.

Animal Genetic Resources, 2011, 48, 127. © Food and Agriculture Organization of the United Nations, 2011

Recent Publication

Foresight. The future of food and farming. Final project report

The Government Office for Science, London
Published in 2011. pp. 211
Available at http://www.bis.gov.uk/assets/bispartners/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf

doi:10.1017/S207863361100021X

This is the final report of the Foresight Global Food and Farming Futures Project, UK Government. The project aimed at investigating forces affecting the global food system between 2011 and 2050 and identifying the decisions that policy makers need to take today and after to ensure that a growing human population can be fed sustainably and equitably. The project has involved some 400 leading experts and stakeholders from about 35 low-, middle- and high-income countries across the world. In its 211 pages the report confers a sense of the need for urgent action in the global food system as diverse factors converge to impact demand, production and distribution of food over the next 40 years. These factors or "drivers for change" are the expected growth in the world human population; the likely increase in individuals' incomes globally; competition for resources – mainly land, water and energy; the need to reduce greenhouse gas emissions; and adaptation to a changing climate. These drivers for change are interplaying in an increasingly globalized environment, exposing the food system to unprecedented economic, social and political pressures. The report stresses that much can be done today, with existing knowledge, to address food security through multiple approaches and sustainable intensification, but certainly not through the use of "a single or particular technology". New technologies, e.g. GMOs, must not be excluded *a priori* on ethical or moral grounds, but due respect should be given to opposing views. The potential of appropriate new technology in overcoming problems in the food system is potentially very good for the poorest people in low-income countries. That is why it is imperative to incorporate possible beneficiaries in decision-making at all stages of the development process. Agriculture can play a main role in improving food systems but agricultural research needs to better funded and more focused, in the meantime supported by efficient extension to bring about sustainability in the global food system which at present is consuming the world's natural resources at unsustainable rate. While the report is mainly addressed to policy makers, it makes very useful reading for socio-economists, agricultural research administrators and environmentalists.

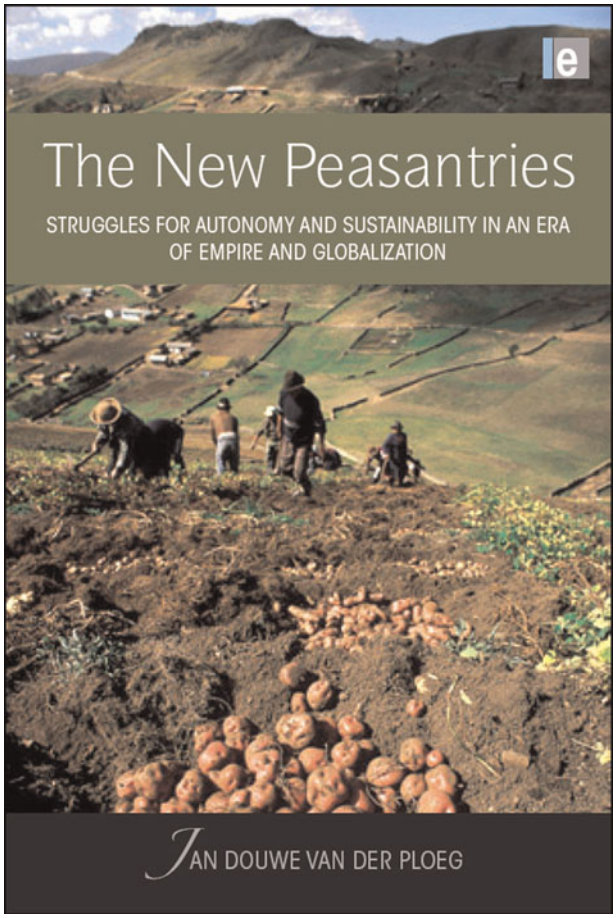
Animal Genetic Resources, 2011, 48, 128. © Food and Agriculture Organization of the United Nations, 2011

Recent Publication

The New Peasantries: Struggles for Autonomy and Sustainability in an Era of Empire and Globalization

Jan Douwe van der Ploeg. 2008.
Earthscan, London. 356pp.
ISBN 978-1-84407-558-4/882-0.

doi:10.1017/S2078633611000221



Today the focus on globalized, intensive agriculture as the only way to feed the world populations usually neglects both history and alternative options. The author points out that humans have fed themselves for millennia without the new food empire of global capitalism, scale and oil-based inputs. A high proportion of the rural populations of the world, which is where half the people live, still feed itself without such inputs. The author provides a valuable descriptive characterization of peasantries in the past with their strong emphasis upon the struggle for autonomy and he argues that they are still with us and are in fact increasing in number. In the past peasants struggled against hostile environments, climate and poverty to maintain their independence, culture, traditional agro-bioresources and livestock. Today they struggle for independence from the new food empire that attacks local economics, indigenous social systems and independence. The integration of peasants with their livestock is particularly important with resonances in cultural as well as economic aspects of life. The author thinks the present squeeze on peasant agriculture is brutal as industrialized farming makes no concessions and is incompatible with peasantry. He identifies three components of the present structures food production chain: capital rich, entrepreneurial and peasant. The author does not concede that the latter will disappear. Rather he provides an unusual perspective on the historic strengths of peasants and considers that they will continue to insist upon their own freedom. He draws examples from Peru, Italy and The Netherlands. Peasants have neither the economic means nor the inclination to join the capitalist model. Some of them may move into the category of entrepreneurs thus maintaining their independence. His advocacy is for the empowerment of peasants to enable them to maintain their historic independence in a globalized world by improved use of their indigenous livestock and other local resources that are so well adapted to the environment and to their historic culture. In this he matches the view of the recent UN-IAASTD Report that advocates research to enhance historic local food production using indigenous resources. Local livestock with genetic adaptation have a large role to play in this scenario and have genetic variation to enable them to respond to modified methods. It may be that the peasants will be the survivors in the inevitable crash that will bring disorder to the large-scale global system. This is a courageous book offering hope from the past for the future.

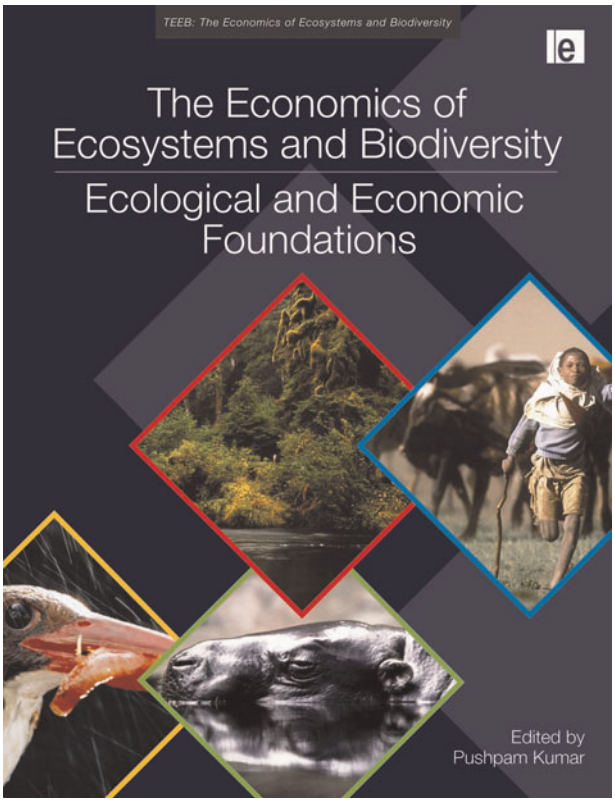
Animal Genetic Resources, 2011, 48, 129. © Food and Agriculture Organization of the United Nations, 2011

Recent Publication

The economics of ecosystems and biodiversity: ecological and economic foundations

Edited by P. Kumar
Earthscan
Published in 2010, pp. 451
Print ISBN: 9781849712125
ebook ISBN: 9781849775489

doi:10.1017/S2078633611000233



The Economics of Ecosystems and Biodiversity (TEEB) project was established with the aim of providing a comprehensive global assessment of the economics of biodiversity loss. Central to the analysis is the concept of ecosystem services: the various benefits that humans derive from well-functioning ecosystems and the biodiversity that contributes ecosystem function. Many of these services do not command any market price. Thus, markets provide insufficient incentives to maintain biodiversity and the consequences of its loss do not register in conventional economic projections. Policy-makers, used to basing their decisions largely on measurable economic outcomes, tend to underestimate the benefits that could be gained from taking action to prevent biodiversity loss. The TEEB project aimed, by showing how ecosystem services and biodiversity can be measured and valued, to provide a means of pushing biodiversity up the policy agenda. This first volume of output from the project presents the ecological and economic foundations of valuing ecosystems and biodiversity. It begins by discussing the principles underlying the conduct of ecosystem assessments that aim to value the services provided by these systems. This is followed by a closer look at the specific links between biodiversity and ecosystem services. Further chapters focus on the roles of measurement and indicators; the cultural context of valuation; the economics of valuating ecosystem services and biodiversity (based on the concept of total economic value); and the various factors, including ethical issues, to be considered in establishing a discounting rate for an economic valuation. The final chapter considers lessons learned and linkages between valuation and national policies.

Animal Genetic Resources, 2011, 48, 130. © Food and Agriculture Organization of the United Nations, 2011

Recent Publication

Sustainability unpacked. Food, energy and water for resilient environments and societies

K.A. Vogt, T. Patel-Weynand, M. Shelton, D.J. Vogt, J.C. Gordon, C.T. Mukumoto, A.S Suntana & P.A. Roads
Earthscan Published in 2010, pp. 305.
ISBN: 978-1-84407-900-1 hardback
ISBN: 978-1-84407-901-8 paperback

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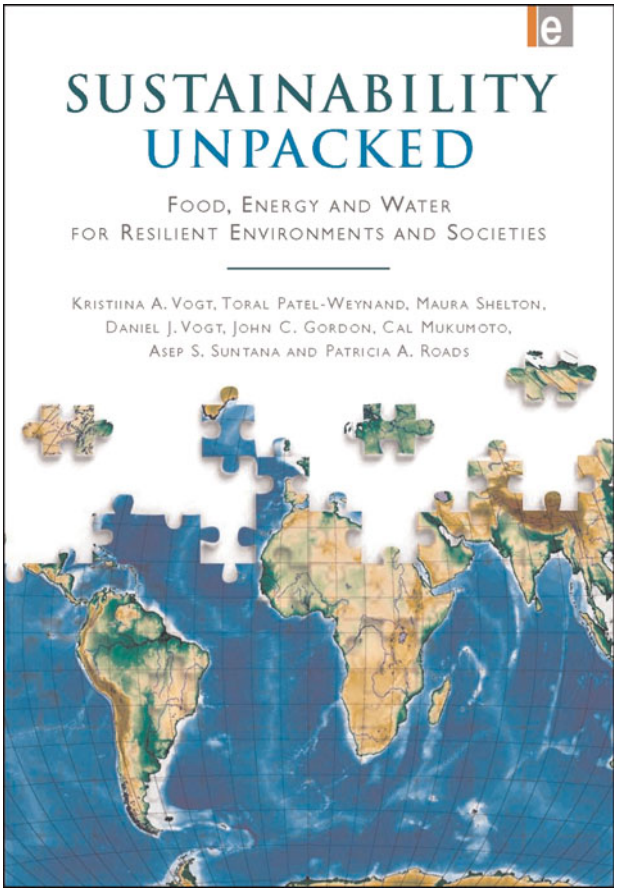

The premise of this book is that sustainable management of natural resources requires recognition of the interacting effects of social, ecological and economic factors, but that this "ecosystem thinking" is not the norm in policy-making or development interventions. Further, it is argued that although there are many recorded examples of practices that proved unsustainable and descriptions of how societies collapsed because of such practices, the lack of sustainability in these cases often arose from unique sets of circumstances that do not pertain elsewhere or at other times. The objective is to "unpack" the factors that influence sustainability and thereby draw lessons on how natural resources can be managed as a basis for building resilient societies. The approach taken involves analysis of various indices that have been developed to measure countries' social and environmental performance. The management of energy, forests, soil and water across a range of countries at various levels of development is reviewed and their environmental and social impacts both locally and globally are assessed. The role of climate and soils as limiting factors for the productivity of any land are then factored into the analysis. Emphasis is given to the concept of "solar income" defined as "the annual increment of fixed carbon captured in agriculture and forestry (or other solar energy captured such as PV, wind or hydro)". It is argued that sustainability in the long term requires a shift towards managing and using this solar income rather than depleting "solar capital" (fossil fuels, forests, etc.). Emphasis is also given to the importance of "human capital", i.e. the knowledge and skills needed to manage natural resources and adapt to environmental challenges. The final chapters of book are devoted to discussing how human and natural capitals can be managed and enhanced in the interests of sustainability.

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Instructions for contributors

Animal Genetic Resources is a trilingual journal, published three times per year online (http://journals.cambridge.org/AGR) and in print. Main papers are published in English, French or Spanish, with a summary in all three languages. The journal has been published since 1983, and all back issues are available at http://dad.fao.org/cgi-bin/EfabisWeb.cgi?sid=−1,refcat_50000044.

The journal encourages submissions from all over the world. Authors who are not fluent in any of the three accepted languages are encouraged to seek assistance in this regard before submitting their manuscripts.

Mission statement

The journal provides an international forum for the publication of papers related to the management of animal genetic resources for food and agriculture (AnGR). It covers the following areas: phenotypic and molecular characterization; surveying and monitoring; development (genetic improvement); sustainable use; conservation; capacity-building in livestock keeper and pastoralist communities; and policies and institutions.

The editors welcome all papers addressing the topics above. Papers related to breeds and technologies contributing to the sustainable management of the world's medium-to-low input production systems, which account for the largest area of land involved in livestock production and for a major part of production from livestock, are of a particular interest.

The journal supports the implementation of the Global Plan of Action for Animal Genetic Resources, the internationally agreed framework for the management of AnGR and the Convention on Biological Diversity.

Disclaimer

Views expressed in the papers published in Animal Genetic Resources represent the opinions of the author(s) and do not necessarily reflect the policies of FAO or the views of the editors or the institutions with which the authors are affiliated.

Peer review

Manuscripts submitted for publication in Animal Genetic Resources undergo full peer review by two referees. The suitability of manuscripts is judged by the reviewers and editors, and the editors' decision on a paper is final.

Categories of papers

Research papers – Findings of work related to the management of AnGR will be considered for publication in AGRI. Authors are encouraged to include relevant high-quality photographs in their manuscripts. If photographs illustrate animals, they should be shown in the primary production environment to which they are adapted.

Review papers – Unsolicited papers reviewing country-level, regional or global developments in one or more aspects of AnGR management will be considered for publication. These papers may include state-of-the-art reviews of specific fields in AnGR management.

Position papers – Invited papers on topical issues will be published when the editors consider there to be such a requirement.

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- book reviews or proposals
- conclusions and recommendations arising from relevant meetings, workshops and conferences
- announcements of training courses and major national, regional and international events

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To be considered for publication in the journal, a manuscript must not have been published previously, nor be under review for publication elsewhere. (Previously published figures may be used sparingly in reviews, provided that permission has been obtained as appropriate.) Prior to publication, an authorization and copyright transfer agreement form must be signed and returned to the publishers by the lead or corresponding author of a manuscript (corresponding authors sign on behalf of any co-authors). The form will be sent to the lead or corresponding author together with the proof of the paper for publication.

Authorship

Papers with multiple authors are reviewed with the assumption that all authors have contributed materially to the research reported, have approved the submitted manuscript, and concur with its submission. A contribution includes the conception and design of the project, the performance of experiments and/or the analysis and interpretation of data. Authors should have made a substantial intellectual contribution to the drafting or critical revision of the manuscript.

Manuscript submission

All manuscripts must be submitted online at http://journals.cambridge.org/AGR. No page charges are required from the author.

Receipt of your manuscript will be acknowledged, a manuscript reference number assigned and the manuscript will be sent out for review. You should quote your manuscript reference number in all subsequent correspondence.

The following instructions must be followed carefully (see *Manuscript preparation and style* for further details):

- Manuscripts may be submitted in English, French or Spanish. If your manuscript is written in French or Spanish, it should include a summary and keywords in that language as well as in English. All published articles will feature a summary in English, French and Spanish. It would be appreciated if, wherever possible, authors could supply a summary in all three languages, as this reduces the need for translating services and therefore expedites processing of the manuscript.
- The preferred file format for submission is Microsoft Word. Word Perfect or other word-processor files are not acceptable. Tables should be included within the same file but at the end of the document. Placeholders should be used within the text to indicate their positioning.
- Figures must be submitted as separate files, and at to-be-published resolution (see Manuscript preparation and style for further details).
- A cover letter should be provided as a separate file. The letter should indicate the category under which the manuscript is submitted (see Appendix 1) and provide the details of the corresponding author (telephone number, fax number and e-mail address).
- Filenames should indicate the name of the first author of the paper, either in full or abbreviated.
- Printed copies of the manuscript, tables and figures are not required and should not be sent.

Please note that correspondence regarding submitted and revised manuscripts will take place with the corresponding author only.

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The manuscript should be formatted with line spacing set to "double". Pages should be numbered sequentially beginning with the title page. Margins should be at least 2.5 cm on all sides. The font should be set to Arial.

Authors and affiliations – Names and affiliations of authors should be presented as follows:

E.C. Quispe[1], T.C. Rodríguez[2], L.R. Iñiguez[3] and J.P. Mueller[4]

[1]Universidad Nacional de Huancavelica, Huancavelica, Perú; [2]Universidad Mayor de San Andrés, La Paz, Bolivia; [3]Cochabamba, Bolivia; [4]Instituto Nacional de Tecnología Agropecuaria, Bariloche, Argentina

Correspondence to: E.C. Quispe, Universidad Nacional de Huancavelica, Huancavelica, Perú. E-mail: edgarquispe62@yahoo.com

A ***Running Head*** of up to 50 characters should be provided on the title page.

The ***Summary*** should be unstructured (i.e., no sub-headings) but must provide the reader with a self-contained summary of the paper. It should include a brief introduction to the paper, the method, the key findings and the conclusions. The summary should be no longer than 210 words in English and 250 words in French and Spanish. A list of three to five keywords or terms for indexing should follow the summary and be separated by commas. The summary and keywords should be provided in the same language as the manuscript as well as in English.

The ***Body of the manuscript*** should begin on page 3 and a new page should be used for the References. The lines of text must be numbered and the manuscript structured with consecutively numbered headers and sub-headers (e.g. 1., 1.1, 1.1.1 etc). However, it is important to *avoid cross-referencing using these numbers*, as the editorial office will remove numbering and apply heading styles in the final version.

Research papers should additionally include the following headers: ***Materials and Methods***; ***Results***; ***Discussion***; ***Conclusions***.

The ***Maximum length*** of the body of the manuscript should not exceed 10 journal pages (approx. 8 500 words). Short communications should not exceed 1 journal page (approx. 750 words or, when an image is included, 550 words).

Tables should be numbered consecutively as they are cited in the text (Table 1, 2 etc.). Each table should be on a separate page (at the end of the document) with the number and heading above and any notes below the table.

Figures should be numbered consecutively as they are cited in the text (Figure 1, 2, etc). Use italic letters for parts a, b, c, etc. Legends must be provided for each figure. If applicable, figures should be supplied as either TIFF or EPS files, preferably at the approximate size in which they are to be reproduced. Line artwork should be supplied in black and white mode at a resolution of 1 200 dpi; combination artwork (line/tone) at a resolution of 800 dpi; black and white halftone artwork should be saved in "grayscale" mode at a resolution of 300 dpi; colour halftone artwork should be saved in CMYK mode at a resolution of 400 dpi. All necessary permissions must be obtained.

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Acknowledgements

In this section authors should acknowledge any support from granting agencies and other sources for the work reported in their paper. The contribution of individuals who assisted with the research but are not included as authors of the paper may also be acknowledged in this section.

The Acknowledgements should be placed after the main body of the text before the references. If there are no Acknowledgements, the title should be inserted followed by "None".

Statement of interest

A conflict of interest exists when an author has interests that might inappropriately influence his or her judgement, even if that judgement is not influenced. Because of this, authors must disclose potentially conflicting interests so that others can make judgements about such effects. At the time of manuscript submission, authors should disclose any financial arrangements or connections they may have that are pertinent to the submitted manuscript and that may be perceived as potentially biasing their paper. Non-financial interests that could be

relevant in this context should also be disclosed. If no relevant interests exist, this should be stated. This requirement applies to all the authors of a paper and to all categories of papers.

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Every reference cited in the text should be included in the reference list and every entry in the reference list should have been mentioned in the text at least once. References should be ordered first alphabetically by the first author's surname, and then by year.

Examples:

1 *Reference in a periodical*:
Köhler-Rollefson, I. 1992. The camel breeds of India in social and historical perspective. *Animal Genetic Resources Information* 10: 53–64.

2 *When there is more than one author*:
Matos, C.A.P., Thomas, D.L., Gianola, D., Tempelman, R.J. & Young, L.D. 1997. Genetic analysis of discrete reproductive traits in sheep using linear and non-linear models: 1. Estimation of genetic parameters, *Journal of Animal Science* 75: 76–87.

3 *For a book or an* ad hoc *publication, e.g., reports, theses*:
FAO, 2007. Global Plan of Action for Animal Genetic Resources and the Interlaken Declaration. Food and Agriculture Organization of the United Nations, Rome, Italy (available at http://www.fao.org/docrep/010/a1404e/a1404e00.htm).
van der Werf, J., Graser, H-U., Frankham, R. & Gondro, C. (eds.) 2009. Adaptation and fitness in animal populations. evolutionary and breeding perspectives on genetic resources management. Springer.

4 *For an article in the proceedings of a meeting*:
Abad, M., Arrigo, J., Gibbons, A., Lanari, M.R., Morris, G. & Taddeo, H. 2002. Breeding scheme for Angora goat production in North Patagonia. Proceedings 7th World Congress on Genetics Applied to Livestock Production, 19-23 August 2002, Montpellier, France, 12–14.

5 *Information hosted on a web site*:
FAO. 2010. Domestic Animal Diversity Information System, http://www.fao.org/dad-is/, Food and Agriculture Organization of the United Nations, Rome, Italy.

For a work that has been accepted for publication but not yet published, "In press" should be written in place of the year of publication. Do not insert an expected year of publication.

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doi:10.1017/S2078633611000294

Instructions pour les auteurs

Animal Genetic Resources/Resources génétiques animales/Recursos genéticos animales est un journal trilingue, publié trois fois par an en ligne (http://journals.cambridge.org/AGR) et en version imprimée. Les articles principaux sont publiés en anglais, français ou espagnol avec un résumé dans les trois langues. Le journal est publié depuis 1983 et tous les anciens numéros sont disponibles à l'adresse électronique http://dad.fao.org/cgi-bin/EfabisWeb.cgi?sid=-1,refcat_50000044.

On encourage la présentation d'articles provenant du monde entier à publier dans le journal. Les auteurs qui ne parlent aucune des trois langues admises sont encouragés à chercher de l'aide à cet égard avant de présenter leurs manuscrits.

Déclaration de mission

Le journal fait office de forum international pour la publication d'articles concernant la gestion des ressources zoogénétiques pour l'alimentation et l'agriculture. Il aborde en particulier les thèmes suivants: la caractérisation phénotypique et moléculaire; les enquêtes et le suivi; la mise en valeur (amélioration génétique); l'utilisation durable; la conservation; le renforcement des capacités au sein des communautés d'éleveurs et de pasteurs; et les politiques et les institutions.

Les éditeurs accueillent favorablement tous les articles abordant les thèmes indiqués ci-dessus. Un intérêt particulier sera attribué aux articles concernant les races et les technologies en faveur de la gestion durable des systèmes de production extensive ou semi-intensive dans le monde, qui représentent la plus grande partie des terres consacrées à l'élevage et une partie considérable de la production provenant de l'élevage.

Le journal soutient la mise en œuvre du Plan d'action mondial pour les ressources zoogénétiques, le cadre internationalement convenu en matière de gestion des ressources animales et la Convention sur la diversité biologique.

Déni de responsabilité

Les opinions exprimées dans les articles publiés dans Animal Genetic Resources/Resources génétiques animales/Recursos genéticos animales sont celles du/des auteur(s) et ne reflètent pas nécessairement les politiques de la FAO ou les opinions des éditeurs ou des institutions pour lesquelles ils travaillent.

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Deux experts s'occuperont de la révision complète des manuscrits présentés pour la publication dans Animal Genetic Resources/Resources génétiques animales/Recursos genéticos animales. L'opportunité ou non de publier un manuscrit sera jugée par les réviseurs et par les éditeurs, et la décision finale sur l'article appartient aux éditeurs.

Types d'articles

Articles de recherche – Seront prises en considération pour leur publication sur AGR les études sur la gestion des ressources animales. On encourage les auteurs à envoyer des photographies de haute qualité avec les manuscrits. S'il s'agit de photographies d'animaux, il faudra montrer les races en question dans leur milieu naturel de production.

Révisions – Occasionnellement, des articles contenant une révision aux niveaux national, régional ou mondial des développements d'un ou de plusieurs aspects se rapportant à la gestion des ressources animales seront pris en considération. Ces articles pourront inclure les mises à jour des différents domaines de la gestion des ressources animales.

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- la révision ou la proposition de livres
- les conclusions et les recommandations résultant de réunions, d'ateliers et de conférences importants
- les informations sur des cours de formation et sur les principaux événements régionaux, nationaux et internationaux.

Originalité et droits d'auteur

Pour que le manuscrit soit considéré pour la publication dans le journal, il faut qu'il n'ait pas été publié auparavant, ni qu'il soit en cours de révision pour la publication dans d'autres ouvrages. (Les chiffres publiés auparavant peuvent s'utiliser avec parcimonie dans les révisions, à condition d'en avoir obtenu l'autorisation.) Avant la publication, il faut que l'auteur principal du manuscrit signe et renvoie aux éditeurs le formulaire d'autorisation et d'accord de transfert des droits d'auteur (les auteurs principaux signent au nom de tous les co-auteurs). Le formulaire sera envoyé à l'auteur principal avec l'épreuve de l'article pour la publication.

Paternité

Les articles écrits par plusieurs auteurs sont révisés en présumant que tous les auteurs ont matériellement participé à la recherche signalée, ont approuvé le manuscrit présenté et approuvent sa présentation. Leur contribution comprend la conception et la création du projet, la performance d'expériences et/ou l'analyse et l'interprétation des données. Les auteurs devront avoir apporté une contribution intellectuelle considérable à la rédaction et à la révision critique du manuscrit.

Présentation du manuscrit

Tous les manuscrits seront présentés en ligne à l'adresse électronique http://journals.cambridge.org/AGR. Aucune charge par page ne sera requise de l'auteur.

On accusera réception du manuscrit, on attribuera un numéro de référence et le manuscrit sera envoyé pour révision. Vous devrez toujours indiquer le numéro de référence de votre manuscrit dans toute correspondance ultérieure.

Il faut suivre avec attention les instructions ci-après (pour de plus amples détails, voir *Préparation et style du manuscrit).*

- Les manuscrits se présenteront en anglais, français ou espagnol. Si votre manuscrit est en français ou en espagnol, il faudra ajouter un résumé et les mots clés dans cette langue ainsi qu'en anglais. On ajoutera à tous les articles publiés un résumé en anglais, français et espagnol. On appréciera si, dans la mesure du possible, les auteurs fournissent un résumé dans les trois langues, car les services de traduction seraient ainsi réduits et le traitement du manuscrit serait par conséquent plus rapide.
- Le format de fichier préféré pour la présentation est Microsoft Word. Word Perfect ou d'autres fichiers de traitement de texte ne sont pas acceptés. Les tableaux seront inclus au même fichier, mais à la fin du document. Les paramètres fictifs seront utilisés dans le texte pour indiquer leur positionnement.
- Les figures se présenteront en tant que fichiers séparés et en résolution publiable (pour de plus amples détails voir *Préparation et style du manuscrit*).
- Une lettre d'envoi sera envoyée dans un fichier séparé. La lettre signalera la catégorie d'appartenance du manuscrit (voir annexe 1) et fournira des informations sur l'auteur principal (numéro de téléphone, de télécopieur et adresse électronique).
- Les fichiers indiqueront le nom de l'auteur principal de l'article, soit en entier soit abrégé.
- Les copies imprimées du manuscrit, des tableaux et des figures ne sont pas requises et ne devront pas être envoyées.

Veuillez noter que la correspondance relative aux manuscrits présentés et révisés se fera uniquement avec l'auteur principal.

Préparation et style du manuscrit

Les manuscrits se présenteront à «double» interligne. Toutes les pages seront numérotées à commencer de la page du titre. Les marges seront d'au moins 2,5 cm pour tous les côtés. La police de caractère sera Arial.

Auteurs et institutions pour lesquelles ils travaillent – Les noms des auteurs et les institutions pour lesquelles ils travaillent se présenteront comme indiqué ci-après:

E.C. Quispe[1], T.C. Rodríguez[2], L.R. Iñiguez[3] et J.P. Mueller[4]

[1]Universidad Nacional de Huancavelica, Huancavelica, Perú; [2]Universidad Mayor de San Andrés, La Paz, Bolivia; [3]Cochabamba, Bolivia; [4]Instituto Nacional de Tecnología Agropecuaria, Bariloche, Argentina

Correspondance à envoyer à: E.C. Quispe, Universidad Nacional de Huancavelica, Huancavelica, Perú. Adresse électronique: edgarquispe62@yahoo.com

Sur la première page du manuscrit, on indiquera le ***titre de l'article*** qui ne devra pas dépasser les 50 caractères.

Le ***résumé*** ne sera pas structuré (c'est-à-dire, sans sous-titres), mais devra fournir au lecteur une brève description de l'article. Il inclura une introduction succincte à l'article, la méthode utilisée, les résultats principaux et les conclusions. Le résumé ne dépassera pas les 210 mots en anglais et les 250 mots en français et en espagnol. Une liste de mots clés ou de termes (entre trois et cinq) pour le sommaire suivra le résumé et les mots-clés seront séparés par des virgules. Le résumé et les mots-clés se présenteront dans la même langue du manuscrit ainsi qu'en anglais.

Le ***corps du manuscrit*** commencera à la page 3 et une nouvelle page sera utilisée pour les références. Les lignes du texte seront numérotées, le manuscrit sera structuré et tous les titres et les sous-titres seront numérotés (par exemple, 1, 1.1, 1.1.1, etc.). Il est toutefois important *d'éviter les références croisées avec ces numéros* car le bureau d'édition enlèvera la numérotation et appliquera des styles de titre dans la version finale.

Les articles de recherche devront en outre inclure les titres suivants: ***Matériels et méthodes; Résultats; Débat; Conclusions.***

La ***longueur maximale*** du corps du manuscrit ne dépassera pas les 10 pages du journal (environ 8 500 mots). Les communications brèves ne dépasseront pas 1 page (environ 750 mots ou, s'il y a également une image, 550 mots).

Les ***tableaux*** seront tous numérotés en suivant l'ordre d'apparition dans le texte (tableau 1, 2 etc.). Chaque tableau sera sur une page séparée (à la fin du document) avec le numéro et le titre au-dessus du tableau et d'éventuelles notes au-dessous.

Les ***figures*** seront toutes numérotées en suivant l'ordre d'apparition dans le texte (figure 1, 2 etc.). Il faudra écrire les lettres des parties a, b, c, etc. en italique et prévoir des légendes pour chaque figure. Les figures se présenteront, si possible, dans un fichier TIFF ou EPS, de préférence dans la taille approximative à utiliser pour la reproduction. Les illustrations graphiques seront fournies en noir et blanc avec une résolution de 1 200 ppp; les artwork combinaisons (ligne/ton) avec un résolution de 800 ppp; les illustrations en demi-ton noir et blanc seront sauvegardées en mode «niveau de gris» avec une résolution de 300 ppp; les illustrations en demi-teinte de couleurs seront enregistrées en mode CMJN avec une résolution de 400 ppp. Il faudra obtenir toutes les autorisations nécessaires.

Abréviations et unités SI – L'utilisation des abréviations, à part celles qui sont largement employées, est vivement déconseillée. Elles ne seront utilisées que si elles améliorent la compréhension du manuscrit. Les sigles s'écriront en entier la première fois qu'elles sont employées. Il faudra utiliser les unités du système métrique (SI).

Remerciements

Dans cette section, les auteurs remercieront pour tout appui reçu des institutions et d'autres sources de soutien pour le travail inscrit dans leur article. On peut ajouter également dans cette section la contribution d'autres particuliers ayant aidé dans le travail de recherche, mais n'étant pas inclus en tant qu'auteurs.

Les remerciements seront placés après le corps principal du texte avant les références. En cas d'absence de remerciements, le titre sera toutefois écrit et suivi par l'indication «aucun remerciement».

Déclaration d'intérêts

On est en présence d'un conflit d'intérêts lorsqu'un auteur a des intérêts qui pourraient influencer de façon inappropriée son jugement, même si ce jugement n'est pas en fait influencé. Pour cette raison, les auteurs doivent révéler les conflits d'intérêts potentiels pour que d'autres puissent juger de ces effets. Au moment de la présentation du manuscrit, les auteurs révéleront tout arrangement ou rapport financier pertinent avec le manuscrit présenté et qui pourrait être perçu comme pouvant porter un préjudice potentiel à l'article. Les auteurs révéleront également les intérêts non financiers qui pourraient être pertinents dans ce contexte. Il faudra également déclarer l'absence d'intérêts pertinents. Cette obligation s'applique à tous les auteurs d'un article et à toutes les catégories d'articles.

Références

Toute référence présente dans le texte devra apparaître sur la liste des références, et chaque entrée de la liste aura été citée au moins une fois dans le texte. Les références iront en ordre alphabétique du nom de l'auteur, suivi de l'année.

Exemples:

1 *Référence sur une revue:*
Köhler-Rollefson, I. 1992. The camel breeds of India in social and historical perspective. *Animal Genetic Resources Information* 10: 53–64.

2 *Lorsqu'il s'agit de plus d'un auteur*:
Matos, C.A.P., Thomas, D.L., Gianola, D., Tempelman, R. J. et Young, L.D. 1997. Genetic analysis of discrete reproductive traits in sheep using linear and non-linear models: 1. Estimation of genetic parameters, *Journal of Animal Science* 75: 76–87.

3 *Dans le cas d'un livre ou d'une publication ad hoc, par exemple, un rapport, une thèse:*
FAO, 2007. Plan mondial d'action pour les ressources zoogénétiques et la Déclaration d'Interlaken. Organisation des Nations Unies pour l'alimentation et l'agriculture, Rome, Italie (disponible à l'adresse électronique http://www.fao.org/docrep/010/a1404f/a1404f00.htm).
van der Werf, J., Graser, H-U., Frankham, R. et Gondro, C. (éds.) 2009. Adaptation and fitness in animal populations. Evolutionary and breeding perspectives on genetic resources management. Springer.

4 *S'il s'agit d'un acte d'une réunion*:
Abad, M., Arrigo, J., Gibbons, A., Lanari, M.R., Morris, G. et Taddeo, H. 2002. Breeding scheme for Angora goat production in North Patagonia. Actes du Septième congrès mondial sur l'application de la génétique à l'élevage, 19-23 août 2002, Montpellier, France, 12–14.

5 *Dans le cas d'informations hébergées sur un site Web:*
FAO. 2010. Domestic Animal Diversity Information System, http://www.fao.org/dad-is/, Organisation des Nations Unies pour l'alimentation et l'agriculture, Rome, Italie.

Dans le cas d'un travail ayant été accepté pour la publication, mais n'ayant pas encore été publié, on écrira «sous presse» à la place de l'année de la publication. Il ne faudra pas écrire l'année prévue de la publication.

Documentation supplémentaire en ligne

La plate-forme en ligne donne la possibilité aux auteurs d'ajouter des données qui seraient autrement impossibles ou pas pratiques à inclure à la version imprimée. Les auteurs pourront inclure des tableaux et des figures ainsi que des données comme des vidéos, des images/structures en trois dimensions, des ensembles de données très détaillées et d'autres matériels supplémentaires ne convenant pas à la reproduction sur papier. Tout le matériel supplémentaire se présentera avec le manuscrit original. Les données supplémentaires seront indiquées dans le texte par le préfixe «S» (par exemple, tableau supplémentaire S1, figure supplémentaire S1). Les fichiers supplémentaires ne seront pas révisés et seront publiés tels que reçus. Les éditeurs devront approuver la publication électronique de ce matériel. Le manuscrit devra être autonome et se suffire à lui-même, sans le matériel supplémentaire (dans l'intérêt des lecteurs ayant uniquement accès à la copie papier).

Processus d'examen

Les manuscrits présentés au journal seront examinés par deux réviseurs externes et évalués par un des éditeurs. Si les éditeurs considèrent que l'article n'est pas pertinent avec ce journal ou que l'examen ne sera pas favorable, l'article pourra être renvoyé à l'auteur après l'examen initial des éditeurs. Ce processus de refus rapide permet à l'auteur de présenter immédiatement son travail ailleurs pour publication. Les manuscrits seront également refusés par les éditeurs s'ils ne sont pas conformes aux recommandations prévues pour leur préparation. Tous les efforts seront faits pour communiquer aux auteurs la décision de l'examen dans un délai de six semaines après la réception du manuscrit. Si les éditeurs demandent des révisions au manuscrit avant sa publication, on accordera un délai maximum d'un mois pour ces révisions.

Epreuves

L'éditeur se réserve le droit de réviser les manuscrits pour veiller à ce que la grammaire et l'orthographe soient cohérentes avec le style du journal. L'auteur principal recevra les épreuves en page pour la correction. Ces épreuves seront contrôlées et renvoyées dans un délai de deux jours après la réception. L'éditeur se réserve le droit de charger les auteurs en cas de correction excessive d'erreurs non typographiques.

Animal Genetic Resources, 2011, 48, 139–141. © Food and Agriculture Organization of the United Nations, 2011
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Instrucciones para los autores

Animal Genetic Resources/Resources génétiques animales/Recursos genéticos animales es una revista trilingüe, publicada tres veces al año electrónicamente en internet (http://journals.cambridge.org/AGR) y de forma impresa. Los principales trabajos son publicados en inglés, francés y español, con resúmenes en estos tres idiomas. La revista viene siendo publicada desde el año 1983 y todas las ediciones pasadas están disponibles en el enlace: http://dad.fao.org/cgi-bin/EfabisWeb.cgi?sid=-1,refcat_50000044

La revista invita a la presentación de trabajos desde cualquier parte del mundo. Aquellos autores que no posean un nivel elevado en alguno de las tres lenguas aceptadas, les solicitamos que busquen la ayuda necesaria en este sentido antes de remitirnos sus manuscritos.

Misión

La revista proporciona un foro internacional para la publicación de trabajos relacionados con la gestión de los recursos genéticos animales para la alimentación y la agricultura (AnGR). En concreto, se tratan las siguientes áreas: caracterización fenotípica y molecular; sondeo y seguimiento; desarrollo (mejora genética); utilización sostenible; desarrollo de las capacidades de los ganaderos y las comunidades de pastores; y políticas e instituciones.

Los editores aceptan todos los trabajos enviados que traten sobre los temas mencionados anteriormente. Trabajos relativos a razas y tecnologías que contribuyan a la gestión sostenible de los sistemas de producción con ingresos medios y bajos en el mundo, que comprenden la mayor parte de las tierras dedicadas a la producción ganadera y la mayor parte de la producción del ganado, que son los que ostentan mayor grado de interés.

La revista apoya la implementación del Plan de Acción Mundial sobre los Recursos Zoogenéticos, el marco de trabajo acordado para la gestión de los AnGR y el Convenio sobre la Biodiversidad.

Descargo de responsabilidad

Los puntos de vista expresados en los trabajos publicados en Animal Genetic Resources/Resources génétiques animales/Recursos genéticos animales son solamente las opiniones del autor o autores y, por tanto, no reflejan necesariamente las políticas de la FAO o los puntos de vista de los editores o de las instituciones a las que dichos autores pertenecen.

Evaluación de expertos

Los manuscritos enviados para su publicación en Animal Genetic Resources/Resources génétiques animales/Recursos genéticos animales serán estudiados minuciosamente por parte de dos críticos externos. Lo ideal es que los manuscritos sean evaluados por los críticos externos y por los editores, recayendo la decisión final acerca de los mismos sobre los editores.

Categorías de los trabajos

Trabajos sobre investigación – Se tomarán en consideración para su publicación en Recursos genéticos animales los trabajos relacionados con la gestión de los AnGR. Se invita a los autores a incluir las fotografías de alta calidad pertinentes relativas al trabajo presentado en sus manuscritos. Si las fotografías ilustran animales, éstas deben mostrar el entorno de producción primario al que estos animales se han adaptado.

Trabajos de revisión – Se podrán tomar en consideración ocasionalmente aquellos trabajos que presenten una revisión del desarrollo a nivel de nacional, regional o mundial en uno o más aspectos de la gestión de los AnGR. Estos trabajos podrán incluir las revisiones del estado actual de campos específicos de la gestión de los AnGR.

Artículos específicos – Los artículos relacionados con los temas de la revista serán publicados cuando los editores lo consideren oportuno.

***Otros trabajos publicados*:** Se invita a los lectores a enviar la siguiente información a la dirección de correo electrónico: AnGR-Journal@fao.org

- Revisiones o propuestas de libros.
- Conclusiones y recomendaciones resultantes de reuniones, talleres y conferencias relevantes.
- Anuncios de cursos de capacitación y eventos a nivel nacional, regional o internacional.

Originalidad y copyright

Para poder ser publicado en la revista Recursos genéticos animales, el manuscrito deberá no haber sido publicado previamente o estar bajo estudio para ser publicado. (Los datos que hayan sido publicados previamente podrán ser usados en la revista con precaución y siempre y cuando se obtenga el permiso necesario). Antes de la publicación, el autor del manuscrito deberá firmar y entregar, en su nombre y en el de los co-autores, una autorización y un formulario de consentimiento de transferencia a la editorial. Este formulario se enviará al autor junto con la prueba del artículo a publicar.

Autoría

Los artículos que tengan múltiples autores serán revisados bajo el supuesto de que todos los autores han contribuido a la investigación descrita en el artículo y aprueban tanto el artículo en su totalidad como el envío y la publicación de éste. Contribución al trabajo presentado supone la concepción y el diseño del proyecto, los resultados de los experimentos y/o el análisis e interpretación de los datos. Los autores deberán haber contribuido sustancialmente al borrador o a la revisión de dicho trabajo.

Presentación del Manuscrito

Todos los manuscritos deberán enviarse online, y sin coste alguno para el autor, a través de la página Web: http://journals.cambridge.org/AGR.

Posteriormente al envío del manuscrito, se mandará acuse de recibo junto con un número de referencia y el manuscrito será presentado para ser estudiado. Para toda correspondencia relacionada con el manuscrito, se deberá incluir el número de referencia mencionado.

Se deberán seguir las siguientes instrucciones (para más información, ir a la sección "Preparación y estilo de manuscrito"):

- Los manuscritos se presentarán en ingles, francés o español. Si el manuscrito está escrito en francés o español se deberá incluir un resumen, así como palabras clave en el mismo idioma además del inglés. Todos los artículos publicados presentarán un resumen en inglés, francés y español. Se agradecerá el envío del resumen en los tres idiomas con objeto de reducir gastos de traducción y acelerar el proceso del manuscrito.
- El formato deseado de documento para la presentación es Microsoft Word. No se aceptarán manuscritos enviados en Word Perfect u otros procesadores de texto. Los cuadros se incluirán al final del documento, siguiendo el orden indicado por los marcadores de posición dentro del texto.
- Las figuras deberán presentarse en documentos separados con una resolución apropiada (Para más información ver "Preparación y estilo de manuscrito").
- Se deberá presentar una carta de presentación en un documento por separado. La carta deberá indicar la categoría bajo la que el manuscrito se presenta (Ver apéndice 1) y los datos del autor (número de teléfono, fax, y dirección de correo electrónico).
- Los nombres de los archivos enviados deberán indicar el nombre completo o abreviado del autor principal.
- No se requiere ni deberá enviarse copia en papel del manuscrito, de los cuadros o de las figuras.

Tenga en cuenta que toda correspondencia en relación con los manuscritos presentados y analizados se hará exclusivamente con el autor principal.

Preparación y estilo del manuscrito

El formato del manuscrito deberá tener un espaciamiento doble entre líneas. Las páginas deberán estar numeradas, siendo la página número uno la que lleva el título del artículo. Los márgenes de las páginas deberán tener al menos 2.5 cm. en todas sus caras. La letra debe ser estilo "Arial".

Autores y afiliaciones – Los nombres y afiliaciones de los autores deberán presentarse en el formato siguiente:

E.C. Quispe[1], T.C. Rodríguez[2], L.R. Iñiguez[3] and J.P. Mueller[4]

[1]Universidad Nacional de Huancavelica, Huancavelica, Perú; [2]Universidad Mayor de San Andrés, La Paz, Bolivia; [3]Cochabamba, Bolivia; [4]Instituto Nacional de Tecnología Agropecuaria, Bariloche, Argentina.

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El título abreviado tendrá un máximo de 50 caracteres y aparecerá en la página 1 del manuscrito.

El ***resumen*** no deberá tener estructura o subtítulos y deberá proporcionar al lector una sinopsis que sea independiente del documento. Deberá incluir una breve introducción, la metodología usada, los resultados obtenidos y las conclusiones. El resumen no deberá exceder de 210 palabras en inglés y 250 palabras en francés y español. El resumen deberá ser seguido de tres a cinco palabras clave separadas por una coma. Tanto el resumen como las palabras clave se escribirán en el mismo idioma del manuscrito además del inglés.

El ***texto principal del manuscrito*** deberá empezar en la página número 3 y las referencias deberán comenzar en una página nueva. Las líneas de texto deberán estar numeradas y el manuscrito estructurado con encabezamientos numerados consecutivamente (eje. 1., 1.1, 1.1.1 etc.). Es importante evitar el uso de referencias cruzadas cuando se use la numeración de los encabezamientos, en cuyo caso la editorial eliminará la numeración y aplicará los estilos de encabezamiento en la versión final.

Adicionalmente, los trabajos de investigación deben incluir los siguientes encabezamientos: ***Materiales y métodos, Resultados, Discusión y Conclusiones***.

La ***extensión máxima*** del texto principal del manuscrito no deberá exceder de 10 páginas (8.500 palabras aprox.). En caso de que el texto sea corto, éste no deberá exceder de una página (750 palabras ó 500 palabras si se incluye una imagen).

Los Cuadros deberán ser numerados consecutivamente tal y como están citados en el texto (Cuadro 1, 2 etc.). Cada cuadro deberá aparecer en una página distinta (al final del documento) con la numeración y título arriba y las anotaciones o comentarios debajo del mismo.

Las figuras se numerarán consecutivamente tal y como están citadas en el texto del documento (Figura 1, 2, etc.). Se deberán usar caracteres en cursiva para apartados a, b, c, etc. Cada figura deberá incluir una leyenda. En caso que corresponda, las figuras se deberán enviar en archivos con formato TIFF o EPS, preferiblemente con el mismo tamaño con el que serán reproducidos o publicados. Las ilustraciones o material gráfico deberán enviarse en blanco y negro con una resolución de 1200 dpi; las combinaciones de material gráfico con una resolución de 800 dpi; el material gráfico en modelo de semitono en blanco y negro deberá guardarse bajo el modo "escala de grises" con una resolución de 300 dpi; el material gráfico en modelo de semitono a color se guardará bajo modo "CMYK" con una resolución de 400 dpi. Se deberán obtener todos los permisos necesarios.

Abreviaturas y el sistema internacional de unidades (SI) – No se recomienda el uso de abreviaturas excepto aquellas extensamente utilizadas. Las abreviaturas deberán usarse sólo en caso de que mejoren la comprensión del manuscrito. Los acrónimos deberán ser escritos en palabras completas la primera vez que se mencionen. Se usarán las medidas del sistema métrico internacional (SI).

Lista de agradecimientos

En esta sección el autor deberá hacer mención a la ayuda económica recibida, por parte de las agencias de financiación u otras fuentes,

para la realización del trabajo documentado en el manuscrito. También se podrán incluir, en esta sección, los agradecimientos a las personas que contribuyeron a la investigación pero que no aparecen como autores.

La lista de agradecimientos deberá aparecer después del texto principal antes de las referencias. En caso de que no haya agradecimientos, la palabra "ninguno" seguirá al encabezamiento "Lista de agradecimientos".

Declaración de interés

Existe conflicto de intereses cuando un autor tiene intereses que pudieran influir de forma inapropiada en su opinión o juicio, incluso si su opinión no ha sido finalmente influenciada. Por esta razón, los autores deberán revelar conflictos de intereses potenciales de forma que se pueda evaluar sobre sus efectos. En el momento en que se envíe el manuscrito, los autores deberán revelar cualquier acuerdo o conexiones económicas que puedan tener, que sean pertinentes al manuscrito enviado y que puedan ser percibidas como potencial amenaza a la imparcialidad del documento. También deberán declararse los intereses no-financieros que pudieran ser relevantes en este contexto. En caso de que no haya intereses relevantes, deberá también indicarse. Este requerimiento será aplicable a todos autores del documento y a todas las categorías de documentos.

Referencias

Toda referencia presente en el texto deberá aparecer en la lista de referencias y, de la misma manera, cada referencia de la lista deberá haber sido citada por lo menos una vez en el texto. Las referencias deben ir en orden alfabético del apellido del autor, seguido por el año.

Ejemplos:

1. *Ejemplo en el caso de una referencia de una revista*:
   Köhler-Rollefson, I. 1992. The camel breeds of India in social and historical perspective. *Animal Genetic Resources Information* 10: 53–64.
2. *Cuando se trate de más de un autor*:
   Matos, C.A.P., Thomas, D.L., Gianola, D., Tempelman, R. J. & Young, L.D. 1997. Genetic analysis of discrete reproductive traits in sheep using linear and non-linear models: 1. Estimation of genetic parameters, *Journal of Animal Science* 75: 76–87.
3. *En el caso de un libro o de una publicación ad hoc, por ejemplo informes, tesis, etc*.
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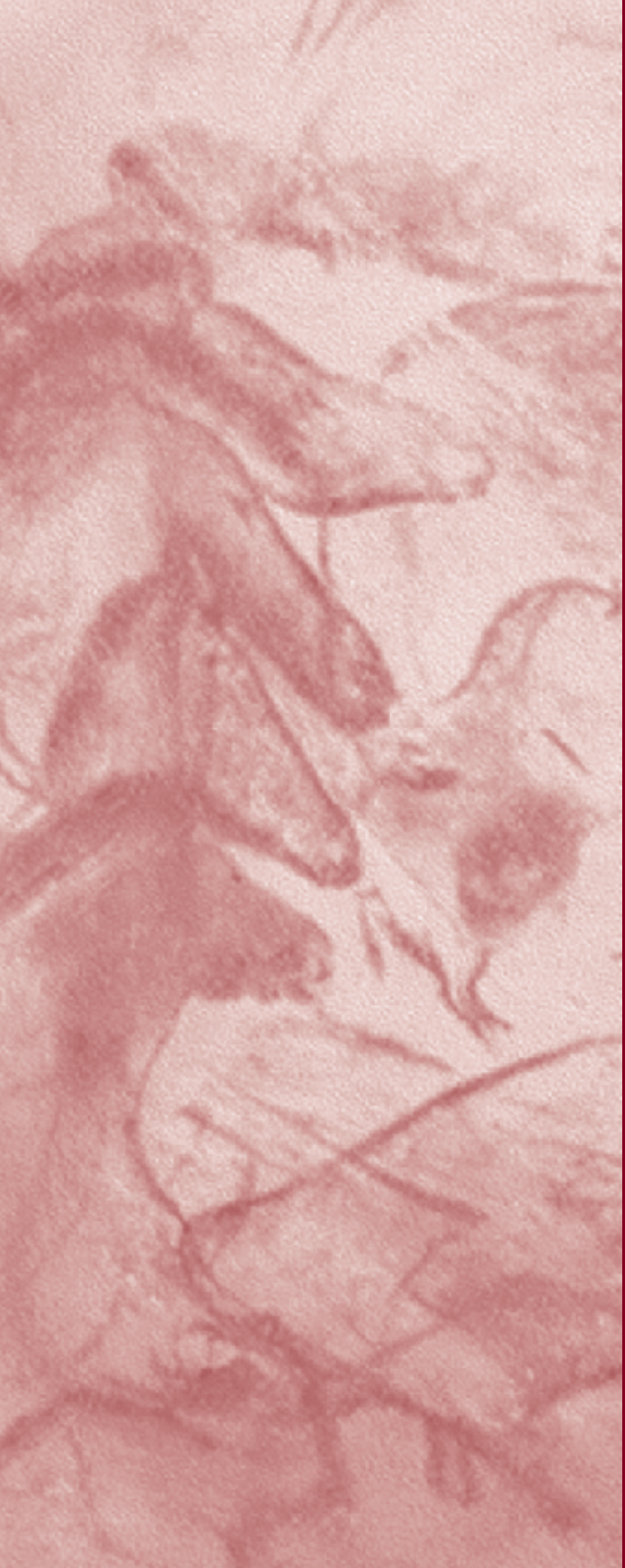

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