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Editorial

Reviewing progress made in the implementation of the Global Plan of Action for Animal Genetic Resources

More than five years have passed since the adoption of the *Global Plan of Action for Animal Genetic* Resources[1]. Progress in the implementation of the *Global Plan of Action* is overseen by the Commission on Genetic Resources for Food and Agriculture[2]. In line with the reporting schedule agreed by the Commission, FAO has recently produced a document entitled *Synthesis progress report on the implementation of the Global Plan of Action for Animal Genetic Resources – 2012*[3], which was presented to the Seventh Session of the Commission's Intergovernmental Technical Working Group on Animal Genetic Resources for Food and Agriculture in October 2012. The report includes a set of indicators of progress in implementing various elements of the *Global Plan of Action*. The indicators are calculated at national, subregional, regional and global levels, and are presented graphically in the form of "traffic light" colours.

To obtain the input needed to prepare the *Synthesis progress report*, FAO invited countries, regional networks and international organizations to report on their implementation of the *Global Plan of Action*. FAO received 85 Country Progress Reports, 4 Regional Progress Reports and 11 reports from international organizations. All these reports have been published online.[4]

Analysis of the impact of the *Global Plan of Action* at country level reveals that substantial improvements have been made since 2007. However, the Country Progress Reports indicate that the state of implementation of the various elements of the *Global Plan of Action*, and the extent to which progress has been made since 2007, vary substantially among countries and regions (although some caution is needed in interpreting the regional figures because of the uneven coverage of the reporting). Implementation is generally at a high level in the Europe and the Caucasus and the North America Regions, at a medium level in Asia, and at a low level in other regions. However, individual countries from all developing regions have reached high levels of implementation in some aspects of the *Global Plan of Action*. Likewise, some countries from developed regions have reached only low levels of implementation in some aspects. For the world as a whole, the indicator for the *Global Plan of Action's* Strategic Priority Area 4 (Policies, institutions and capacity building) shows a lower level of implementation than the indicators for the other three strategic priority areas. However, for several developing regions, it is Strategic Priority Area 3 (Conservation) that has the lowest indicator scores.

In all regions, the indicators for the state of collaboration and for the state of funding show a lower level of implementation than those for the strategic priority areas themselves. Financial constraints are also the problems most frequently mentioned in the Country Progress Reports as barriers to the implementation of the *Global Plan of Action*.

Regional Progress Reports present a mixed picture of the state of collaboration at regional level in the implementation of the *Global Plan of Action*. Several regions of the world do not yet have a Regional Focal Point or regional network. Activities are most advanced in Europe, the region with the longest-established Regional Focal Point, where a range of activities are reported across all the strategic priority areas of the *Global Plan of Action*. A more limited range of activities is reported by the Regional Focal Point for Latin America and the Caribbean and the Animal Genetic Resources Network – Southwest Pacific. The Sub-Regional Focal Point for West and Central Africa, launched only in June 2011, has established regional priorities for action in the various strategic priority areas of the *Global Plan of Action*.

The reports from international organizations show that a small number of such organizations continue to make an important contribution to the implementation of the *Global Plan of Action*, often via innovative, efficient and participatory programmes and projects. The activities of these organizations span the four strategic priority areas of the *Global Plan of Action*.

Overall, the *Synthesis progress report* concludes that despite the significant impact of the *Global Plan of Action,* the task of improving the management of the world's animal genetic resources management remains far from complete. The reason for this lies mainly in a lack of sufficient financial resources, but also in low levels of collaboration between countries, a lack of established policies and legal frameworks, and a lack of strong institutional and human capacity for planning in the livestock sector.

The editors would like to encourage the readership of *Animal Genetic Resources* to contribute to the implementation of the Global Plan of Action and to collaborate with their respective National Coordinators for the Management of Animal Genetic Resources.[5]

[1] www.fao.org/docrep/010/a1404e/a1404e00.htm
[2] http://www.fao.org/nr/cgrfa/en/
[3] http://www.fao.org/docrep/meeting/026/me636e.pdf
[4] http://www.fao.org/ag/againfo/programmes/en/genetics/Reporting_system.html
[5] http://dad.fao.org/cgi-bin/EfabisWeb.cgi?sid=−1,contacts

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Éditorial

Révision des progrès réalisés dans la mise en œuvre du Plan d'Action Mondial pour les Ressources Zoogénétiques

Plus de cinq ans se sont écoulés depuis l'adoption du *Plan d'Action Mondial pour les Ressources Zoogénétiques*[1]. La Commission des Ressources Génétiques pour l'Alimentation et l'Agriculture[2] supervise les progrès dans la mise en œuvre du *Plan d'Action Mondial*. En accord avec le calendrier de présentation des rapports convenu par la Commission, la FAO a récemment produit un document intitulé *Synthesis progress report on the implementation of the Global Plan of Action for Animal Genetic Resources – 2012*[3] (Rapport intérimaire de synthèse sur la mise en œuvre du Plan d'Action Mondial pour les Ressources Zoogénétiques – 2012), qui a été présenté lors de la Septième Réunion du Groupe de Travail Technique Intergouvernemental sur les Ressources Zoogénétiques pour l'Alimentation et l'Agriculture de la Commission en octobre 2012. Le rapport inclut une série d'indicateurs des progrès réalisés dans la mise en œuvre de plusieurs éléments du *Plan d'Action Mondial*. Les indicateurs sont calculés à l'échelon national, sous-régional, régional et mondial, et sont présentés graphiquement avec les couleurs des feux de signalisation.

Pour obtenir les données nécessaires à la préparation du *Rapport intérimaire de synthèse*, la FAO a encouragé les pays, les réseaux régionaux et les organisations internationales à informer sur leur mise en œuvre du *Plan d'Action Mondial*. La FAO a reçu 85 rapports nationaux, 4 rapports régionaux et 11 rapports d'organisations internationales. Tous ces rapports ont été publiés en ligne[4].

L'analyse de l'influence du *Plan d'Action Mondial* au niveau des pays révèle les améliorations substantielles qui ont été apportées depuis 2007. Cependant, les rapports intérimaires des pays indiquent que l'état d'avancement des divers éléments du *Plan d'Action Mondial* et l'ampleur des progrès réalisés varient fortement d'un pays ou d'une région à l'autre (il convient néanmoins de se montrer prudent lorsque l'on interprète les chiffres régionaux car la couverture assurée par les rapports est inégale). La mise en œuvre est généralement bien avancée dans la region Europe et Caucase et en Amérique du Nord, moyennement en Asie et faiblement dans les autres régions. Toutefois, dans toutes les régions en développement, plusieurs pays sont parvenus à un niveau de mise en œuvre élevé sur certains aspects du *Plan d'Action Mondial*. À l'inverse, dans les régions développées, certains pays n'ont atteint qu'un niveau de mise en œuvre faible sur certains points. À l'échelle mondiale, l'indicateur relatif au domaine prioritaire 4 (Politiques, institutions et renforcement des capacités) atteste un niveau de mise en œuvre plus bas que dans les trois autres domaines prioritaires. Dans certaines régions en développement, cependant, c'est le domaine stratégique 3 (Conservation) qui connaît les résultats les plus faibles.

Dans toutes les régions, les indicateurs portant sur la situation de la collaboration et du financement affichent des scores moins élevés que ceux des domaines prioritaires eux-mêmes. Par ailleurs, les facteurs financiers sont les obstacles à la mise en œuvre du *Plan d'Action Mondial* les plus fréquemment cités.

Les rapports d'activité régionaux sur l'état d'avancement de la mise en œuvre du *Plan d'Action Mondial* dépeignent un tableau plus nuancé de la situation de collaboration à l'échelon régional. Plusieurs régions du monde ne disposent pas encore de centre de coordination ni de réseau régional. C'est en Europe que les activités sont les plus avancées: ce continent a vu la création du premier centre de coordination régional et toute une série d'activités y sont réalisées dans l'ensemble des domaines prioritaires du *Plan d'Action Mondial*. Le centre de coordination régional pour l'Amérique Latine et les Caraïbes et le Réseau sur les Ressources Zoogénétiques – Pacifique Sud-Ouest rendent compte d'un éventail d'activités plus limité. Le centre de coordination sous-régional pour l'Afrique Occidentale et Centrale, en fonction depuis juin 2011, a établi des priorités d'action régionales dans les différents domaines prioritaires du *Plan d'Action Mondial*.

Les rapports des organisations internationales montrent que quelques unes de ces organisations continuent d'apporter une contribution importante à la mise en œuvre du *Plan d'Action Mondial*, souvent au travers de programmes et projets novateurs, efficaces et participatifs. Leurs activités sont regroupées en fonction de leur pertinence quant aux quatre domaines prioritaires du *Plan d'Action Mondial*.

Globalement, le *Rapport intérimaire de synthèse* conclut que, malgré l'influence significative du *Plan d'Action Mondial*, il reste encore beaucoup à faire pour améliorer la gestion des ressources zoogénétiques mondiales. Cela s'explique essentiellement par l'insuffisance des ressources financières mais aussi par la faible collaboration entre les pays, l'absence de politiques et de cadres juridiques établis, et le manque de capacités humaines et institutionnelles fortes en matière de planification dans le secteur de l'élevage.

[1] http://www.fao.org/docrep/010/a1404f/a1404f00.htm
[2] http://www.fao.org/nr/cgrfa/cgrfa-home/fr/
[3] http://www.fao.org/docrep/meeting/026/me636e.pdf
[4] http://www.fao.org/ag/againfo/programmes/fr/genetics/Reporting_system.html

Les rédacteurs voudraient encourager les lecteurs de *Ressources Génétiques Animales* à contribuer dans la mise en œuvre du *Plan d'Action Mondial* et à collaborer avec leurs respectifs Coordonnateurs Nationaux pour la gestion des Ressources Zoogénétiques[5].

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

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Editorial

Revisión de los progresos realizados en la aplicación del Plan de Acción Mundial sobre los Recursos Zoogenéticos

Han transcurrido más de cinco años desde la adopción del *Plan de Acción Mundial sobre los Recursos Zoogenéticos*[1]. La Comisión de Recursos Genéticos para la Alimentación y la Agricultura[2] supervisa los avances en la implementación del *Plan de Acción Mundial*. En línea con el calendario de presentación de informes acordado por la Comisión, la FAO ha producido recientemente un documento titulado *Synthesis progress report on the implementation of the Global Plan of Action for Animal Genetic Resources – 2012*[3] (Informe de síntesis de los progresos realizados en la aplicación del Plan de Acción Mundial sobre los Recursos Zoogenéticos – 2012), que ha sido presentado en la Séptima Reunión del Grupo de Trabajo Técnico Intergubernamental sobre los Recursos Zoogenéticos para la Alimentación y la Agricultura de la Comisión en octubre de 2012. El informe incluye una serie de indicadores del avance alcanzado en la implementación de varios elementos del *Plan de Acción Mundial*. Los indicadores son calculados a nivel nacional, subregional, regional y mundial, y se presentan gráficamente con los colores del semáforo.

Con el fin de obtener los datos necesarios para la preparación del *Informe de síntesis de los progresos realizados*, la FAO ha animado a los países, redes regionales y organizaciones internacionales a informar sobre su aplicación del *Plan de Acción Mundial*. La FAO ha recibido 85 informes nacionales, 4 informes regionales y 11 de organizaciones internacionales. Todos estos informes han sido publicados en internet[4].

El análisis de las repercusiones del *Plan de Acción Mundial* a nivel nacional revela que se han realizado mejoras sustanciales desde 2007. No obstante, los informes de los progresos realizados en los países indican que el estado de aplicación de los diversos elementos del *Plan de Acción Mundial*, y la medida de tales progresos desde 2007, varían considerablemente entre países y regiones (aunque se precisa cierta cautela al interpretar las cifras regionales, debido a la desigual cobertura de los informes presentados). La aplicación alcanza en general elevados niveles en Europa y el Cáucaso y en América del Norte, niveles medios en Asia, y niveles bajos en otras regiones. Sin embargo, los distintos países de todas las regiones en desarrollo han alcanzado elevados niveles por lo que respecta a la aplicación de algunos aspectos del *Plan de Acción Mundial*. Análogamente, algunos países de las regiones desarrolladas han alcanzado bajos niveles de aplicación de algunos aspectos. En cuanto al mundo en su conjunto, el indicador del área estratégica prioritaria 4 del *Plan de Acción Mundial* (Políticas, instituciones y creación de capacidad) muestra un nivel de aplicación más bajo que el de los indicadores de las otras tres áreas estratégicas prioritarias. No obstante, en varias regiones en desarrollo, es en el área estratégica prioritaria 3 (Conservación) donde se han alcanzado las puntuaciones más bajas de los indicadores.

En todas las regiones, los indicadores relativos al estado de colaboración y al estado de financiación presentan un nivel más bajo de aplicación que los relativos a las propias áreas estratégicas prioritarias. Las limitaciones financieras representan también los obstáculos mencionados con mayor frecuencia por lo que respecta a la aplicación del *Plan de Acción Mundial*.

Los informes relativos a los progresos regionales en la aplicación del *Plan de Acción Mundial* presentan un panorama mixto en cuanto al estado de colaboración a nivel regional. Varias regiones del mundo no disponen todavía de un centro de coordinación o red regional. Las actividades se encuentran en situación más avanzada en Europa, la región con el centro de coordinación regional más antiguo, respecto de la cual se informa de una serie de actividades en todas las áreas estratégicas prioritarias del *Plan de Acción Mundial*. Se informa en cambio de una gama más limitada de actividades en los informes del centro de coordinación regional para América Latina y el Caribe y la Red de Recursos Zoogenéticos – Pacífico Sudoccidental. El centro de coordinación subregional para el África Occidental y Central, inaugurado apenas en junio de 2011, ha establecido prioridades regionales de acción en las distintas áreas estratégicas prioritarias del *Plan de Acción Mundial*.

Los informes de las organizaciones internacionales muestran que un reducido número de tales organizaciones sigue contribuyendo de manera importante a la aplicación del *Plan de Acción Mundial*, a menudo a través de programas y proyectos innovadores, eficientes y participativos. Las actividades de estas organizaciones abarcan las cuatro áreas estratégicas prioritarias del *Plan de Acción Mundial*.

En general, el *Informe de síntesis de los progresos realizados* concluye que pese a la importante repercusión ejercida por el *Plan de Acción Mundial*, la tarea de mejorar la ordenación de los recursos zoogenéticos mundiales dista todavía de estar completada. Ello se debe principalmente

[1] http://www.fao.org/docrep/010/a1404s/a1404s00.htm
[2] http://www.fao.org/nr/cgrfa/cgrfa-home/es/
[3] http://www.fao.org/docrep/meeting/026/me636e.pdf
[4] http://www.fao.org/ag/againfo/programmes/es/genetics/Reporting_system.html

a la falta de recursos financieros suficientes, pero también a la escasa colaboración entre los países, a la falta de políticas y marcos jurídicos establecidos, y a la falta de una sólida capacidad institucional y humana para la planificación en el sector ganadero.

Los editores querrían animar a los lectores de *Recursos Genéticos Animales* a contribuir en la aplicación del *Plan de Acción Mundial* y a colaborar con sus respectivos Coordinadores Nacionales en la ordenación de los Recursos Zoogenéticos[5].

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

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Fipa cattle in the southwestern highlands of Tanzania: socio-economic roles, traditional management practices and production constraints

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Summary
This study aimed at determining the socio-economic roles, traditional management practices and production constraints of the Fipa cattle, was conducted in Rukwa region of South-Western Tanzania, using a structured questionnaire. The results indicate that most (90.8 percent) of the respondents depended on crop and livestock production for household income and food security. The Fipa cattle were preferred to other cattle strains by most (91.6 percent) of the farmers owing to their multiple socio-economic functions, adaptive qualities and low management requirements. The Fipa cattle were essentially kept for provision of draught power, income, manure, meat and security against uncertainties. Herded grazing on communal land was practiced by most (99.2 percent) of the farmers all the year-round without any supplementation. However, most (87.5 percent) farmers utilized crop residues *in situ* during the dry season, after harvesting cereal crops. Kraals made of untreated thorny bushes were the predominant shelters used for Fipa cattle by most (95.8 percent) of the respondents. The majority of respondents mentioned diseases/parasites (94.2 percent) and feed shortages (61.7 percent) during the dry season as the main production constraints. The farmers' preference for Fipa cattle coupled with the multiple roles of the cattle and traditional management practices used by farmers should be used as the entry point for improvement and sustainable utilization of the strain.

Keywords: *Fipa cattle, Fipa plateau, management practices, production challenges, roles*

Résumé
Cette étude visait à définir les fonctions socio-économiques, les pratiques traditionnelles de gestion et les contraintes relatives à la production des bovins Fipa. Elle a été réalisée dans la région Rukwa, située dans le sud-ouest de la Tanzanie, en utilisant un questionnaire structuré. Les résultats indiquent que la plupart (90,8 pour cent) des personnes interrogées dépendent de la production végétale et de l'élevage en ce qui concerne leurs revenus et la sécurité alimentaire de leurs ménages. La plupart (91,6 pour cent) des agriculteurs préfèrent les bovins Fipa à d'autres souches bovines en raison de leurs fonctions socio-économiques multiples, de leurs qualités d'adaptation et des faibles exigences de gestion. Les bovins Fipa sont principalement élevés pour la traction, le revenu, le fumier, la viande et en tant que sécurité contre les incertitudes. La plupart (99,2 pour cent) des agriculteurs pratiquent le pâturage surveillé en troupeau sur les terres en commun pendant toute l'année, sans aucune complémentation. Toutefois, la plupart (87,5 pour cent) des agriculteurs utilisent des résidus végétaux *in situ* pendant la saison sèche, après la récolte des cultures céréalières. La plupart (95,8 pour cent) des personnes interrogées utilisent des enclos construits avec des buissons épineux non traités comme abri pour les bovins Fipa. Les principales contraintes à la production mentionnées par les personnes interrogées sont les maladies/parasites (94,2 pour cent) et les pénuries d'aliments pour animaux (61,7 pour cent) au cours de la saison sèche. La préférence des agriculteurs pour les bovins Fipa, ainsi que les fonctions multiples de la race et les pratiques traditionnelles de gestion utilisées par les agriculteurs devraient constituer le point de départ pour l'amélioration et l'utilisation durable de cette souche.

Mots-clés: *bovins Fipa, plateau des Fipa, pratiques de gestion, défis de production, fonctions*

Resumen
El objetivo de este trabajo ha estado centrado en la determinación del papel socio-económico, las prácticas tradicionales de manejo y las limitaciones de producción del ganado Fipa, llevado a cabo en la región Rukwa, en el suroeste de Tanzania, por medio de encuestas. Los resultados indican que la mayoría de los encuestados (90,8%) dependían de la producción agrícola y ganadera para sus ingresos familiares y la seguridad alimentaria. La mayor parte de los ganaderos (91,6%) prefiere el ganado Fipa a otras razas de vacuno debido a sus múltiples funciones socioeconómicas, a sus características de adaptación y pocos cuidados en su manejo. El ganado Fipa se ha mantenido fundamentalmente como animal de tiro o trabajo y para proporcionar ingresos, estiércol, carne y disponer de seguridad de cara al futuro. La mayor parte de los ganaderos (99,2%) llevan a cabo el pastoreo conjunto en pastos comunales, a lo largo de todo el año y sin realizar ningún tipo de suplementación. Sin embargo, la mayoría de los ganaderos (87,5%) utilizan residuos de

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los cultivos in situ durante la estación seca, después de cosechar los cereales. La mayoría de los encuestados (95,8%) respondió que los corrales utilizados como refugio para el ganado Fipa están hechos de arbustos espinosos no tratados. La mayor parte de los encuestados mencionó las enfermedades y los parásitos (94,2%) y la escasez de alimentos (61,7%) durante la estación seca como las limitaciones principales en la producción. Las preferencias de los ganaderos por el ganado Fipa, junto con las múltiples funciones de estos animales, además de las prácticas tradicionales de manejo llevadas a cabo, deben ser utilizadas como punto de partida para la mejora y la utilización sostenible de esta población.

Palabras clave: *ganado vacuno Fipa, meseta Fipa, prácticas de manejo, desafíos de la producción, rol*

Submitted 14 July 2011; accepted 15 March 2012

Introduction

Tanzania has an estimated 21.4 million cattle of which about 95 percent are of indigenous types. The indigenous breeds represent an important genetic resource that contributes significantly to the employment of the majority of people in rural areas and to the National Gross Domestic Product (MLDF, 2011). Indigenous cattle contribute more than 90 percent of the meat and 70 percent of the milk consumed in the country (Njombe and Msanga, 2008). They also provide tangible non-food products such as hides, horns and manure for crop production. Moreover, they are used in agricultural and socio-cultural functions such as draught activity, dowry payments, traditional feasts and religious ceremonies (Scarpa *et al.*, 2003). Tanzanian indigenous cattle rearing thus constitutes a major occupation mainly in the rural areas of the country where cropping activities are also practised (Msechu, 2001).

About 95 percent of the Tanzanian indigenous cattle breeds are kept under the agro-pastoral farming system, where the farming community comprised sedentary farmers who combine crop production with livestock keeping for sustenance of their livelihoods (URT, 2006). The dominant management practice under this system is herded grazing in communal lands, fallow lands and in crop fields after harvesting cereal grains (Oumam, Abdulai and Drucker, 2005). Unlike the pastoral communities that keep cattle for provision of cash income and meat and also as a repository of wealth and dowry payments; most agro-pastoral communities keep cattle for draught power, manure, income, dowry payment, milk and security against future uncertainties (Maeda-Machang'u *et al.*, 2000). The crop–livestock interaction gives an important synergism as animals provide draught power for land tillage, transport and manure for crop production, whereas crop residues are consumed by the livestock (Oluka *et al.*, 2008).

The dominant cattle breeds kept under the agro-pastoral system are the Tanzania Shorthorn Zebu (TSZ) and Sanga derivatives. The TSZ breed comprised a number of strains, such as Iringa red, Maasai, Mkalama dun, Singida white, Mbulu, Gogo, Chaga and Pare (Msanga, Mbaga and Msechu, 2001), whereas the Sanga and Sanga × Zebu crosses include the Ankole breed, the Tarime and Fipa strain (Rege and Tawah, 1999). The Fipa cattle are mainly kept by Fipa communities in Rukwa region, in the South-Western Highlands of Tanzania. The Fipa people are settled agro-pastoral farmers and depend mainly on food crops production (maize, wheat, finger millet, beans, sunflower, potatoes and rice) and livestock keeping (cattle, goats, sheep, donkeys, turkeys and local chickens). The Fipa communities have persisted keeping Fipa cattle for generations despite the introduction of high-producing dairy breeds in urban areas for the last three decades as well as the encroachment of other indigenous cattle in some parts of the region. However, dairy cattle constitute only about 1 percent of the total cattle population in the region (URT, 2010). Although Fipa cattle do not receive much attention in terms of selection, housing, feeding and disease control, they are claimed to maintain a reasonable level of productivity in terms of fertility, growth rate, body weight and milk yield. The strain also shows relatively high resilience to tick-borne diseases in comparison with other cattle strains in the same area (Mwakilembe *et al.*, 2007). The traditional knowledge and local customs of the Fipa communities are the main forces responsible for shaping the roles, values and adaptive characteristics of Fipa cattle through artificial selection (Msanga, Mbaga and Msechu, 2001).

Despite the strain's considerable (40 percent) contribution to households' food security and income, and being a major component of crop–livestock integrated system in Rukwa region (Mwakilembe *et al.*, 2007), little is known and documented about its socio-economic roles, its production challenges and management practices employed by Fipa community for raising it. This study was therefore aimed at determining and documenting the socio-economic roles, traditional management practices and production challenges of the Fipa cattle in order to lay a foundation for rational improvement and sustainable utilization of the strain.

Materials and methods

Study area

The study was conducted in three districts of Rukwa region, Tanzania, viz. Sumbawanga rural, Sumbawanga urban and Nkasi district. The Rukwa region lies between

latitudes 3°00″ and 9°00″S and longitudes 30°00″ and 33° 00″E. The region has a unimodal rainfall pattern that starts in November and ends in May. The prolonged dry season extending from June to November, is a limiting factor for forage availability.

The estimated population of cattle in Rukwa region is 512 722, of which more than 50 percent are Fipa cattle (URT, 2010). The whole region has a total land area of 75 250 km^2 of which about 86 percent is used for agricultural activities, wildlife and forestry. Of the total agricultural land, about 62.5 percent is communally owned through local authorities for expansion of cropping activities and grazing of animals, whereas about 37.5 percent of the total land is privately owned for different uses. Farm size per household for cropping activities is moderate (2–15 acres) (URT, 2010).

The Rukwa region is divided into five agro-ecological zones (AEZs) based on altitude, soil types, land use, climatic condition, natural vegetation, agricultural suitability and other economic activities (Table 1). Among these AEZs, the Fipa plateau is the main one. The plateau is situated between latitudes 6°50″ and 9°40″S and longitudes 30°26″ and 32°54″E. It occupies about 60 percent of the total area of the region, mainly the highland terrain of Sumbawanga rural, urban and Nkasi districts, and is dominated by settled agro-pastoral farming system, particularly maize – Fipa cattle farming system (Mussei *et al.*, 1999). The Fipa plateau was chosen for this study because it has a large proportion (over 90 percent) of the total number of Fipa cattle and also its climate and landscape across the three districts is distinctive. Other livestock species such as sheep, goats, chickens, donkeys, pigs and turkeys are kept in the area and various food crops are produced. Livestock keeping is the second dominant agricultural activity after crop production. The predominant natural vegetation along the plateau is the tropical savannah mainly with grasses such as *Hyperenia rufa, Pannicum*

Table 1. Rukwa region AEZs with some environmental features.

Description	AEZs and locations				
	Fipa plateau: large parts of Sumbawanga rural, urban and Nkasi district	**Katumba–Inyonga plains: Mpanda district**	**Mpanda–Mwese range: Mpanda and parts of Nkasi district**	**Lake Rukwa basin: Sumbawanga rural district**	**Lake Tanganyika shore: Nkasi and Sumbawanga rural district**
Landform	Dissected escarpment with moderate undulating and lowering plain (predominant)	Plain to rolling terrain	Hills sloping to piedmonts and flat valleys	Flood plains and piedmonts	Coastal plain
Altitude (masl)	1200–2100	1000–1500	1100–1900	800–1000	700–1000
Rainfall pattern and amount (mm)	Unimodal, 900–1300	Unimodal, 900–1200	Unimodal, 1200–1300	Unimodal, 800–1200	Unimodal, 1200
Rainfall season	November–May	December–April	November–April	November–March	December–March
Temperature regime (°C)	Isothermic (10–28)	Isothermic (15–30)	Isothermic (14–30)	Isohyperthermic (16–31)	Isohyperthermic (18–32)
Soil types	Shallow dark brown sandy loams	Deep sands and red clays	Deep clays over sandy loam	Sandy clay to clay over sandy loam	Dark clay with some sandy clays
Land use (crops)	Mainly Maize, finger millet, beans and sunflower	Mainly maize, tobacco, groundnuts, etc.	Coffee, maize, groundnuts, beans, etc.	Rice, maize, beans, finger millet, etc.	Rice, coconut, cassava, etc.
Land use (livestock)	Mainly Fipa cattle, sheep, goat chickens, pigs, donkeys and turkeys	Mainly Tarime and Ankole cattle, sheep, goats, chickens, pigs and donkeys	Mainly Tarime and Ankole cattle, sheep, goats, chickens, pigs and donkeys	Mainly Tarime, cattle, sheep, goats, chickens, pigs and donkeys	Mainly Tarime and Ankole cattle, sheep, goats, chickens and donkeys
Natural vegetation	Tropical savannah with few natural trees in Sumbawanga district and modest forestry in Nkasi district	Tropical savannah dominated with scanty trees	Tropical savannah dominated with modest natural forestry	Tropical savannah with sparingly natural trees	Tropical savannah with sparingly natural trees
Cattle production system	Extensive system	Extensive system	Extensive system	Extensive system	Extensive system
Availability of feed resources	More grazing land in Nkasi (85%) than in Sumbawanga rural (77%), urban (67%) and Mpanda district (42%)				

Source: Rukwa region livestock profile report, 2010. masl, metres above sea level.

maximum (Guinea grass), *Setaria sphacelata* (Giant setaria) and *Heteropogon contortus* with scanty natural trees in Sumbawanga rural and urban districts and modest forestry in Nkasi district (URT, 2010).

The other four AEZs of Rukwa region are mostly low land zones, characterized with relatively low rainfall and high temperature. These zones have high number of other Tanzanian local cattle, particularly Tarime and Ankole, which have been brought by immigrant agro-pastoralists from Shinyanga, Mwanza and Tabora regions of Tanzania since 1970s. Other characteristics of lowland zones are indicated in Table 1.

Livestock keeping system in the Fipa plateau

One major Fipa cattle management system in the Fipa plateau is extensive which consists of herded grazing in the communal grazing land, fallow land and crop fields after crop harvest. The system is largely traditional and subsistence oriented with very minimal management inputs in terms of breeding, disease control and supplementary feeds (Mwakilembe *et al.*, 2007). The farmers have also little control over the natural feed resources. Fipa cattle are used for draught, sales, savings and cultural commitments. The Fipa cattle are widely distributed in the Fipa plateau, mainly between latitude 5°31′ and –10°23′S and longitude 30°00′ and –32°36′E. The crop–livestock production system in the Fipa community is characterized by the use of crop by-products as animal feed, whereas livestock provide manure as fertilizer.

In the plateau, livestock feed availability fluctuates with seasonal changes and location. Livestock feed resources are more in Nkasi than in Sumbawanga rural and urban district owing to availability of big grazing area in relation to available cattle and human population, low cropping activities and poor accessibility. Inaccessibility has also been reported to hinder regular movements of people and livestock for socio-economic activities in Nkasi district. As a result, Nkasi Fipa communities are relatively poorer in terms of household incomes with relatively high illiteracy levels than their counterparts from Sumbawanga rural and urban districts (URT, 2010).

Research design

A cross-sectional research design was employed in this study. To obtain the desired data, purposive sampling was used to select two wards per district, making the total number of study wards to be 6 of the 39 wards from the entire study area. Selection of study wards was based on extension staff suggestions for the wards with large numbers of Fipa cattle with no evidence of admixture with other types of cattle populations and their easy accessibility. In each ward, two villages were randomly selected from the list of villages, making the total number of study villages to be 12 (Figure 1). In each village, ten households were randomly selected using random numbers from the list of all households who had been keeping more than 10 Fipa cattle in the last 10 years, making a sample size of 120 households (Table 2). Data were collected during the dry season from June to August 2010.

Data collection

A structured questionnaire containing both closed and open-ended questions was used for data collection. The questionnaire was administered through individual interview of household heads by the research team with assistance from the extension staff. Other members of the household were allowed to supplement relevant information during the interview. The questionnaire was pre-tested to check clarity and appropriateness of the questions. Some of the information collected during interviews were supported by on-site observation. The questionnaire was designed to obtain information on general household characteristics, livestock kept and herd structure, traditional management practices, production objectives and production constraints. Similar information particularly on traditional management practices, production objectives and production challenges for Fipa cattle was also collected from the extension officers in order to crosscheck its consistency.

Data processing and analysis

Qualitative data from the field survey were coded and analysed using the Statistical Package for Social Sciences (SPSS, 2008) computer software in order to generate descriptive statistics such as means and frequencies or percentages. The χ^2 test of independence was run to compare proportions of respondents from different districts with respect to particular responses. Quantitative data were also analysed using SPSS in order to generate and compare means between districts. Column charts were used to compare values or proportions of respondents across the districts using Microsoft Excel. The recorded information from the extension staff was synthesized and summarized.

Results and discussion

Household socio-economic characteristics

The average household size across the entire sample was 5.9. The mean household size was larger (7.4) in Sumbawanga rural than in Sumbawanga urban district (5.0). The average age of the respondents was 44 years. A similar mean age was observed in all the study districts. This implies that both young and old people keep Fipa cattle, and therefore suggesting the sustainability of the strain in the Fipa community. Most of the respondents were also in the active working age and could, therefore, be involved in the development of sustainable utilization strategies of the strain.

Seventy-two percent of the respondents had received primary education, and therefore, could read and write,

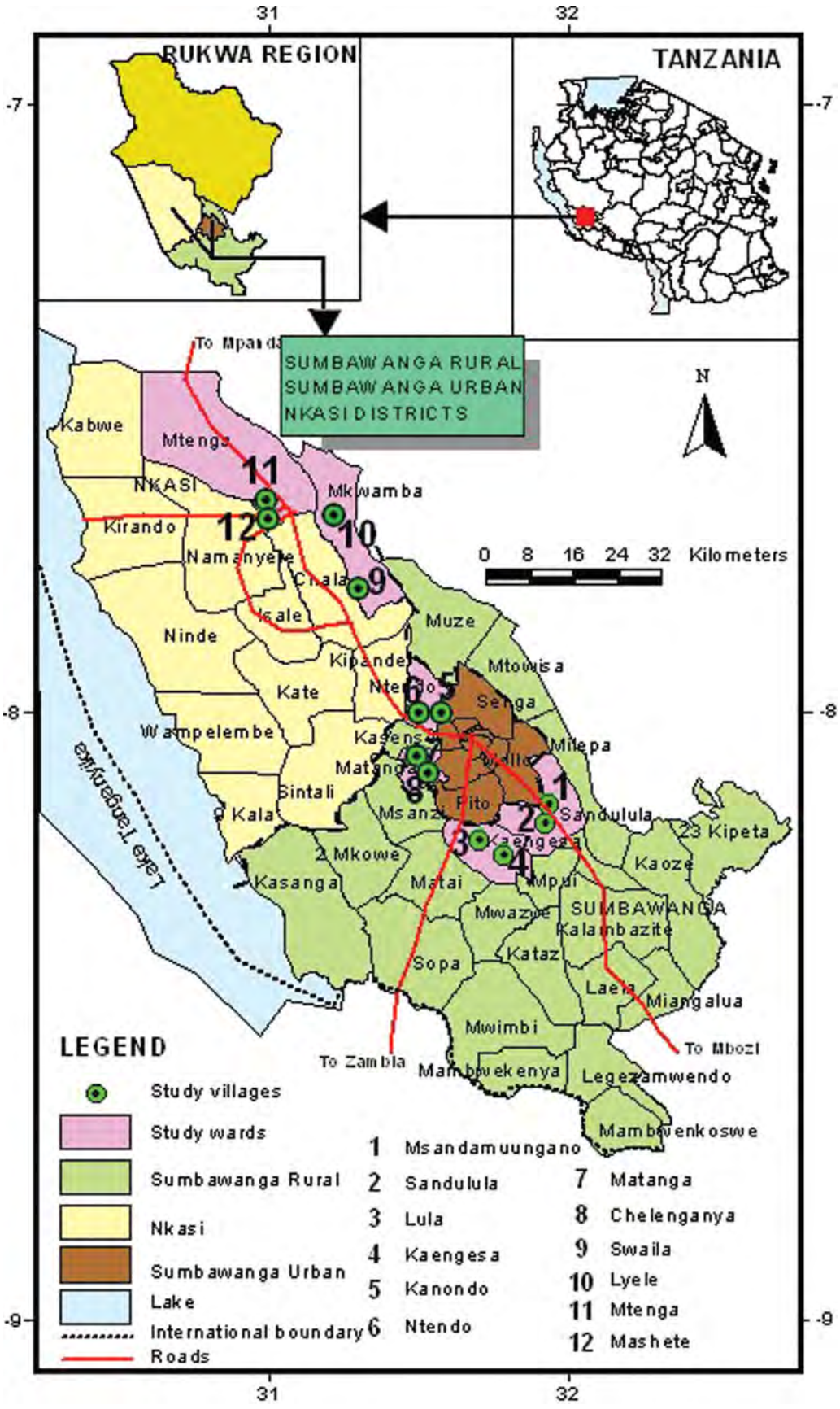

Figure 1. Map of Tanzania showing the study districts, wards and villages.

Table 2. Sampling frame of the districts, wards, villages and respondents in the study area.

Districts ($n = 3$)	Wards ($n = 6$)	Villages ($n = 12$)	Number of respondents ($n = 120$)
Sumbawanga rural	Kaengesa	Lula	10
		Kaengesa	10
	Sandulula	Sandulula	10
		MsandaMuungano	10
Sumbawanga urban	Ntendo	Kanondo	10
		Ntendo	10
	Matanga	Matanga	10
		Chellenganya	10
Nkasi	Nkwamba	Swaila	10
		Lyele	10
	Mtenga	Mashete	10
		Mtenga	10

whereas 5.8 and 21.7 percent had received secondary and informal education, respectively. There were relatively more (75 percent) farmers with primary education in Sumbawanga rural and urban than in Nkasi district (67.5 percent). Most of the respondents had therefore, formal education that can be capitalized on rational decision-making regarding improvement and conservation strategies of the Fipa cattle. The present study revealed that the majority (90.8 percent) of the respondents were males while a few (9.2 percent) were females. There were more (97.5 percent) male respondents in Sumbawanga rural than in Nkasi district (82.5 percent). The reverse was true for the female respondents. These observations are in agreement with the findings of Maeda-Machang'u *et al.* (2000) who previously reported similar education and male headed household levels of other Tanzanian agro-pastoral communities.

In most (61.7 percent) of the households interviewed animals were jointly owned by husband and wife, more in Nkasi (75 percent) than in Sumbawanga rural district (37.5 percent). In 25 percent of all households, cattle ownership was exclusively the prerogative of the husband, a larger proportion in Sumbawanga rural (37.5 percent) than in Nkasi district (12.5 percent). In about 11 percent of the households cattle belonged to the sons of the household, mainly in Sumbawanga rural district (25 percent) (Table 3). Joint ownership of cattle suggests either a gradual change of mindset to be taking place among males on gender equality or the presence of customary norms of the Fipa community which allow both the husband and wife to jointly own, access and use household resources. This observation is inconsistent with the findings reported by Sungael (2005) on the Hehe agro-pastoral communities in which husbands dominated the ownership and decision-making on the use of household resources.

On average, about 24.8 acres of land was owned per household. The average land owned per household was

Table 3. Socio-economic characteristics of the households in the study area.

Characteristics	Sumbawanga rural ($n = 40$)	Sumbawanga urban ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	χ^2 test
Sexes of respondents (%)					
Male	97.5	92.5	82.5	90.8	(df = 2), 1.455^{ns}
Female	2.5	7.5	17.5	9.2	
Educational levels of respondents (%)					
Primary	75	75	67.5	72.5	(df = 4), 1.416^{ns}
Secondary	2.5	5	10	5.8	
Informal	22.5	20	22.5	21.7	
Land used for grazing (%)					
Communal	92.5	57.5	90	80	(df = 4), 2.615^{ns}
Private	5	32.5	2.5	13.3	
Communal and private	2.5	10	7.5	6.7	
Sources of household income (%)					
Crops and livestock sales	87.5	85	90	87.5	(df = 2), 1.477^{ns}
Crops, livestock and petty businesses	12.5	15	10	12.5	(df = 2), 2.004^{ns}
Fipa cattle ownership (%)					
Husband	37.5	25	12.5	25	(df = 8), 1.532^{ns}
Husband and wife	37.5	72.5	75	61.7	
Sons	25	0	7.5	10.8	
Husband and sons	0	2.5	2.5	1.7	
Wife	0	0	2.5	0.8	
Age of respondents (mean ± SE)	43.72 ± 6.33^a	44.74 ± 3.94^a	44.50 ± 7.27^a	44.32 ± 4.34	
Household size (mean ± SE)	7.42 ± 1.29^a	5.00 ± 0.80^b	5.27 ± 1.48^b	5.90 ± 1.32	
Land size for agricultural uses (acres/household)					
Forestry	0.95 ± 0.29 (3.6%)	0.84 ± 0.23 (3.9%)	0.59 ± 0.21 (2.2%)	0.79 ± 0.14 (3.2%)	
Grazing	8.60 ± 3.60 (32.7%)	11.52 ± 5.47 (53.2%)	11.98 ± 3.67 (45.3%)	10.70 ± 2.49 (43.2%)	
Cropping	16.75 ± 4.96 (63.7%)	9.29 ± 1.37 (42.9%)	13.88 ± 2.17 (52.5%)	13.30 ± 1.87 (53.6%)	
Total	26.30	21.65	26.45	24.79	

Note: N, number of respondents; [a]means with the same superscripts along the row are not significantly different at $P > 0.05$; [ns]not significant ($P > 0.05$).

relatively more in Nkasi (26.5 acres) than in Sumbawanga rural district (21.7 acres). The overall average land owned per household was slightly lower than that of the entire region (27.8 acres). It was further reported that farmers allocate a relatively large proportion (53.6 percent) of their agricultural land for cropping. More (63.7 percent) land was allocated for cropping in Sumbawanga rural than in Sumbawanga urban district (42.7 percent). The reverse was true for the land allocated for grazing. About 43.2 percent of the total land was allocated for grazing, whereas only 3.2 percent was reserved as forest land. Allocation of large proportion of land for cropping is an indication of cropping activities to be more predominant in the study area than the other agricultural activities. Similar results have been reported by Msalale (2007) and Maeda-Machang'u *et al.* (2000) on the grazing land size and ownership in Sukuma and Hehe agro-pastoral communities, respectively, in Tanzania. However, the findings differ from those reported by Mwacharo and Drucker (2005) on the predominance of private grazing land compared with communal grazing and cropping land in agro-pastoral communities of South-Eastern Kenya.

The majority (80 percent) of the farmers herded their animals on natural pastures, on communal grazing lands, more in Sumbawanga rural (92.5 percent) and Nkasi (90 percent) than in Sumbawanga urban district (57.5 percent). Few farmers grazed their animals on private (13.3 percent) and both communal and private lands (6.7 percent). A considerable proportion (32.5 percent) of farmers from Sumbawanga urban used private land for grazing than those of the other districts. Generally, the proportions of respondents belonging to the different sexes, educational levels, grazing land ownership, sources of household income and Fipa cattle ownership were almost similar across the study districts.

The results in Table 3 also reveal that 87.5 percent of the respondents depended on crop and livestock production for household income and food security, relatively more (90 percent) in Nkasi than in Sumbawanga urban district (85 percent). Only a few (12.5 percent) respondents had petty businesses in addition to crop and livestock production. A similar trend was also depicted with regard to the ranking of the sources of households' income and food security. Crop production was ranked first across all the districts, followed by livestock keeping (Table 4). This observation implies that there is strong integration between cropping and livestock keeping activities in the Fipa community. This remark is consistent with that of Dinucci, Fre and Case (2003) and Rass (2006), who reported that more than 50 percent of the agro-pastoral household gross revenue comes from farming and 10–50 percent comes from livestock production. The present study revealed that Fipa cattle contribute considerably to food security indirectly through provision of draught power and manure which improves production of food crops, as well as directly through sales of cattle and their products and by providing meat for the family. Cattle are sold during the periods of food shortage and the money accrued is used to buy cereal grains. These findings agree with those of Köhler-Rollefson (2005) and Oumam, Abdulai and Drucker (2005) for agro-pastoral communities in developing countries. These authors concluded that cattle play a crucial role in coping with risks and in providing livelihood strategies in the face of increasing climate instability.

Livestock species kept by households

All the farmers reported keeping more than one livestock species. Fipa cattle were kept by all the respondents with a mean herd size of 19.58 heads. Also most (89.2 percent) of the respondents kept local chickens and the average flock size was 10.41 birds. About 79.2, 59.2, 26.7, 23.3 and 19.2 percent of the respondents also kept goats,

Table 4. Ranking of sources for households' income.

Locations	Income sources	Frequency per rank order			Total weighting[a]	Ranking position
		First	Second	Third		
Sumbawanga rural	Crops	33	7	0	113	1
	Livestock	7	33	0	87	2
	Salary/wages	0	0	0	0	
	Petty business	0	0	3	3	
Sumbawanga urban	Crops	34	6	0	114	1
	Livestock	6	34	0	86	2
	Salary/wages	0	0	3	3	
	Petty business	0	0	0	0	
Nkasi	Crops	33	7	0	113	1
	Livestock	7	33	0	87	2
	Salary/wages	0	0	1	1	
	Petty business	0	0	2	2	
Overall	Crops	100	20	0	340	1
	Livestock	20	100	0	260	2
	Salary/wages	0	0	4	4	
	Petty business	0	0	5	5	

[a]Based on weighting of 3 for first rank order, 2 for second rank order and 1 for third rank order.

donkeys, sheep, turkeys and pigs, respectively (Table 5). Ranking of the different livestock species was as follows: cattle, local chickens, goats, donkeys, sheep, turkeys and pigs, in that order of importance. There were significantly ($P < 0.05$) more local chickens in Sumbawanga rural and urban than in Nkasi district. Diversification of livestock species is becoming increasingly important since it provides multiple strategies for economic success and risk management (Fratkin, 1994). This practice might also aim at utilizing rangelands and household waste better as feed preferences differ among livestock species. The observed tendency to keep many livestock species in the present study is also common in other agro-pastoral communities in the developing countries and is influenced by socio-economic and socio-cultural setting (Bebe *et al.*, 2003; Sungael, 2005). However, the average herd size of Fipa cattle was bigger than that reported for Kamba agro-pastoralists in Kenya (Mwacharo and Drucker, 2005).

A relatively large number of Fipa cattle compared with other livestock species were reported per household. This finding reflected farmers' preference and perceived importance of Fipa cattle to the livelihood of the Fipa communities in comparison with other livestock species. These results are consistent with those of Msechu (2001) who reported that indigenous cattle are preferred to exotic cattle and other livestock species kept in several agro-pastoral communities of Tanzania.

Means of acquisition of initial stock of Fipa cattle

Most (72.5 percent) of the farmers acquired their initial stock of Fipa cattle through purchases (Table 6). Other means of acquisition were inheritance (13.3 percent), exchange and inheritance (11.7 percent) and exchange with other stocks (2.5 percent). The means of acquisition of the initial stock of Fipa cattle were almost similar in all the study districts. These observations are in agreement with those reported by Sungael (2005) and Chenyambuga *et al.* (2008) with regard to ways of acquiring Iringa red and Tarime cattle, respectively.

Fipa cattle herd composition

Results on herd structure of Fipa cattle indicate that the overall proportion of cows was much larger than those of other categories (Table 7). In total, the female cattle contributed about 47.5 percent of the total herd size while more than half (52.5 percent) of the animals were males. The young and growing males (<4 years) were proportionately more numerous than growing females. The proportion of oxen (mature castrated bulls) was also considerable (27.1 percent), particularly in Sumbawanga rural and urban district. The observed high proportion of oxen in the present study reflects the dominance of cropping activity in the study area as oxen are mainly used

Table 5. Livestock herd sizes and proportion (%) of respondents keeping different types of livestock species.

Species	Sumbawanga rural ($n = 40$)		Sumbawanga urban ($n = 40$)		Nkasi ($n = 40$)		Overall mean ($n = 120$)		Ranking position
	Herd size (mean ± SE)	Percentage of farmers	Herd size (mean ± SE)	Percentage of farmers	Herd size (mean ± SE)	Percentage of farmers	Herd size (mean ± SE)	Percentage of farmers	
Cattle	19.42 ± 3.39	100	19.18 ± 1.65	100	20.15 ± 2.54	100	19.58 ± 1.50	100	1
Goats	5.15 ± 1.06	75	5.10 ± 0.91	77.5	4.82 ± 0.82	85	5.02 ± 0.53	79.2	3
Donkeys	4.93 ± 2.96	60	1.50 ± 0.87	57.5	4.75 ± 1.12	60	4.42 ± 1.49	59.2	4
Sheep	0.45 ± 0.33	32.5	0.25 ± 0.18	20	0.58 ± 0.30	27.5	0.42 ± 0.16	26.7	
Turkeys	0.32 ± 0.24	27.5	0.20 ± 0.03	17.5	0.70 ± 0.53	25	0.35 ± 0.20	23.3	
Pigs	0.18 ± 0.09	15	0.62 ± 0.21	30	0.28 ± 0.10	12.5	0.36 ± 0.09	19.2	
Chickens	11.38 ± 1.38[a]	85	12.95 ± 1.68[a]	90	6.82 ± 1.33[b]	92.5	10.41 ± 0.87	89.2	2

Note: N, number of respondents. Frequencies were based on multiple responses; means without superscripts along the rows are insignificantly different at $P > 0.05$.

Table 6. Means of acquiring Fipa cattle by the households.

Means of acquisition (%)	Sumbawanga rural ($n = 40$)	Sumbawanga urban ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	χ^2 test
Inheritance	7.5	20	12.5	13.3	(df = 6), 1.127^{ns}
Purchases	70	70	77.5	72.5	
Exchange with other stock	5	2.5	0	2.5	
Inheritance and exchange	17.5	7.5	10	11.7	

Note: N, number of respondents; ^{ns}not significant ($P > 0.05$).

Table 7. Herd structure of Fipa cattle.

Herds' categories	Sumbawanga rural mean (%)	Sumbawanga urban mean (%)	Nkasi mean (%)	Overall mean (%)
Male calves (<1 year)	2.52 (13.0)	1.90 (9.9)	1.95 (9.7)	2.13 (10.9)
Male weaners (<4 years)	1.44 (7.4)	1.75 (9.1)	2.52 (12.5)	1.84 (9.4)
Castrates	5.69 (29.3)	5.31 (27.7)	4.69 (23.3)	5.31 (27.1)
Mature bulls	0.76^{b} (3.9)	0.81^{b} (4.2)	1.61^{a} (8.0)	1.00 (5.1)
Female calves (<1 year)	1.42 (7.3)	1.52 (7.9)	1.43 (7.1)	1.47 (7.5)
Female weaners (<4 years)	1.17 (6.0)	1.71 (8.9)	1.53 (7.6)	1.49 (7.6)
Cows	6.41 (33.1)	6.21 (32.4)	6.43 (31.9)	6.36 (32.5)
Mean herd size ± SE	19.42 ± 3.39	19.18 ± 1.65	20.15 ± 2.54	19.58 ± 1.50

Note: Means along the rows without superscripts are not significantly different at $P > 0.05$.

in ploughing of crop fields and transportation of crop produce. The importance of draught animals was also reported to have an influence on farmers' decision to castrate strong Fipa bulls and even to keep oxen of different indigenous cattle in Sumbawanga rural and urban districts.

The ratio of intact bulls to cows for the households that possessed breeding bulls was 1:5.2. The ratio portrays a proportionately larger number of breeding bulls in relation to herd size. However, like castrates, some bulls were reported to be used also for draught purposes. This ratio is similar to that of most of the Sudan and Ethiopia agro-pastoral communities (Mukasa-Mugerwa, 1981). The ratio is lower than those which have been reported for the Iringa red (Sungael, 2005) and Small East African Zebu (SEAZ) (Mwacharo and Rege, 2002). However, it is higher than the recommended ratio (1:25) for usual herd mating. The ratio implies that missed oestrus periods would be unlikely.

There was a highly significant ($P < 0.01$) difference between districts with respect to the number of mature intact bulls. Proportionately more breeding bulls were observed in Nkasi than in the other two districts. This observation suggests that there are management differences particularly in breeding practices among Fipa communities in the three districts. The Fipa community of Nkasi district was found to be more aware of the importance of possessing own breeding bulls than those of Sumbawanga rural and urban districts, where draught activities were more intense. The closeness of the Sukuma agro-pastoral community to Fipa community in Nkasi district which insists on keeping of own bulls for breeding purposes in every household could have had an influence on the observed trend.

Purpose of keeping Fipa cattle

The results in Figure 2 reveal that the main purposes of keeping Fipa cattle include: provision of draught power, cash income, manure and meat, in that order of significance. The strain is valued also for investment for future uses and limited production of milk for home consumption in some households. The importance of Fipa cattle for manure, meat and milk production was more evident in Sumbawanga rural than in the other districts. The ranking of the uses of the Fipa cattle obtained in the current study is similar to that reported by Msalale (2007) and Sungael (2005) for Sukuma and Iringa red cattle, respectively. However, the results are somewhat inconsistent with those reported by Rege and Gibson (2003) on the uses of SEAZ in Kenya. The perceived value of the Fipa cattle as cash source surpassed those of other uses, except draught power in Sumbawanga urban and Nkasi district. This trend is consistent with that reported by Mwacharo and Rege (2002) on SEAZ in Kenya. However, these results

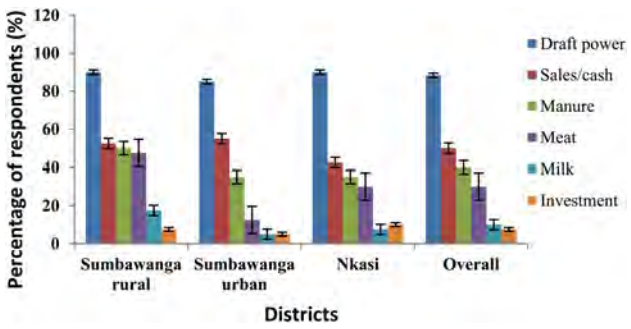

Figure 2. Proportions (%) of respondents falling under each purpose of keeping Fipa cattle.

are inconsistent with those reported by Maeda-Machang'u *et al.* (2000) on several Tanzanian agro-pastoral communities. The considerable reliance on Fipa cattle as source of income indicates the integration of the Fipa cattle production activities into the cash economy, contrary to the conventional socio-cultural roles of most of the African indigenous cattle. However, this tendency may have a side-effect on the sustenance of the Fipa cattle strain since as the communities become more integrated into cash economy, farmers may tend to switch to more productive breeds that might threaten the long-term existence of the strain through substitution or cross-breeding.

Traditional management practices of Fipa cattle

Table 8 shows different management practices for the Fipa cattle. The majority (96.7 percent) of the farmers practiced extensive grazing system, whereby the cattle were herded during the dry and wet season on communal grazing land and harvested grain crop fields. Backyard system (grazing around homesteads) was rarely practised by very few (3.3 percent) farmers, particularly during the cropping season. These observations are consistent with those reported by Oumam, Abdulai and Drucker (2005) and Msalale (2007) for management of SEAZ and Sukuma cattle, respectively. Normally under communal grazing land, farmers are not obliged to improve the nutritive value of the natural pastures through rotational grazing or oversowing of improved pasture seeds or leguminous plants. Instead, regular movements of cattle herds are employed to restore overgrazed areas. Availability of feed for dry season feeding could also be improved by saving grazing areas in the form of standing hay or establishment of fodder banks. In this system, production of other indigenous cattle is also attractive because it offers opportunity for diversification and spreading risks (URT, 2010).

In Fipa communities supplementary feeding of cattle with energy, protein or minerals was practically non-existent, a tendency that can be attributed either to lack of awareness of the importance of supplementation or inability to buy supplementary feeds. Crop residues particularly maize stovers were utilized *in situ* during the dry season, perhaps owing to their ready availability at relatively low cost. However, according to Mwakilembe *et al.* (2007), utilization of crop residues *in situ* is inefficient owing to associated losses of edible feed material through trampling, wind blowing, soiling, leaching and termite damage, despite enriching nutrients recycling for sustainable agriculture.

The majority (95.8 percent) of the farmers kept their animals in open kraals enclosed with untreated thorny bushes at night. The floor was earthen and muddy, hence predisposing the animals to foot rot disease particularly during the rainy season. These findings are similar to those reported by Maeda-Machang'u *et al. (*2000) for many other agro-pastoral communities of Tanzania. Most (72.5 percent) of the calves were penned and grazed together with adult animals, thus predisposing them to tick-borne diseases at their early stages of life. However, a few (27.5 percent) of the farmers housed calves separately under a roof either in their own pens, goat pens or in kitchens to keep away from their dams to avoid suckling. Mature male and female animals were kept in the same kraals.

A considerable proportion (30 percent) of the households neither milked their cows nor did they take milk as a source of protein. This habit might be the reason for some households sheltering calves together with adult animals, unlike the practice of other agro-pastoral communities in Tanzania. These observations are inconsistent with those reported by Mwacharo and Drucker (2005) and Sungael (2005) on Kamba and Hehe agro-pastoral communities, respectively, where calves are housed separately and cows are milked. In general, Fipa farmers employed almost similar management practices across all the study districts.

Cattle watering amenities

The distance to the watering points (rivers) varied considerably, but on average it was 1–5 km from the homesteads. All the animals were watered at least once a day throughout the year. The water used was described as clear/clean all year round. The level of availability of water sources, distances to watering points and frequencies of watering of the Fipa cattle were almost similar across the study districts (Table 9). Water sources were readily available all the year round and the sources were the same

Table 8. Proportion (%) of farmers falling under different categories of cattle management practices.

Management practices	Sumbawanga rural ($n = 40$)	Sumbawanga urban ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	χ^2 test
Extensive (herded) grazing	95	100	95	96.7	(df = 2), 1.115^{ns}
Backyard system	5	0	5	3.3	
Kraal housing	97.5	82.5	100	95.8	(df = 2), 1.078^{ns}
Yard housing	2.5	17.5	0	4.2	
Housing calves with adults	67.5	85	65	72.5	(df = 2), 1.388^{ns}
Housing calves separately	32.5	15	35	27.5	
No supplementation	100	90	82.5	90.8	(df = 2), 1.532^{ns}

Note: N, number of respondents; ^{ns}not significant ($P > 0.05$).

Table 9. Proportion (%) of farmers with exposure to different watering amenities.

Watering amenity	Sumbawanga rural ($n = 40$)	Sumbawanga urban ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	χ^2 test
Water sources					
Rivers	90	90	82.5	87.5	(df = 8), 1.334^{ns}
Borehole	0	2.5	7.5	3.3	
Dam/pond	2.5	5	7.5	5	
Rivers and boreholes	2.5	2.5	2.5	2.5	
Rivers and wells	5	0	0	1.7	
Distance to watering points					
Watering distance <1 km	57.5	57.5	12.5	42.5	(df = 4), 1.565^{ns}
Watering distance 1–5 km	37.5	37.5	72.5	49.2	
Watering distance >5 km	5	5	15	8.3	
Water purity					
Clear water – dry season	90	87.5	82.5	86.7	(df = 2), 1.425^{ns}
Clear water – wet season	97.5	100	92.5	96.7	(df = 2), 1.382^{ns}
Watering frequency					
Once per day – dry season	20	17.5	10	15.8	(df = 4), 1.899^{ns}
Twice per day – dry season	20	7.5	72.5	33.3	
Thrice per day – dry season	60	75	17.5	50.8	
Freely – wet season	87.5	87.5	92.5	89.2	(df = 4), 1.318^{ns}
Once per day – wet season	5	5	2.5	4.2	
Twice per day – wet season	7.5	7.5	5	6.7	

Note: Data were based on multiple responses; *N*, number of respondents; ^{ns}not significant ($P > 0.05$).

during the dry and wet season. This finding is consistent with that reported by Sungael (2005) for the availability of water for Iringa red cattle. Thus, the availability of water all the year round in the Fipa communities could be among the opportunities that can be tapped to improve productivity of the Fipa cattle.

Role played by different household members in the management of Fipa cattle

The roles played by different household members in various traditional management practices for the Fipa cattle are summarized in Table 10. It was reported that cattle

Table 10. Proportion (%) of respondents indicating roles of different household members in management of Fipa cattle.

Role	Sumbawanga rural ($n = 40$)	Sumbawanga urban ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	χ^2 test
Animal purchases					
Husband	50	17.5	10	25.8	(df = 6), 1.565^{ns}
Wife	2.5	7.5	22.5	10.8	
Husband and wife	45	55	50	50	
Family	2.5	20	17.5	13.3	
Selling/slaughtering					
Husband	42.5	17.5	12.5	24.2	(df = 6), 1.515^{ns}
Wife	5	10	12.5	9.2	
Husband and wife	50	50	57.5	52.5	
Family	2.5	22.5	17.5	14.2	
Herding					
Husband	35	17.5	15	22.5	(df = 8), 1.389^{ns}
Boys	37.5	45	52.5	45	
Hired labour	22.5	12.5	20	18.3	
Husband and boys	0	25	12.5	12.5	
Husband and hired labour	5	0	0	1.7	
Milking					
Husband	20	15	22.5	19.2	(df = 6), 1.774^{ns}
Boys	35	45	47.5	42.5	
Hired labour	10	7.5	7.5	8.3	
Not milking	35	32.5	22.5	30.0	
Health care					
Husband	80	77.5	90	82.5	(df = 4), 1.086^{ns}
Wife	7.5	7.5	7.5	7.5	
Boys	12.5	15	2.5	10	

Note: N, number of respondents; ^{ns}not significant ($P > 0.05$).

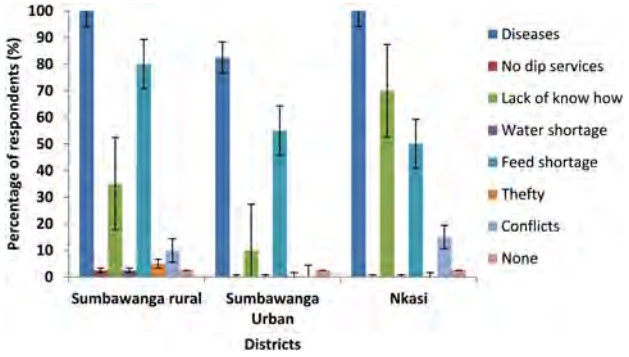

Figure 3. Frequencies (%) of respondents falling under each main production constraint.

purchases and disposals were largely decided upon by both husband and wife. However, the herding of cattle, which is the most time-consuming activity in livestock production, as well as the task of milking were assigned to boys. This might have some negative effects in that it may leave little room for boys to attend school properly. These observations are inconsistent with those reported by Maeda-Machang'u *et al.* (2000) and Sungael (2005) for several other Tanzanian agro-pastoral communities where the herding of cattle was done by adult males and hired labour. On the other hand, the health of the animals was largely under the jurisdiction of the husband.

Also, in contrast to other agro-pastoral communities where the processing of milk into dairy products was the responsibility of women (Sungael, 2005), in the Fipa communities, some of the households did not milk their cows nor process the milk. Therefore, there were no roles assigned solely to women with regard to the Fipa cattle management practices. Generally, the distribution of roles among the household members was almost similar across all the study districts, particularly on animal purchases, disposal, herding and milking.

Production constraints of Fipa cattle

Figure 3 indicates the main production constraints of the Fipa cattle. According to the farmers and extension staff, diseases, feed shortages and lack of appropriate knowledge on management practices, in that order of importance, were the main production constraints that reduced productivity of Fipa cattle. The problem of diseases was significant across all the study districts. These observations are similar to those reported by Maeda-Machang'u *et al.* (2000) on the production constraints of the other agro-pastoral communities of Tanzania. Feed shortage was a more important problem in Sumbawanga rural and urban than in Nkasi district, particularly during the dry season. However, no feed conservation strategies were employed to cope with feed shortages possibly owing to lack of knowledge of this aspect. These observations are consistent with those reported by Sungael (2005) on Hehe agro-pastoral communities where the same trend of feed shortage and absence of conservation strategies was observed. The weakening of traditional management of communal grazing lands, overgrazing, encroachment of crop production activities onto grazing land and human population growth might be the reasons behind the shrinkage of the grazing land, particularly in Sumbawanga rural and urban districts.

Tick-borne diseases were reported to be the most prevalent diseases (Table 11). Worm infestations and foot rot disease

Table 11. Proportion (%) of respondents indicating the prevalent diseases, control measures commonly used and availability of extension services.

Diseases and control measures	Sumbawanga rural ($n = 40$)	Sumbawanga rural ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	χ^2 test
Prevalent diseases/parasites					
TBDs	50	40	27.5	39.2	(df = 10), 1.258^{ns}
TBDs and worms	7.5	15	15	12.5	
BQ	2.5	5	0	2.5	
TBDs, worms, BQ and IBK	20	25	17.5	20.8	
IBK	0	0	2.5	0.8	
TBDs, worms, foot rot, FMD, and CBPP	20	15	37.5	24.2	
Disease control measures					
Vaccination	75	92.5	92.5	86.7	(df = 2),1.051^{ns}
Dipping	57.5	67.5	87.5	70.8	(df = 2), 1.388^{ns}
Deworming	62.5	95	65	74.2	(df = 2), 1.233^{ns}
Availability of extension services					
Private practitioners	12.5	2.5	0	5	(df = 8), 1.622^{ns}
Government staff	62.5	95	82.5	80	
Government and private service	15	2.5	5	7.5	
Personal (local knowledge)	2.5	0	0	0.8	
None	7.5	0	12.5	6.7	

Note: N, number of respondents; ^{ns}not significant ($P > 0.05$); TBDs, tick-borne diseases; BQ, black quarter; IBK, infectious bovine keratoconjuctivitis; CBPP, contagious bovine pleuro-pneumonia; FMD foot-and-mouth disease.

were also considerably important particularly during the wet season. Generally, the incidence of these diseases was rather low compared with the findings reported from other studies in similar production systems (Rwambo *et al.*, 1998; Maeda-Machang'u *et al.*, 2000). This observation may denote not only a low susceptibility of the Fipa cattle to various infections, but also the recent gradual improvement of the state and private extension services in the rural settings, particularly through dipping, vaccination and deworming, might have had an influence on the low incidence of the diseases.

Most of the respondents reported to control viral/bacterial diseases through vaccination (86.7 percent), tick-borne diseases through routine dipping (70.8 percent) and worm infestations through deworming (74.2 percent). The prevalent diseases/parasites and control measures thereof were almost the same across the study districts.

Table 11 further reveals that most (80 percent) of the respondents had access to government extension services in their respective districts. Some of them (12.5 percent) depended also on private extension providers, particularly in Sumbawanga rural district. However, a few (6.7 percent) of the farmers had no access to any extension service providers, mainly in Nkasi (12.5 percent) and Sumbawanga rural district (7.5 percent). The levels of availability of the extension services to the farmers were almost similar across all the study districts.

Conclusion and recommendations

Based on the findings of the current study, it is concluded that:

1. Fipa cattle have multiple roles. The major roles include provision of draught power, income, meat and manure for soil nutrients recycling. Milk production and other socio-cultural uses are considered to be of minor importance by the Fipa community.
2. Fipa communities keep more than one livestock species as means to minimize risks and diversification of sources of household income.
3. Herded grazing system on natural pastures is commonly practiced mainly on communal grazing lands and in private crop fields *in situ* after harvesting cereal grains.
4. Diseases particularly tick-borne diseases and feed shortages during the dry season are the main production constraints that hinder productivity of the Fipa cattle.

Therefore, any conservation and improvement strategies of the Fipa cattle need to incorporate farmers' preferences, traditional management practices and multiple roles the strain plays in the Fipa community.

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Fipa cattle in the southwestern highlands of Tanzania: morphometric and physical characteristics

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Summary
Assessment of diversity is a prerequisite for the management and conservation of farm animal genetic resources. To study the morphological features of Fipa cattle in Southwestern Tanzania, 108 herds were studied. Fourteen body measurements (body weight, body length, height at withers, heart girth, ear length, ear width, horn length, horn-base thickness, horn-base spacing, horn-tip spacing, rump width, rump length, tail length and tail-base thickness) and qualitative traits were recorded from 307 animals. Measurements were classified according to location and animal sex. Both location and sex significantly ($P < 0.05$) influenced all the measurements, with castrates and bulls superseding cows. Most measurements were positively and highly significantly ($P < 0.001$) correlated with the body weight predicted accurately from heart girth. The animals had variable colour patterns, but being predominantly red (20.9 percent), pied black and white (18.6 percent), black (17.9 percent) and pied red and white (14.7 percent). All animals had sloping rumps and most (81.8 percent) had small-sized humps. Most (94.8 percent) animals had pyramid-shaped humps located in the cervico-thoracic position. Most (91.5 percent) animals had upward–forward oriented and lyre-shaped horns. All the animals had flat faces and backs, and laterally oriented ears. Most (97.1 percent) animals had medium-sized dewlaps, medium-sized teats (93.6 percent) and medium-sized quarters (87.2 percent). The navel flap was absent in most (87.6 percent) animals. Thus, the Fipa cattle can be classified as a medium-sized strain with considerable variation in body size and morphological features within and between districts.

Keywords: *body measurements, characterization, Fipa cattle, qualitative traits, variation*

Résumé
L'évaluation de la diversité est une condition préalable de la gestion et de la conservation des ressources génétiques des animaux domestiques. Pour étudier les caractéristiques morphologiques des bovins Fipa dans le sud-ouest de la Tanzanie, on a analysé 108 troupeaux. Quatorze mensurations corporelles (poids et longueur du corps, hauteur au garrot, périmètre thoracique, longueur et largeur des oreilles, longueur des cornes, épaisseur et espacement de la base des cornes, espacement de la pointe des cornes, largeur et longueur de la croupe, longueur de la queue et épaisseur de la base de la queue) et les caractères qualitatifs de 307 animaux ont été enregistrés. Les mesures ont été classées selon l'emplacement et le sexe des animaux. Les emplacements ainsi que le sexe influencent considérablement ($P < 0,05$) toutes les mesures, les animaux châtrés et les taureaux ayant des valeurs dépassant celles des vaches. La plupart des mesures sont absolument et exactement ($P < 0,001$) corrélées au poids corporel prévu à partir du périmètre thoracique. Les animaux ont des couleurs différentes, mais ils sont principalement de couleur rouge (20,9 pour cent), pie noire et blanche (18,6 pour cent), noire (17,9 pour cent) et pie rouge et blanche (14,7 pour cent). Tous les animaux présentent des croupes inclinées et la plupart (81,8 pour cent) ont des petites bosses, dont la majorité (94,8 pour cent) sont en forme de pyramide, situées dans la zone cervico-thoracique. Les cornes de la plupart des animaux (91,5 pour cent) sont en forme de lyre et orientées vers le haut et en avant. Chez tous les animaux, la face et le dos sont aplatis et les oreilles sont orientées latéralement. Beaucoup d'animaux présentent des fanons (97,1 pour cent), des trayons (93,6 pour cent) et des quartiers (87,2 pour cent) de taille moyenne. La plupart des animaux (87,6 pour cent) ne possède aucun repli ombilical. Par conséquent, on peut classer les bovins Fipa comme une souche de taille moyenne avec des variations considérables entre et à l'intérieur des districts en ce qui concerne le poids corporel et les caractéristiques morphologiques.

Mots-clés: *mensurations corporelles, caractérisation, bovins Fipa, caractères qualitatifs, variation*

Resumen
La valoración de la diversidad es un requisito previo para la gestión y conservación de los recursos genéticos de los animales domésticos. Para conocer las características morfológicas de ganado vacuno Fipa en el suroeste de Tanzania se estudiaron 108 rebaños. Se estudiaron en 307 animales, catorce medidas corporales (peso corporal, diámetro longitudinal, alzada a la cruz, perímetro torácico, longitud de la oreja, anchura de la oreja, longitud de los cuernos, el grosor de la base de cuerno, el espacio entre las bases de los cuernos, la distancia entre las puntas de los cuernos, ancho de la grupa, la longitud de la grupa, la longitud de la cola y grosor de la base de la cola) y determinados caracteres de tipo cualitativo. Las medidas se clasificaron de acuerdo con la ubicación y el sexo de los animales. Tanto la ubicación como el sexo influyeron de forma significativa ($P < 0,05$) en todas las

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mediciones, con bueyes y toros. La mayoría de las mediciones fueron positivas y altamente significativas ($P < 0{,}001$), correlacionadas con el peso corporal predicho a partir del perímetro torácico. Los animales presentaban diferentes patrones de color, predominando la capa roja (20,9%), la berrenda en negro (18,6%), la negra (17,9%) y la berrenda en negro (14,7%). Todos los animales presentaban grupa derribada y la mayoría (81,8%) presentaban una giba de pequeño tamaño. La mayoría de los animales (94,8%) presentaban giba con forma piramidal ubicada a nivel cérvico-torácico. La mayoría de los animales (91,5%) presentaban cuernos con forma de lira hacia arriba y hacia delante. Todos los animales presentaban la cara y la espalda planas y las orejas dirigidas hacia los lados. La mayoría de los animales (97,1%) presentaban un tamaño medio de papada, pezón de tamaño mediano (93,6%) y ubres medianas (87,2%). La mayoría de los animales (87,6%) no presentaba pliegue umbilical. Así, el ganado bovino Fipa puede ser clasificado como de mediano tamaño con una considerable variación en cuanto a talla y características morfológicas, dentro y entre distritos.

Palabras clave: *medidas corporales, caracterización, ganado bovino Fipa, caracteres cualitativos, variación*

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Introduction

All indigenous cattle in Tanzania belong either to the humped and short-horned Zebu (TSZ), the small humped and long-horned Sanga or to the stabilized cross-breds of the Small East African Shorthorn Zebu (SEAZ) and the Sanga (Gwakisa, Barendse and Teale, 1996). The value of these breeds is mainly for the provision of draft power, manure, revenue, meat and hides (URT, 2006). The TSZ cattle belong to the SEAZ, which constitutes the majority of cattle in eastern and some parts of south-central Africa, including Madagascar (Mwacharo *et al.*, 2006). The TSZ is the dominant breed type in Tanzania and is widely distributed throughout the Tanzanian mainland. There is broad phenotypic and genetic diversity between and within strains of this breed type (Msechu, 2001).

The Ankole breed is a Sanga type while the Tarime and Fipa strains are stabilized cross-breds of Sanga with the SEAZ (Rege and Tawah, 1999). Large and distinct populations of the Ankole and Fipa cattle are found only in Western and Southwestern Tanzania (Alderson and Bodo, 1992). Fipa cattle are the most useful indigenous animals in the socio-economic activities of the Fipa and Nyamwanga communities of Southwestern Tanzania and Northeastern Zambia, respectively.

The general phenotypic and probably genetic variations among the indigenous cattle breeds have resulted from an adaptive response to the natural environment, level of management and, to some extent, the effect of breeding practices (Mwacharo *et al.*, 2006). The assessment of phenotypic and genetic diversity of the population is, therefore, of interest not only as a first step in the organization and conservation of genetic resources but also for the design of genetic improvement programmes of any cattle breed. Phenotypic characteristics, including productive and adaptive traits, are important in identifying breed/strain attributes that are relevant to the immediate farming community's needs and utility.

Morphological characteristics are useful attributes in the characterization of a breed as they are easily assessed and understood by the relevant communities. Morphological descriptions have been used to classify animal populations according to their levels of phylogenetic distinctiveness (Gatesy and Arctander, 2000), thus allowing the differentiation between breeds and strains. Moreover, morphological description can be used to evaluate breeding goals (Zechner *et al.*, 2001) or to determine such goals retrospectively, especially in traditional systems where breeding practices are not documented (Rege, 2001). Variability in body measurements across locations, sex, age and breeds can be exploited in predicting live body weight (BW) and hence the economic value of cattle, camel, sheep or goats (Semakula *et al.*, 2010). Linear body measurements and productive attributes can also be used to assess the type and function of beef and dairy cattle, sheep and goats and the animals' potential value as breeding stock (Alderson, 1999).

Unlike several other TSZ strains and the Ankole breed whose qualitative traits have been documented, albeit mainly on the basis of limited qualitative features and the owning tribe or geographical location where they are predominant, there is scanty documented information on the Fipa cattle population with regard to its phenotypic characteristics. For appropriate decision-making on any strain management and utilization, a much more broad and meaningful documentation based on phenotypic and genetic characterization is required. The present study was, therefore, undertaken to document morphometric and physical characteristics of the Fipa cattle so as to facilitate their field identification, classification and development of a sustainable strain improvement programme.

Materials and methods

Study area

The study was carried out in three administrative districts (Sumbawanga rural, Sumbawanga urban and Nkasi) of Rukwa region located in the southwest Highlands of Tanzania (Figure 1). These districts have the highest Fipa cattle population in Tanzania (Mwakilembe *et al.*, 2007). The Fipa cattle are the main source of beef for

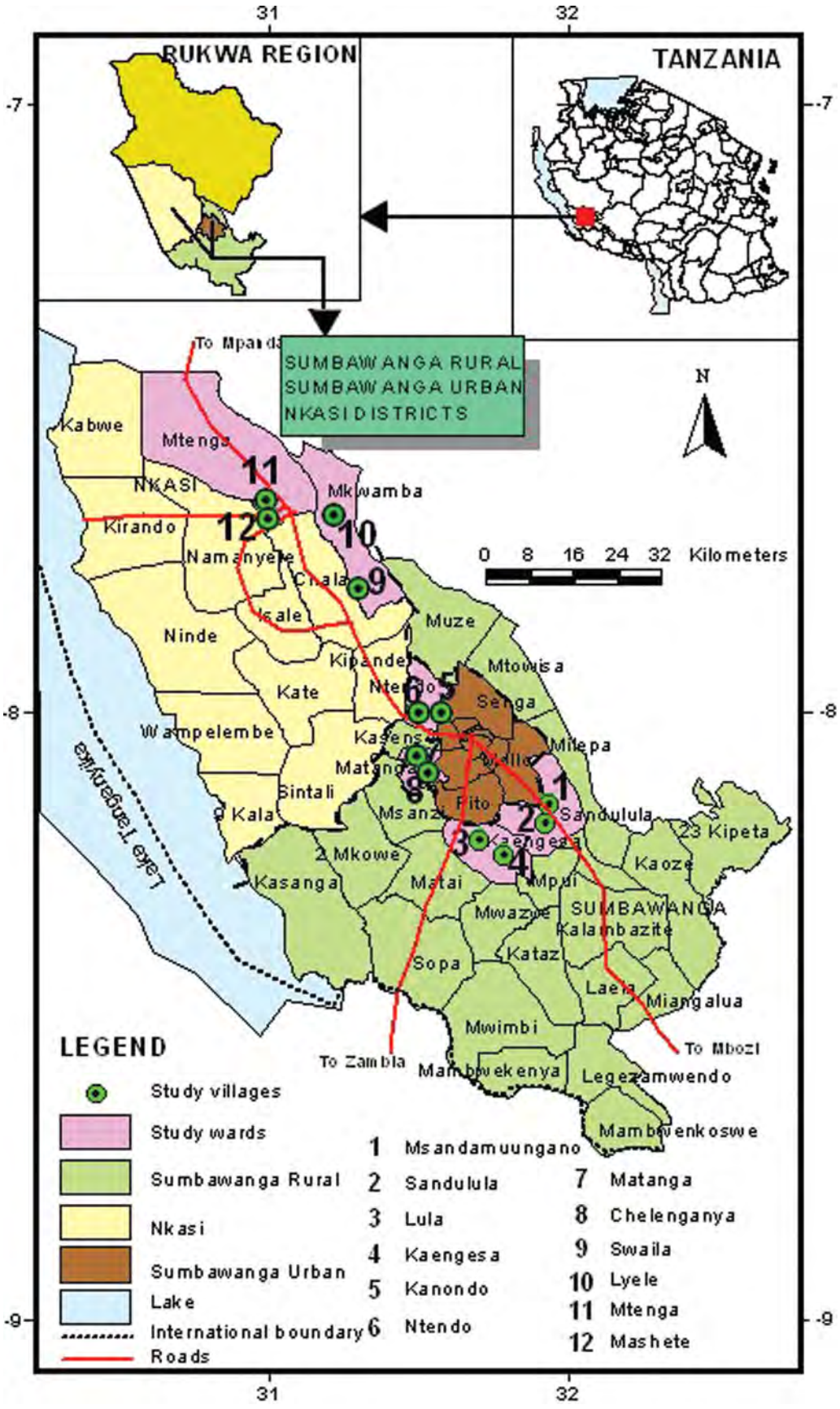

Figure 1. A map of Tanzania showing the study villages where Fipa cattle were measured.

local consumption and export. The other local beef cattle breeds that are kept in Rukwa region include Tarime and Ankole. The geographical location, climate, vegetation, agro-ecological zones (AEZs), landscape, soil types and common farming systems of the study area have been described by Mwambene *et al*. (2012).

Research design and sampling frame

The study employed a cross-sectional design whereby all the information was collected once in the same period. To obtain the desired data, sampling of wards in the study districts was purposive, targeting wards with large numbers of Fipa cattle. The selected wards included Kaengesa and Sandulula in Sumbawanga rural, Ntendo and Matanga in Sumbawanga urban, and Mashete and Mkwamba in Nkasi district. However, selection of study villages within wards was random as described by Mwambene *et al*. (2012).

Two villages were randomly chosen per ward, making a total of 12 study villages. In each village, at least seven Fipa cattle herds were purposively selected, targeting farmers who have had herds with more than 10 Fipa cattle for the last 10 years, making a total of study herds for the entire study area to be 108. At least one mature (>4 years) bull, cow and castrate per herd were then randomly selected for detailed qualitative and quantitative traits appraisal and measurement, respectively. Overall, body measurements and qualitative trait descriptions were recorded on a total of 307 Fipa cattle comprising 96 bulls, 109 cows and 102 castrates. However, body colour patterns were studied on a total of 2 137 animals from all 108 herds across the study area (Table 1).

Quantitative data collection procedure

The various body measurements were taken on randomly selected mature male, female and castrate animals once, as described by Mason (1996). Measurements were taken on 14 traits as described by Francis *et al.* (2002) and Adeyinka and Mohammed (2006). BWs and heart girths (HG) were estimated and measured, respectively, using a weigh band calibrated both in kilograms and centimetres, on different sides of the band. The bands (Rondo$^{(R)}$) used have been calibrated from some East African indigenous beef cattle breeds (Shirima *et al.*, 2005). Before the actual estimation of BWs of the 307 animals was established, the correctness of the calibration was validated by comparing the actual weights and estimated weights of 30 mature bulls, cows and castrates. The BW was estimated and HG measured as the perimeter of the body immediately behind the shoulder blades in a vertical plane, perpendicular to the long-axis of the body. A tailor's measuring tape was used to measure tail length

Table 1. Sampling frame of the household herds and individual animals for morphometric measurements and observations.

Districts	Wards	Villages	Location (coordinates)	Number of herds sampled	Number of animals measured and appraised				Animals observed* for body colours
					Bull	Cow	Castrate	Total	
Sumbawanga rural	Kaengesa	Lula	08°30″S, 031° 67″E	7	3	7	7	17	715
		Kaengesa	08°28″S, 031° 72″E	12	9	12	11	32	
	Sandulula	Sandulula	08°19″S, 031° 84″E	9	10	9	9	28	
		Msanda-Muungano	08°11″S, 031° 85″E	9	6	9	8	23	
Sumbawanga urban	Ntendo	Kanondo	07°92″S, 031° 58″E	9	8	9	9	26	782
		Ntendo	07°90″S, 031° 54″E	10	9	10	8	27	
	Matanga	Matanga	08°02″S, 031° 51″E	11	8	9	9	26	
		Chellenganya	08°07″S, 031° 53″E	9	9	9	9	27	
Nkasi	Mkwamba	Swaila	07°56″S, 031° 38″E	10	10	9	9	28	640
		Lyele	07°38″S, 031° 29″E	8	8	8	6	22	
	Mtenga	Mashete	07°41″S, 031° 13″E	7	9	10	8	27	
		Mtenga	07°35″S, 031° 09″E	7	7	9	8	24	
Overall 3	6	12		108	96	109	102	307	2 137

Note: *Number of animals whose body colours were described and recorded.

(TL), as the distance from the base of the tail to the end of tail switch; tail base (TB), as the circumference of the TB; horn length (HL), as the straight distance between the base and tip of horn; horn circumference (HC), as the thickness of the horn base (HB); HB spacing, as the distance between the HBs; and horn-tip (HT) spacing, as the distance between the HTs. A mason's measuring tape was used to determine the body length (BL), as the distance from the shoulder point to the pin bone; height at withers (HW), as the distance from the hoof base to the withers; rump width (RW) as the widest point of hip bone; and rump length (RL), as the length of the hip bone. All measurements were taken by one person to minimize between-individual variations and were repeated three times with the animal being moved to a "normal" position, i.e. standing on a flat surface with the forelegs together and the head held up for each measurement (Figure 2).

Measurements were taken early in the morning before the animals were sent out to graze in order to avoid upward biases of certain variables following feeding. Visibly pregnant females were excluded from the study. Each animal was identified by location (herd, village, ward and district) and sex (entire male, female or castrate). The ages of the animals were estimated based on dentition according to the method of Schmidt and Yeates (1985). Only mature animals, i.e. those with more than three permanent pairs of incisor teeth were randomly selected for measurements.

Qualitative data collection procedure

Coat colour was scored using a standard colour descriptor manual (SADC/ILRI Animal Genetic Resources Survey Colour Chart; SADC, 2001). Seven coat colour patterns were identified (Uniform, Pied, Spotted, Shaded, Striped/Brindle, Roan and Dun) (Figure 3). Body part profiles were also observed and described among the sampled animals (Figure 4).

Data analysis

All quantitative data were analysed using the General Linear Models Procedure of the Statistical Analysis Systems, Ver. 9.1.3 (SAS, 2004), with the MANOVA option for calculating partial correlation coefficients among the various body measurement variables. Location (district) and sex were used as fixed effects and villages within location as nested effects. The statistical model used for the body measurements took the following form:

$$Y_{ijkl} = \mu + L_{i+}S_j + (L \times S)_{ij} + L_i(V_k) + E_{ijkl},$$

where Y_{ijkl} is the measurement on the lth animal of the jth sex from the ith district and kth village for estimated BW and linear body measurements; μ is the general mean common to all animals considered in the study; L_i is the effect of the ith district (i = Sumbawanga urban, Sumbawanga rural or Nkasi); S_j is the effect of the jth sex (j = male, female or castrate); $(LS)_{ij}$ is the interaction between the ith location (district) and the jth sex; $L_i(V_k)$ is the effect of kth village within the ith location (district); and E_{ijkl} is the random effects peculiar to each animal.

Stepwise regression procedure of SAS (2004) was used to generate and test various prediction equations for estimating live BWs using various linear body measurements. The analyses were carried out within and between sexes for each district individuals as well as for the entire study area. The coefficients of determination (R^2) from the regression equations were used to determine the suitability of the linear body measurements as predictors of animal live BW. The data on body part colour and profile patterns were analysed using the FREQ procedure of SAS (SAS, 2004). Tests of significance of associations (χ^2 test) between qualitative variables and districts were undertaken

Figure 2. Some measurements performed on Fipa bulls, cows and castrates.

Figure 3. A Fipa cow with preferred reddish colour pattern.

Figure 4. A herd of Fipa cattle showing animals with small, cervico-thoracic positioned humps and majority with lyre-shaped horns. See calves being housed with adult animals.

in order to assess whether the occurrences of these patterns were random or specific to certain districts.

Results

Body morphometric characteristics

Table 2 shows the analysis of variance (ANOVA) summary for various body measurements of Fipa cattle. Body measurements were significantly ($P \leq 0.05$) influenced by location, sex and location × sex interaction. However, the interaction of sex and location had no significant ($P > 0.05$) influence on HT, TL, TB, RL, RW, EW (ear width) and EL (ear length).

Effect of location (districts) and sex on BW and linear body measurements

The least-square means for the body measurements taken on the Fipa cattle are summarized in Table 3. Generally, the body measurements (BW, HW, BL, HG, RW and RL) and TL, EL and HC measurements of the castrates and intact bulls from Nkasi district were significantly ($P < 0.05$) greater than those of the Sumbawanga rural and urban district, except for EW, TB, HB, HL and HT. On the other hand, the linear body measurements of the cows from Nkasi district were not significantly ($P > 0.05$) greater than those of the other districts, except for RL body measurement and HB, EL, EW, TL and TB measurements. The RW of the cows; RL of bulls; HL, EL, EW, TB and HB of bulls, cows and castrates; and HC of the bulls and cows from Sumbawanga urban district were significantly ($P < 0.05$) greater than those of the Sumbawanga rural district. Generally, castrates, bulls and cows from Sumbawanga rural and urban districts were smaller in body size than their counterparts from Nkasi district.

Effect of location (districts) on BW and linear body measurements

The least-square means for the body measurements of Fipa cattle studied in the three districts are presented in Table 4. The body measurements for the Fipa cattle from Nkasi district were significantly ($P < 0.05$) larger than those of the Sumbawanga rural and urban districts, except for EW and HT, implying that the animals of Nkasi district were much bigger than those of the other districts. The body measurements of the Fipa cattle from Sumbawanga urban district were not significantly ($P < 0.05$) different from those of Sumbawanga rural district, except for RW, RL, HB, EW, EL and TB.

Effect of sex on BW and linear body measurements

The effect of sex on the body measurements of Fipa cattle are presented in Table 5. Generally, the body measurements for the castrate animals were significantly ($P \leq 0.05$) greater than those of the intact bulls and cows, except for EL, meaning that castrate animals were larger than bulls and cows. However, the majority of the body measurements of the intact bulls were not significantly

Table 2. Summary of ANOVAs for body measurements of Fipa cattle.

Source of variation	Df	Levels of significance for various body measurements													
		BW	HG	BL	HW	HL	HT	HB	HC	TL	TB	RW	RL	EW	EL
Location (district)	2	***	***	***	***	*	*	***	***	***	***	***	***	***	***
Sex	2	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Location × Sex	4	*	*	***	**	*	ns	*	*	ns	ns	ns	ns	ns	ns
District(villages)	9	*	*	*	**	*	ns	***	*	ns	***	***	**	***	***
Residual	232	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note: ***Very highly significant ($P < 0.001$); **highly significant ($P < 0.01$); *significant ($P \leq 0.05$); nsnon-significant ($P > 0.05$).
Df, degree of freedom; BW, body weight; BL, body length; HG, heart girth; EL, ear length; EW, ear width; HL, horn length; HC, horn-base thickness; HB, horn-base spacing; HT, horn tip spacing; HW, height at withers; RL, rump length; RW, rump width; TL, tail length; TB, tail base thickness.

($P > 0.05$) different from those of the cows except for BW, HT, HL, HB and EL.

Table 6 gives the ratios between selected linear measurements for the Fipa cattle. In general, the HG:HW or BL:HW ratios were almost consistent across the study districts, showing the proportionate relationships of the selected body measurements of the animals across the study districts.

The phenotypic partial correlations among the various traits of Fipa cattle are given in Table 7. The correlation coefficients were all positive and the majority were highly significant ($P \leq 0.001$), except for EW vs HL, EL vs HT, HB vs HT, EW vs HT, EL vs HC, EW vs HC, TB vs HC, TL vs EL and TB vs EL.

Linear regression of HG on BW was conducted within each sex and for all categories of Fipa cattle in each district and across all the districts. Generally, the BW of castrates from Nkasi district was predicted more accurately than their counterparts in Sumbawanga urban district. The BW of bulls and cows was predicted more accurately than castrates almost in all the three districts. Based on the coefficient of determination (R^2) and regression coefficients, the HG of animals from Nkasi district predicted BWs of animals more accurately than the other linear traits. The relationships among live BW and HG and other linear measurements were further studied using a stepwise multiple regression analysis by adding one trait at a time, to the HG of all animals in each district. The essence was to determine how other linear traits influence the precision of live BW predictions compared with using HG alone (Vargas *et al.*, 2000). However, the multiple regression analysis improved coefficients of determination (R^2) thus indicating that addition of one or more other measurements to HG resulted in significant improvement in accuracy of prediction (Table 8).

Physical characteristics

Table 9 presents the occurrence of various body colour patterns of the Fipa cattle. Overall, the predominant colour patterns were red (20.92 percent), pied black and white (18.58 percent), black (17.92 percent) and pied red and white (14.74 percent) (Figure 1). The predominant body colours and colour patterns were different for each study district.

Table 10 gives the occurrence of different colour patterns on various body parts of the Fipa cattle. Overall, the predominant colour patterns were black (49.5 percent), red (27.4 percent) and brown (15.6 percent) for ear tips; black (64.5 percent) and brown (26.7 percent) for muzzles; black (49.5 percent), grey (22.5 percent) and white (16.6 percent) for tail switches; black (46.1 percent) and brown (48.1 percent) for horns and black (71.0 percent) and red (16.9 percent) for hooves. The occurrences of predominant colour patterns of ears, muzzles and horns were almost

Table 3. Least square means (±SE) for BWs and linear body measurements of Fipa cattle, summarized by districts and sex.

Traits	Sex	Nkasi	Sumbawanga urban	Sumbawanga rural
BW (kg)	Bulls	362.38 ± 12.39^{a}	300.29 ± 11.35^{b}	271.62 ± 12.70^{b}
	Castrates	447.21 ± 13.06^{a}	384.73 ± 13.20^{b}	371.69 ± 11.72^{b}
	Cows	291.68 ± 12.15^{a}	286.25 ± 11.54^{a}	277.83 ± 11.16^{a}
HW (cm)	Bulls	130.90 ± 1.44^{a}	123.17 ± 1.32^{b}	118.55 ± 1.47^{c}
	Castrates	135.31 ± 1.51^{a}	129.21 ± 1.53^{b}	129.88 ± 1.36^{b}
	Cows	119.43 ± 1.41^{a}	118.38 ± 1.34^{a}	116.94 ± 1.29^{a}
BL (cm)	Bulls	137.21 ± 1.97^{a}	122.84 ± 1.80^{b}	117.61 ± 2.02^{b}
	Castrates	143.00 ± 2.08^{a}	135.61 ± 2.10^{b}	133.82 ± 1.86^{b}
	Cows	127.42 ± 1.93^{a}	123.78 ± 1.83^{a}	124.94 ± 1.77^{a}
HG (cm)	Bull	163.21 ± 2.06^{a}	153.33 ± 1.89^{b}	148.25 ± 2.11^{b}
	Castrates	176.18 ± 2.17^{a}	166.38 ± 2.19^{b}	164.44 ± 1.95^{b}
	Cows	153.31 ± 2.02^{a}	151.89 ± 1.92^{a}	150.59 ± 1.85^{a}
RW (cm)	Bull	22.45 ± 0.50^{a}	20.46 ± 0.46^{b}	18.00 ± 0.52^{c}
	Castrates	23.94 ± 0.53^{a}	22.28 ± 0.54^{b}	20.76 ± 0.48^{c}
	Cows	22.75 ± 0.49^{a}	21.25 ± 0.47^{b}	18.82 ± 0.45^{c}
RL (cm)	Bull	39.67 ± 0.71^{a}	37.27 ± 0.65^{b}	34.76 ± 0.73^{c}
	Castrates	41.26 ± 0.75^{a}	39.27 ± 0.76^{b}	38.64 ± 0.68^{b}
	Cows	38.10 ± 0.70^{a}	37.08 ± 0.67^{b}	35.65 ± 0.64^{b}
HL (cm)	Bull	23.80 ± 1.88^{a}	18.55 ± 1.72^{b}	12.94 ± 1.92^{c}
	Castrates	38.09 ± 1.98^{a}	37.57 ± 2.00^{a}	39.66 ± 1.78^{a}
	Cows	31.41 ± 1.84^{a}	28.31 ± 1.75^{a}	27.04 ± 1.69^{a}
HTspacing (cm)	Bull	47.53 ± 2.82^{a}	37.88 ± 2.58^{b}	34.63 ± 2.89^{b}
	Castrates	57.82 ± 2.97^{a}	55.46 ± 3.00^{a}	57.91 ± 2.67^{a}
	Cows	50.17 ± 2.76^{a}	50.84 ± 2.63^{a}	45.94 ± 2.54^{a}
HB spacing (cm)	Bull	16.50 ± 0.52^{a}	14.59 ± 0.47^{b}	12.81 ± 0.53^{c}
	Castrates	19.65 ± 0.54^{a}	16.33 ± 0.55^{b}	14.73 ± 0.49^{c}
	Cows	16.52 ± 0.51^{a}	16.29 ± 0.48^{a}	11.94 ± 0.46^{b}
HB thickness (cm)	Bull	22.87 ± 0.81^{a}	20.24 ± 0.74^{b}	17.09 ± 0.83^{c}
	Castrates	24.84 ± 0.85^{a}	22.49 ± 0.86^{a}	23.28 ± 0.77^{a}
	Cows	19.65 ± 0.79^{a}	18.94 ± 0.75^{a}	16.28 ± 0.73^{b}
EL (cm)	Bull	16.86 ± 0.35^{a}	14.51 ± 0.32^{b}	12.68 ± 0.36^{c}
	Castrates	18.03 ± 0.37^{a}	15.62 ± 0.37^{b}	13.49 ± 0.33^{c}
	Cows	17.25 ± 0.34^{a}	15.81 ± 0.33^{b}	12.71 ± 0.32^{c}
EW (cm)	Bull	11.90 ± 0.20^{a}	11.50 ± 0.19^{a}	8.30 ± 0.21^{b}
	Castrates	12.75 ± 0.22^{a}	12.63 ± 0.22^{a}	9.58 ± 0.19^{b}
	Cows	11.84 ± 0.20^{a}	11.66 ± 0.19^{a}	8.79 ± 0.18^{b}
TL (cm)	Bull	102.18 ± 1.80^{a}	93.65 ± 1.65^{b}	92.58 ± 1.84^{b}
	Castrates	110.38 ± 1.90^{a}	101.55 ± 1.92^{b}	103.33 ± 1.70^{b}
	Cows	101.04 ± 1.76^{a}	96.65 ± 1.68^{ab}	94.64 ± 1.62^{b}
TB thickness (cm)	Bull	19.65 ± 0.41^{a}	18.72 ± 0.38^{a}	16.01 ± 0.42^{b}
	Castrates	21.79 ± 0.43^{a}	20.78 ± 0.44^{a}	18.26 ± 0.39^{b}
	Cows	19.29 ± 0.40^{a}	18.91 ± 0.38^{a}	16.98 ± 0.37^{b}

[a,b,c]Least-square means with different superscripts within a row are significantly different at $P \leq 0.05$.

similar across the study districts, while they were not similar for hoofs and tail switches.

The sizes, shapes and profiles of different body parts of the Fipa cattle are given in Table 11. Most (87.6 percent) of the animals had no navel flap, whereas the profiles for rump, face and back were sloping for the rump and flat for the face and back in all the animals. The hump size was small in most (81.8 percent) of the animals, except bulls. Most (94.8 percent) of the animals had pyramid-shaped humps that were at the cervico-thoracic position. Most (91.5 percent) of the animals had upward–forward oriented and lyre-shaped horns. They had small- to medium-sized udder and the teats and quarters were medium sized. They had laterally oriented ears and medium-sized dewlaps. There were significant ($P < 0.05$) differences of the proportions of sizes, shapes and status of the body parts between the study districts, except the hump sizes and position, horn shapes and orientation, quarter sizes, ear orientation, face, back, rump and ear profiles.

Discussion

Body measurements

The body measurements of the mature Fipa cattle in the Rukwa region clearly differed between the three districts. The BW and linear body measurements for the Nkasi Fipa cattle were significantly greater than those of the Sumbawanga urban and rural districts, except for EW

Table 4. Comparison of least-square means (±SE) for body measurements of Fipa cattle summarized by districts.

Traits	Nkasi ($n = 101$)	Sumbawanga urban ($n = 106$)	Sumbawanga rural ($n = 100$)
HW (cm)	128.55 ± 0.84^{a}	123.59 ± 0.80^{b}	121.79 ± 0.82^{b}
BW (kg)	367.09 ± 7.22^{a}	323.76 ± 6.95^{b}	307.05 ± 7.11^{b}
BL (cm)	135.87 ± 1.15^{a}	127.41 ± 1.10^{b}	125.45 ± 1.13^{b}
HG (cm)	164.24 ± 1.20^{a}	157.20 ± 1.15^{b}	154.43 ± 1.18^{b}
RW (cm)	23.05 ± 0.29^{a}	21.33 ± 0.28^{b}	19.19 ± 0.29^{c}
RL (cm)	39.68 ± 0.42^{a}	37.87 ± 0.40^{b}	36.35 ± 0.41^{c}
HL (cm)	31.10 ± 1.09^{a}	28.14 ± 1.05^{b}	26.55 ± 1.08^{b}
HT spacing (cm)	51.84 ± 1.64^{a}	48.06 ± 1.58^{ab}	46.16 ± 1.62^{b}
HB spacing (cm)	17.56 ± 0.30^{a}	15.73 ± 0.29^{b}	13.16 ± 0.30^{c}
HB thickness (cm)	22.45 ± 0.47^{a}	20.56 ± 0.45^{b}	18.89 ± 0.46^{c}
EL (cm)	17.38 ± 0.20^{a}	15.31 ± 0.20^{b}	12.95 ± 0.20^{c}
EW (cm)	12.16 ± 0.12^{a}	11.93 ± 0.11^{a}	8.89 ± 0.12^{b}
TL (cm)	104.53 ± 1.05^{a}	97.28 ± 1.01^{b}	96.85 ± 1.03^{b}
TB thickness (cm)	20.24 ± 0.24^{a}	19.47 ± 0.23^{b}	17.08 ± 0.24^{c}

Note: n = number of animals measured; least-square means with different superscripts within a row are significantly different at $P \leq 0.05$.

and HT spacing. The differences in body measurements of the Fipa cattle found in the three districts indicate that the Fipa cattle population is subdivided into subpopulations perhaps due to differences in availability of feed resources and breeding practices used, breeding barrier caused by physical distance between districts or inherent genetic differences (Mwambene *et al*., 2012). The smaller stature of the Sumbawanga Fipa cattle might, therefore, be an adaptive mechanism to poor availability of feed due to shortage of grazing land caused by high human population pressure and expansion of cropping activities. Furthermore, differential natural selection for adaptation to cope with the harsher environment, where a smaller-framed animal would be better suited, might have also affected the growth rate of the Sumbawanga rural and urban Fipa cattle than those of Nkasi district because of differences in availability of feed resources. Similarly, the Fipa community being small-scale mixed farmers who rely mostly on animal draft power from cattle might have preferred short and compact animals as it is believed that such types of animals are better at pulling ploughs for longer hours than taller animals (Mwacharo *et al.*, 2006). Thus, their breeding goals might have for a long time been oriented towards achieving such a short and compact animal. On the other hand, the shortage of breeding bulls of high vigour caused by indiscriminate castration coupled with random/uncontrolled mating practices particularly in Sumbawanga rural and urban district (Mwambene, *et al*. 2012) could have affected the body size of the resultant animals.

Table 5. Comparison of least-square means (±SE) for body measurements of Fipa cows, bulls and castrates.

Traits	Castrate ($n = 102$)	Bull ($n = 96$)	Cow ($n = 109$)
HW (cm)	131.47 ± 0.85^{a}	124.21 ± 0.81^{b}	118.25 ± 0.78^{c}
BW (kg)	401.21 ± 7.32^{a}	311.4 ± 7.02^{b}	285.26 ± 6.71^{c}
BL (cm)	137.48 ± 1.16^{a}	125.88 ± 1.12^{b}	125.38 ± 1.07^{b}
HG (cm)	169.00 ± 1.22^{a}	154.93 ± 1.17^{b}	151.93 ± 1.11^{b}
RW (cm)	22.33 ± 0.30^{a}	20.31 ± 0.28^{b}	20.94 ± 0.27^{b}
RL (cm)	39.72 ± 0.42^{a}	37.23 ± 0.40^{b}	36.94 ± 0.39^{b}
HL (cm)	38.44 ± 1.11^{a}	18.43 ± 1.06^{c}	28.92 ± 1.02^{b}
HT spacing (cm)	57.06 ± 1.67^{a}	40.01 ± 1.60^{c}	48.98 ± 1.53^{b}
HB spacing (cm)	16.90 ± 0.30^{a}	14.64 ± 0.29^{b}	14.92 ± 0.28^{b}
HB thickness (cm)	23.53 ± 0.48^{a}	20.07 ± 0.46^{b}	18.29 ± 0.44^{c}
EL (cm)	15.71 ± 0.21^{a}	14.68 ± 0.20^{b}	15.26 ± 0.19^{a}
EW (cm)	11.65 ± 0.12^{a}	10.58 ± 0.12^{b}	10.76 ± 0.11^{b}
TL (cm)	105.08 ± 1.06^{a}	96.13 ± 1.02^{b}	97.44 ± 0.97^{b}
TB thickness(cm)	20.28 ± 0.24^{a}	18.13 ± 0.23^{b}	18.39 ± 0.22^{b}

The values of the linear body measurements, such as HW (121–128 cm) of the Fipa cattle, are slightly larger than those of the Tarime (107–116 cm) (Chenyambuga *et al.*, 2008), Iringa red (107–116 cm) and Tanzanian Maasai zebu (111–120 cm) (Sungael, 2005). The three subgroups studied are shorter at the withers than Ngaudere (132–136 cm) (Rege, 1999). The observed differences in HW might be due to genetic or breed differences.

The BL (125–137 cm) and HG (154–169 cm) estimates for the Fipa cattle obtained in this study compare well with those of the Tanzanian Maasai zebu (129 and 160 cm) and Kamba zebu (130 and 159 cm) (Mwacharo *et al.*, 2006) and Iringa red (116 and 158 cm) (Sungael, 2005). However, they are slightly larger than those of Malawi zebu (95.3 and 154.9 cm) (Butterworth and McNitt, 1984) and Tarime zebu (90 and 150 cm) (Chenyambuga *et al.*, 2008). The values for BL and HG observed in this study are lower compared with those of Ankole (150 and 190 cm) (Petersen *et al.*, 2003). Differences in BL are normally contributed by genotype of the strain and kind of management which the cattle receive, and age of the animals (Hall, 1991). The HG values observed in the present study are also slightly lower than those of Butana (174–184 cm) and Kenana (167–180 cm) (Osman, 1985), but similar to that of Boran cattle (152–171 cm (Kimenye, 1985). This difference in HG is attributed to the differences in body size and degree of fatness (body condition), and are largely influenced by both genetic potential and environment.

Table 6. Ratios of selected linear measurements for adult Fipa cattle observed in the study.

Ratio	Sex	Sumbawanga rural ($n = 100$)	Sumbawanga urban ($n = 106$)	Fipa Nkasi ($n = 101$)
HG:HW	Female	1.29	1.28	1.28
	Male	1.25	1.24	1.25
	Castrate	1.27	1.29	1.30
BL:HW	Female	1.07	1.05	1.07
	Male	0.99	1.00	1.05
	Castrate	1.03	1.05	1.06

Note: n = number of animals measured.

Table 7. Partial correlation coefficients and significance levels among various body measurements of Fipa cattle.

Traits	HW	BL	HG	RW	RL	HL	HT	HB	HC	EL	EW	TL	TB
BWT	0.78***	0.69***	0.96***	0.43***	0.61***	0.46***	0.24***	0.22***	0.22***	0.20***	0.29***	0.50***	0.46***
HW		0.65***	0.78***	0.46***	0.57***	0.38***	0.19**	0.25***	0.20**	0.25***	0.27***	0.48***	0.35***
BL			0.67***	0.30***	0.57***	0.34***	0.22***	0.18**	0.11^{ns}	0.17**	0.32***	0.39***	0.36***
HG				0.40***	0.60***	0.40***	0.23***	0.19**	0.21**	0.18**	0.28***	0.49***	0.50***
RW					0.39***	0.35***	0.21**	0.19**	0.18**	0.18**	0.23***	0.31***	0.27***
RH						0.31***	0.16*	0.29***	0.17*	0.15*	0.24***	0.35***	0.31***
HL							0.44***	0.20**	0.50***	0.17*	0.10^{ns}	0.19**	0.19**
HT								0.06^{ns}	0.28***	0.01^{ns}	0.10^{ns}	0.19**	0.19**
HB									0.17**	0.32***	0.18**	0.20**	0.16*
HC										0.06^{ns}	0.11^{ns}	0.16*	0.06^{ns}
EL											0.35***	0.11^{ns}	0.09^{ns}
EW												0.17**	0.23***
TL													0.30***

Note: *Significant at $P < 0.05$; **highly significant at $P < 0.01$; ***very highly significant at $P < 0.001$; ^{ns}not significant at $P > 0.05$.

The ratio of HG to HW of mature Fipa cattle (1.24–1.30) is comparable to those of Kamba (1.30–1.37) and Maasai (1.31–1.33) (Mwacharo *et al.*, 2006). The ratio of BL to HW of Fipa cattle (0.99–1.07) is comparable to that of the Kamba zebu (1.05–1.15), but inconsistent with that reported for Maasai cattle in Kenya (Mwacharo *et al.*, 2006). This indicates that the Fipa cattle are compact animals with a characteristically beef-type conformation. They are slightly longer in BL and shorter in HW. Hall (1991) reported that this type of body structure has evolved as a result of it being more effective in dissipating heat than a squat body. This reason can also be associated with the Fipa cattle as majority (oxen, entire bulls or sometimes cows) are used for draft activities thus necessitating heat dissipation.

The average RW for all sex classes of the Fipa cattle are lower than those reported by Joshi, McLaughln and Philips (1957) for the other TSZ, Ankole and Boran. The observations on RW suggest that the Fipa cattle strain is among the Tanzanian indigenous cattle with medium body size.

The phenotypic partial correlation coefficients between the morphometric measurements were positive and the majority highly significant. BW was highly and positively correlated with HG (0.96), HW (0.78), BL (0.69) and RL (0.61); hence, the latter traits can reliably be used as a proxy (either singly or in combination with other linear traits) for estimating BW for this strain. These findings are almost similar to those reported by Alsiddig *et al.* (2010) for Baggara cattle and Mwacharo *et al.* (2006) for Maasai cattle in Kenya. However, the coefficients were higher than those reported by Okeyo *et al.* (1996) for the Kenyan Kavirondo zebu. The regression equation of BW on HG had R^2 of 0.99 for the Nkasi Fipa cattle subgroup which gave more confidence in the use of this parameter to predict BW of this cattle subgroup. The regression coefficient relating BW and HG was larger for the Fipa cattle from Nkasi district than those of the other two districts, more so for castrates than for intact bulls and females. This indicates that as HGs of Nkasi Fipa cattle increase, their BW increased at a higher rate than their counterparts in the other districts. This might be associated with high correlation of HG and BW for Nkasi animals than that of the other districts, implying better availability of feed levels in the district as both HGs and BWs are highly influenced by the environment particularly feed. Generally, from the observed correlation and regression coefficients and high R^2 values (>90), HG would be the best estimator for live BW. However, the accuracy of estimation was further improved when the HG was combined with other traits in multiple regression analysis.

Marked differences between castrates, males and females in linear body measurements have also been reported by many scholars (Mwacharo *et al.*, 2006; Kugonza *et al.*, 2011). In the present study, sexual dimorphism

Table 8. Linear regression parameter estimates for prediction of BWs using HGs in mature Fipa cattle presented by districts, sexes and across the study area.

District	Sex	Dependent variable (y)	Regression	Independent variables (x)	Intercept (a)	Regression coefficients ± SE (b)	Adjusted R^2
Nkasi	Bull	BWT	Simple	HG	−624.57	6.05 ± 0.18	0.980***
	Castrate		Simple	HG	−837.51	7.29 ± 0.15	0.990***
	Cow		Simple	HG	−583.44	5.71 ± 0.17	0.980***
	All animals		Simple	HG	−720.27	6.21 ± 0.09	0.990***
	All animals		Multiple	HG + RW	−709.42	6.70 ± 0.10+ −1.02 ± 0.51	0.991***
	All animals		Multiple	HG + RW + HW	−720.60	6.42 ± 0.17+ −1.17 ± 0.50 + 0.46 ± 0.23	0.994***
Sumbawanga rural	Bull	BWT	Simple	HG	−482.48	5.09 ± 0.15	0.98***
	Castrate		Simple	HG	−622.91	6.05 ± 0.31	0.93***
	Cow		Simple	HG	−482.68	5.06 ± 0.21	0.95***
	All animals	Simple	HG	−598.77	5.87 ± 0.14	0.960***	
	All animals		Multiple	HG + HW	−631.74	5.20 ± 0.24 + 1.11 ± 0.34	0.964***
Sumbawanga urban	Bull	BWT	Simple	HG	−634.26	6.09 ± 0.26	0.95***
	Castrate		Simple	HG	−333.09	4.35 ± 0.61	0.71***
	Cow		Simple	HG	−487.77	5.10 ± 0.17	0.97***
	All animals		Simple	HG	−562.50	5.63 ± 0.21	0.90***
	All animals	Multiple	HG + RW	−576.80	5.22 ± 0.23 + 3.70 ± 1.08	0.91***	
	All animals		Multiple	HG + RW + BL	−601.00	4.60 ± 0.31 + 3.82 ± 1.03 + 0.93 ± 0.33	0.92***
Overall	Bull	BWT	Simple	HG	−597.71	5.87 ± 0.12	0.97***
	Castrate		Simple	HG	−603.69	5.95 ± 0.24	0.89***
	Cow		Simple	HG	−503.25	5.19 ± 0.11	0.96***
	All animals		Simple	HG	−629.46	6.06 ± 0.09	0.95***
	All animals		Multiple	HG + HW	−656.34	5.42 ± 0.16 + 0.97 ± 0.23	0.95***
	All animals		Multiple	HG + HW + HL	−638.48	5.29 ± 0.17 + 0.98 ± 0.22 + 0.35 ± 0.10	0.96***

Note: ***Very highly significant at $P < 0.001$.

Table 9. Occurrence of body coat colour patterns in Fipa cattle summarized by districts.

Colour pattern	Nkasi		Sumbawanga rural		Sumbawanga urban		Overall	
	Frequency (*n*)	%	Frequency (*n*)	%	Frequency (*n*)	%	Frequency (*n*)	%
Red	189	29.53	115	16.08	143	18.29	447	20.92
Black	118	18.44	141	19.72	124	15.86	383	17.92
Pied (black and white)	120	18.75	108	15.10	169	21.61	397	18.58
Pied (brown and white)	18	2.81	6	0.84	25	3.20	49	2.29
Spotted (black and white)	11	1.72	60	8.39	23	2.94	94	4.40
Brown	40	6.25	46	6.43	27	3.45	113	5.29
Pied (red and white)	90	14.06	90	12.59	135	17.26	315	14.74
Dun	9	1.41	16	2.24	12	1.53	37	1.73
Grey	12	1.88	56	7.83	57	7.29	125	5.85
Pied (grey and white)	3	0.47	0	0	6	0.77	9	0.42
Spotted (brown and white)	1	0.16	1	0.14	1	0.13	3	0.14
Brindle	7	1.09	6	0.84	8	1.02	21	0.98
White	14	2.19	2	0.28	23	2.94	39	1.82
Pied (brindle and white)	3	0.47	0	0	0	0	3	0.14
Spotted (grey and white)	3	0.47	0	0	0	0	3	0.14
Spotted (red and white)	2	0.31	55	7.69	29	3.71	86	4.02
Roan	0	0	13	1.82	0	0	13	0.61
Total (observed animals)	640	100	715	100	782	100	2 137	100

χ^2-value (df = 32) = 242.09; $P < 0.001$.

was evident in the Fipa cattle, with castrates and entire males having significantly greater linear measurements than the females for most of the traits studied. However, there were insignificant differences between bulls and cows with respect to the BL, RW, RL, HB, EW, TL and TB thickness. The sex-related differences are most probably the result of the usual between-sex differential hormonal effects on growth. On the other hand, the superiority of castrates for all body measurements might be associated with imposed accretion of subcutaneous fats, which in turn affect live weight and other body measurements (Berg and Butterfield, 1976). Castration, especially at early age, also increases growth and changes body structure. It stimulates growth of the lumbar vertebrae, hind limb bones, patella and hindquarter bones but inhibits growth of the ribs, scapula, carpus, forelimb bone and forequarter bone. At the same time steers as compared with bulls show a shift in bone weight distribution towards the hindquarter, pistol and long bones.

The mean BWs of the Fipa cattle were slightly higher than those reported for Tarime cattle (Chenyambuga *et al.*, 2008), Iringa red (Sungael, 2005) and SEAZ (Mwacharo and Rege, 2002), but were almost similar to those of Ethiopian Boran, Karamajong, Abyssinia and Maasai zebu (Payne and Hodges, 1997), and other several tropical cattle (Butterworth, 1985). However, the BWs were lower than those of Kenyan Boran, Kenana and Butana (Osman, 1985). The BWs of the Fipa bulls and castrates observed in the present study suggest that under good feeding management and purposive selection for birth weights and growth rates, they should be a good beef resource that can compete well with the Boran.

Physical characteristics

The Fipa cattle had variable body colour patterns with some community colour preference across the study area. The predominant colours were red, pied (black and white), black and pied (red and white). Other colours such as brown, grey, spotted (black or red and white), pied (brown and white), dun, white, roan and brindle were found in small proportions in the herds of cattle. The majority of farmers preferred Fipa cattle with black or red or mixture of either red or black and white. The white was reported to be not preferred by many farmers due to being associated with high tick infestations. Non-preference for white was reported to also have an effect on the price of selling such animals. This finding is similar to that reported for Tarime (Chenyambuga *et al.*, 2008) and Baggara cattle (Alsiddig *et al.*, 2010).

Most of the animals had black, red and brown ear tips; black and brown muzzles; black, red and white tail switches; black and brown horns and black and red hooves. The observation of animals with multicolour has also been reported by Zulu (2008) for Angoni and Barotse cattle in Zambia and Msanga, Mbaga and Msechu (2001) for many TSZ strains.

Most of the Fipa cattle had no navel flap. They had sloping rump, cervico-thoracic positioned humps, small-sized humps in females and castrates but medium in bulls and pyramid-shaped humps in most animals. The animals had flat faces and backs, and majority were naturally horned. The horns of mature animals were moderately long in castrates and cows, but short in bulls. The horns were upward–forward oriented and lyre-shaped with long (below the hock joint) tails. The udders were small- to

Table 10. Frequency of occurrence of various colours on different body parts of Fipa cattle summarized by districts.

Body part	Colour	Nkasi		Sumbawanga rural		Sumbawanga urban		Overall	
		Frequency ($n = 101$)	%	Frequency ($n = 100$)	%	Frequency ($n = 106$)	%	Frequency ($n = 307$)	%
Tail	Black	57	56.54	48	48.00	47	44.34	152	49.51
	White	20	19.80	7	7.00	24	22.64	51	16.61
	Red	17	16.83	23	23.00	29	27.36	69	22.48
	Grey	2	1.98	2	2.00	3	2.83	7	2.28
	Brown	5	4.95	15	15.00	3	2.83	23	7.49
	Dun	o	0.00	1	1.00	0	0.00	1	0.33
	Pied (black and white)	0	0.00	2	2.00	0	0.00	2	0.65
	Pied (brown and white)	0	0.00	1	1.00	0	0.00	1	0.33
	Roan	0	0.00	1	1.00	0	0.00	1	0.33
		χ^2-value (df = 16) = 34.70**							
Ear	Brown	13	12.87	22	22.00	13	12.26	48	15.64
	Black	55	54.46	50	50.00	47	44.34	152	49.51
	Red	27	26.73	24	24.00	33	31.13	84	27.36
	Grey	2	1.98	2	2.00	11	10.38	15	4.89
	White	3	2.97	1	1.00	2	1.89	6	1.95
	Brindle	1	0.99	0	0.00	0	0.00	1	0.33
	Dun	0	0.00	1	1.00	0	0.00	1	0.33
		χ^2-value (df = 12) = 21.01^{ns}							
Muzzle	Black	74	73.27	60	60.00	64	60.38	198	64.50
	Brown	21	20.79	28	28.00	33	31.13	82	26.71
	Red	5	4.95	9	9.00	8	7.55	22	7.17
	Not pigmented	1	0.99	1	1.00	2	1.88	4	1.31
	Dun	0	0.00	1	1.00	0	0.00	1	0.33
	Grey	0	0.00	1	1.00	0	0.00	1	0.33
		χ^2-value (df = 12) = 12.23^{ns}							
Horn	Black	52	57.14	39	39.39	45	42.86	136	46.10
	Not pigmented	28	30.77	37	37.37	40	38.10	105	35.59
	Brown	7	7.69	16	16.16	14	13.13	37	12.54
	Red	4	4.40	4	4.04	5	4.76	13	4.41
	Grey	0	0.00	3	3.03	1	0.95	4	1.36
		χ^2-value (df = 8) = 10.74^{ns}							
Hoof	Black	78	77.23	70	70.00	70	66.04	218	71.01
	Red	20	19.80	10	10.00	22	20.75	52	16.94
	Brown	3	2.97	19	19.00	13	12.26	35	11.40
	Brindle	0	0.00	1	1.00	0	0.00	1	0.33
	Not pigmented	0	0.00	0	0.00	1	0.94	1	0.33
		χ^2-value (df = 8) = 20.57**							

Note: **Highly significant at $P < 0.01$; ^{ns}not significant at $P > 0.05$.

medium-sized and the teats and quarters were medium-sized. The animals had laterally oriented ears and medium-sized dewlaps. These observations are consistent with those observed for Baggara (Alsiddig *et al.*, 2010) and Tarime cattle (Chenyambuga *et al.*, 2008).

Conclusion and recommendations

Based on the findings obtained from the present study, it is concluded that:

1. Fipa cattle have medium body size and multiple coat colours (mainly red, pied black and white, black and pied red and white). Their body sizes are bigger than those of common TSZ but similar to or bigger than the Tanzanian Maasai cattle.
2. Fipa cattle live BWs and linear body measurements are significantly influenced by location and sex of the animals.
3. Although a number of traits measured could be used to predict BW accurately, HG would be the best estimator of BW in Fipa cattle either singly or in a combined regression analysis with other linear traits.
4. The evident wide within and between subpopulation variations in body measurements and qualitative traits observed in this study clearly indicate large phenotypic diversity which exists in the Fipa cattle population.

Therefore, under good management practices such as feeding, selective breeding and disease control, the Fipa cattle promise to be a good local beef breed in Tanzania. Thus development of conservation and improvement strategies

Table 11. Frequency (%) of occurrence of size, shape and profile of various body parts of Fipa summarized by districts.

Body part	Quality	Nkasi ($n = 101$)	Sumbawanga rural ($n = 100$)	Sumbawanga urban ($n = 106$)	Overall ($n = 307$)	χ^2-test
Dewlap sizes	Medium	100.00	94.00	97.17	97.07	(df = 2), 6.36*
	Small	0.00	6.00	2.83	2.93	
Hump sizes	Medium	10.89	16.00	17.92	14.98	(df = 4), 5.20^{ns}
	Small	83.17	82.00	80.19	81.76	
	Large	5.94	2.00	1.89	3.26	
Hump shapes	Pyramidal	90.10	98.00	96.23	94.79	(df = 2), = 7.03*
	Drooping	9.90	2.00	3.77	5.21	
Horn shapes	Lyre	90.11	92.93	91.43	91.53	(df = 4), 2.19^{ns}
	Straight	8.79	7.07	6.67	7.46	
	Curved	1.10	0.00	1.90	1.02	
Horn orientation	Upward–forward	90.11	92.93	91.43	91.53	(df = 12), 20.92^{ns}
	Lateral	2.20	6.06	5.71	4.75	
	Oblique–upward	5.49	0.00	0.00	1.69	
	Downward	1.10	0.00	1.90	1.02	
	Oblique–backward	1.10	0.00	0.00	0.34	
	One up–one down	0.00	1.01	0.00	0.34	
	One lateral–one down	0.00	0.00	0.95	0.34	
Horn status	Polled	9.90	1.00	0.94	3.91	(df = 2), 14.39***
	Horned	90.10	99.00	99.06	96.09	
Navel flap	Absent	84.16	97.00	82.08	87.62	(df = 4), 13.11*
	Small	12.87	2.00	16.04	10.42	
	Medium	2.97	1.00	1.89	1.95	
Udder size	Medium	52.18	48.65	50.00	50.46	(df = 2), 8.8377*
	Small	47.22	51.35	50.00	49.54	
Quarter size	Medium	83.33	86.49	91.67	87.16	df = 6), 7.67^{ns}
	Small	16.67	13.51	5.56	11.93	
	Large	0.00	0.00	2.78	0.92	
Teat sizes	Medium	86.11	100.0	94.44	93.58	(df = 4), 9.53*
	Small	13.89	0.00	5.56	6.42	
Hump position	Cervico-thoracic	100.00	100.00	100.00	100.00	
Face profile	Flat	100.00	100.00	100.00	100.00	
Back profile	Flat	100.00	100.00	100.00	100.00	
Rump profile	Sloping	100.00	100.00	100.00	100.00	
Ear shape	Straight edged	100.00	100.00	100.00	100.00	
Ear orientation	Lateral	100.00	100.00	100.00	100.00	

Note: n = number of animals observed; *significant at $P < 0.05$; **highly significant at $P < 0.01$; ***very highly significant at $P < 0.001$; ^{ns}not significant at $P > 0.05$.

for the strain is essential through mobilization of Fipa communities, non-governmental organizations, policy-makers and research institutions.

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Ethical clearance statement

Research protocols followed the guidelines stated in the Guide for the Care and Use of Agricultural Animals in Research and Teaching (FASS, 2010).

Statement of interest

The authors strongly declare that there are no conflicts of interest.

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Fipa cattle in the southwestern highlands of Tanzania: molecular characterization

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Summary
This study aimed at characterising the genetic diversity of two Fipa cattle populations (Sumbawanga and Nkasi) of South-Western Tanzania, and establishing their genetic relationships with the other indigenous cattle strains (Tarime, Iringa red and Ankole) and Friesian cattle found in the area. The genetic diversity was analysed using 30 microsatellite markers. All the markers used were highly polymorphic. The Nkasi Fipa cattle exhibited the highest mean number of alleles (7.31) and mean genetic diversity (0.732) per locus, followed by Sumbawanga Fipa cattle with 7.10 mean number of alleles and 0.725 mean genetic diversity per locus, with the latter population having a very low mean inbreeding coefficient ($F_{IS} = 0.027$). Three percent of the genetic diversity was due to differences among indigenous strains while the rest was due to differences among individuals within the strains. Small genetic distances (D_A) were observed between Sumbawanga Fipa and Nkasi Fipa (0.032), Tarime (0.073), Iringa red (0.076) and Ankole cattle (0.086). As expected, the largest genetic distances were observed between the Friesian and all indigenous strains since this breed has a quite distinct genetic origin. In the assignment test, the proportion of animals from each group correctly assigned to their source population ranged from 55.3 percent (for Nkasi Fipa) to 100 percent (for Friesian). Despite the low genetic differentiation and genetic indistinctiveness of the Sumbawanga Fipa population from the other indigenous strains, its high genetic diversity, very low inbreeding coefficient and a threat emanating from population admixture with other indigenous strains underscore the importance of establishing appropriate conservation and management strategies for it.

Keywords: *conservation, genetic diversity, Fipa population, indigenous strains, microsatellites*

Résumé
Cette étude visait à caractériser la diversité génétique de deux populations de bovins Fipa (Sumbawanga et Nkasi) en Tanzanie du Sud-Ouest, et à établir leurs relations génétiques avec les autres souches indigènes de bovins (Tarime, Iringa Red et Ankole) et avec les bovins Friesian présents dans la région. La diversité génétique a été analysée en utilisant 30 marqueurs microsatellites. Tous les marqueurs utilisés étaient hautement polymorphiques. Les bovins Fipa Nkasi présentaient le nombre moyen d'allèles (7,31) et la diversité génétique moyenne (0,732) par locus les plus élevés, suivis par les bovins Fipa Sumbawanga qui possédaient un nombre moyen d'allèles de 7,10, une diversité génétique moyenne par locus de 0,725 et un coefficient de consanguinité très faible ($F_{IS} = 0,027$). Trois pour cent de la diversité génétique provenait des différences entre les souches indigènes tandis que le reste résultait des différences entre les animaux au sein des souches. Les distances génétiques (D_A) étaient faibles entre les bovins Fipa Sumbawanga et Nkasi (0,032), Tarime (0.073), Iringa Red (0,076) et Ankole (0.086). Comme prévu, on a observé les distances génétiques les plus élevées entre toutes les souches indigènes et les bovins Friesian en raison des origines génétiques assez différentes de cette race. Lors du test d'attribution, la proportion d'animaux de chaque groupe qui ont été correctement assignés à leur population d'origine variait entre 55,3 pour cent (pour les Fipa Nkasi) et 100 pour cent (pour les Friesian). Malgré la faible différenciation génétique et le manque de traits génétiques distinctifs de la population de Fipa Sumbawanga par rapport aux autres souches indigènes, sa diversité génétique élevée, son coefficient de consanguinité très faible et la menace provenant du mélange génétique avec les autres souches indigènes mettent en évidence l'importance de planifier des stratégies adéquates pour sa conservation et sa gestion.

Mots-clés: *conservation, diversité génétique, population de bovins Fipa, souches indigènes, microsatellites*

Resumen
Este estudio tuvo como objetivo caracterizar la diversidad genética de dos poblaciones bovinas de la raza Fipa (Sumbawanga y Nkasi) de la región suroccidental de Tanzania, y establecer sus relaciones genéticas con otras razas bovinas que se encuentran en la zona, tanto autóctonas (Tarime, roja Iringa y Ankole) como la Frisona. La diversidad genética se analizó utilizando 30 marcadores microsatélites. Todos los marcadores utilizados fueron altamente polimórficos. La población Nkasi Fipa presentó el mayor número medio de alelos (7,31) y la mayor diversidad genética media (0.732) por locus, seguida por la población Sumbawanga Fipa con un número medio de alelos de 7,10 y una diversidad genética media por locus de 0.725, mostrando esta última población un coeficiente promedio de

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consanguinidad muy bajo (F_{IS} = 0,027). El 3% de la diversidad genética se debió a las diferencias entre razas autóctonas, mientras que el resto se debió a las diferencias entre individuos de la misma raza. Se observaron distancias genéticas (D_A) pequeñas entre Sumbawanga Fipa y Nkasi Fipa (0.032), Tarime (0.073), roja Iringa (0.076) y Ankole (0,086). Como era de esperar, las mayores distancias genéticas se observaron entre la Frisona y todas las razas indígenas, ya que esta raza tiene un origen genético muy diferente. En la prueba de asignación, la proporción de animales de cada grupo asignado correctamente a su población de origen osciló entre 55,3 percent (para Nkasi Fipa) y el 100 percent (para la Frisona). A pesar de la baja diferenciación genética y de la indiferenciación genética de la población Sumbawanga Fipa respecto a las otras razas autóctonas, su alta diversidad genética, su muy bajo coeficiente de consanguinidad y la amenaza que representa el cruzamiento con otras razas indígenas resaltan la importancia de establecer estrategias adecuadas de conservación y de manejo de esta población.

Palabras clave: *conservación, diversidad genética, población Fipa, razas indígenas, microsatélites*

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Introduction

The Fipa population is a native, Tanzanian cattle strain reared mainly in the Fipa plateau of the Rukwa region, in the South-Western Highlands of Tanzania, where it has always been reared and much valued by the local farmers (Mwambene *et al.*, 2012). Together with the Tanzanian Shorthorn Zebu (TSZ), Tarime and Ankole breed, the Fipa cattle are the main sources of beef in the country. They also provide draft power, manure, milk and fulfil many socio-cultural functions to rural communities (URT, 2006). The estimated population of cattle in Rukwa region is 512 722, of which more than 50 percent are Fipa cattle kept by about 123 467 households (URT, 2010). Fipa cattle exist also in some parts of Zambia, while the Ankole cattle are found also in Uganda, Rwanda, Burundi and the Democratic Republic of Congo (Kugonza *et al.*, 2011).

The origin of Fipa cattle is uncertain, but it is likely that it is a stabilised crossbred of 'Sanga and Zebu' (Rege and Tawah, 1999). A recent morphometric analysis of Fipa cattle involving 14 body measurements revealed that the strain has a medium-sized stature, with multiple body colours and colour patterns, which contrast it with the other Tanzanian cattle strains (Mwambene *et al.*, 2012). Recently, interest in Fipa cattle has increased due to being highly preferred by the Fipa community *vis-a-vis* other Tanzanian indigenous cattle. The preference is attributed to their provision of optimal draft power, tasty meat, large body size, saleability, high fertility, resistance to disease/parasites and tolerance to drought/feed shortages (Mwambene *et al.*, 2012). The management of the animals need few inputs since they are well adapted to varied conditions, thus making them a low-risk resource to the owners (Köhler-Rollefson, 2005). The animals subsist mainly on natural pastures and crop residues *in situ*, and so play a positive role in environmental sustainability through on-farm nutrient recycling (Mwambene *et al.*, 2012).

Since the 1980s the Fipa cattle population has been gradually declining due to the decrease in grazing rangelands caused by the increase in human population and the expansion of cropping activities. The situation has been made worse by the unrestricted movements of other cattle strains in search of pastures and water, particularly the Tarime and Ankole, in some parts of the Fipa plateau in the last four decades. These developments pose a threat to the long-term existence and uniqueness of the Fipa cattle. However, it is not known to what extent genetic exchange has taken place between the Fipa and other indigenous cattle during this period of their coexistence in the area. So far no measure has been undertaken to characterise and conserve Fipa cattle, or to prevent genetic introgression from other cattle strains. The disappearance of an indigenous strain would undermine the food and livelihood security of the poor livestock keepers as well as their capacity to survive in marginal areas (Okomo-Adhiambo, 2002). Normally the diversity and uniqueness of a strain, coupled by the farmers' preference for the strain and the stable relationship between the strain and the environment provides a good starting point for implementation of a conservation programme of the strain in its native environment where it can perform at its best. Therefore, immediate steps should be taken to characterise the diversity and uniqueness of such cattle populations so that they may be considered as genetic resources for conservation.

In any case, the first step towards designing a conservation programme is to understand the genetic structure and morphometric characteristics of the relevant population. So far most classification studies that have been undertaken on livestock breeds in Africa have been based on historical, anthropological and morphological evidences. Such criteria are usually subjective and imprecise. Morphological features are also influenced by the environment (Rege, 1992). These criteria are therefore most often not sufficiently informative for the purpose of prioritisation and establishment of conservation and improvement programmes. Furthermore, morphological characteristics alone cannot be used as a basis for the establishment of ethnological relationships (Mwacharo *et al.*, 2006). They need to be complemented by analysis of genetic markers that measure the genetic diversity at molecular level (FAO, 2007) in order to provide valuable information for conservation decisions. Molecular

characterisation is more reliable, since it is based on polymorphic and informative markers that examine diversity at DNA level (Mukesh *et al.*, 2004). So far such information is not available for Fipa cattle. The elucidation of genetic variability and genetic relationships among breeds has direct relevance on sustainable use of domestic animal genetic resources (Rehman and Khan, 2009). Therefore, the aim of the current study was to assess the within-population genetic variability of Fipa cattle population, as well as establish its genetic relationship with the other cattle strains found in the area, using microsatellite markers.

Materials and methods

Study area

The study was conducted in the Fipa plateau of Rukwa region, in the South-Western Highlands of Tanzania. The Fipa plateau is the main agro-ecological zone (AEZ) of Rukwa region, and it is located at about latitudes 6°50′–9°40′S and longitudes 30°26′–32°54′E, with an elevation of 1 200–2 100 m above sea level. The locations, AEZs, geographical characteristics, climatic condition, altitudes, soil types, landscapes and farming systems of the study area were described in detail in the previous paper (Mwambene *et al.*, 2012).

Blood sampling and DNA amplification

A total of 240 blood samples (40 samples per population) were collected from four indigenous cattle strains: two subpopulations of Fipa cattle (Sumbawanga and Nkasi), Ankole, Tarime and Iringa red. In addition, the Friesian dairy cattle breed was included to serve as a reference breed. The division of the Fipa strain into two subpopulations was based on its recent history: the subpopulations being separated by a distance of about 100 km or more and the geographical proximity of the Nkasi Fipa cattle to other indigenous cattle strains (Tarime and Ankole) in Nkasi and Mpanda districts. The division was aimed at first, appraising if the two subpopulations represent identical or genetically distinct (differentiated) populations and secondly, ascertaining the genetic introgression of other cattle strains into the Fipa cattle strain. The Ankole, Tarime and Iringa red strains represent the Sanga, 'Zebu × Sanga' crossbreds and TSZ cattle, respectively. The Friesian dairy breed represents the taurine cattle.

The samples for Fipa cattle were collected from four distantly located villages on the same set of animals from which morphological measurements had been undertaken previously. The samples for Tarime and Ankole cattle were collected from four distantly located villages for each breed in Nkasi and Mpanda districts. The Iringa red samples were collected from three distantly located villages in Mufindi district, in Iringa region. In all cases, about 10 unrelated animals were bled per village (at most two unrelated animals per household). The blood samples for Friesian cattle were collected from two Government Livestock Research and Training farms at Uyole, in Mbeya region (Figure 1).

The blood samples were collected by jugular vein puncture using 5 ml EDTA vacutainer tubes. In all populations, efforts were made to sample from equal numbers of males and females to ensure that the animals were as representative of the population as possible. Farms in which there had been recent crossbreeding/interbreeding with other local or commercial breeds were excluded from the study. The processing and preservation of the blood samples were performed as described by Okomo (1997). DNA samples were then extracted from the buffy-coat using a standard phenol-chloroform procedure (Sambrook, Fritsch and Maniatis, 1989). The extracted DNA samples were quantified using JENWAY GENOVA spectrophotometer and diluted to about 30 ng/µl using double distilled H_2O and then stored at 4 °C before being sent to the laboratory for genotyping.

Thirty microsatellite markers used were selected based on the degree of polymorphism and genome coverage, and in accordance with the FAO and ISAG recommendations (FAO, 2004). Six PCR multiplex reactions were done to amplify the microsatellites according to standard protocols: *ETH225* (D9S1), *HEL5* (D21S15), *HEL9*, *INRA23* (D3S10), *BM1824* (D1S34), *INRA35* (hexaplex 1), *MM12* (D9S20), *INRA32*, *INRA37*, *HAUT24* (D22S26), *ILSTS005* (D10S25), *TGLA126* (D20S1) (hexaplex 2), *HEL1*, *BM1818*, *CSRM60* (D10S5), *SPS115* (D15), *TGLA53* (pentaplex 3), *ETH185*, *BM2113*, *ILSTS006*, *INRA63*, *ETH3*, *CSSM66*, *ETH152* (dexaplex 4), *HEL13*, *INRA005*, *ETH10* (triplex 5), *TGLA227*, *TGLA122* and *HAUT27* (triplex 6). The DNA samples were combined with fluorescent-labelled oligonucleotide primers (0.5 ml for ABI kit). PCR amplifications were performed using 10–11 µl reaction volumes with about 30 ng template DNA, 1 pmol/µl of primer forward and reverse, 1X PCR buffer (16 mM $(NH_4)_2SO_4$, 67 mM Tris–HCl, pH 8.8, 0.01 percent Tween 20), 0.26 mM of every dNTPs, 2.5 mM of $MgCl_2$ and 1 U of Taq DNA polymerase, in a final volume of 20 µl. The markers were amplified using the Qiagen Multiplex PCR kit at the following conditions: initial denaturation step of 15 min at 95°C, followed by 30 cycles of 30 s at 94°C, annealing for 90 s at 52°C for multiplexes 1, 2 and 3; 55°C for multiplex 6 and 58°C for multiplexes 4 and 5, a final elongation at 72°C for 1 min and 1 cycle at 60° C for 30 min, and a touchdown cycle profile at 4°C. Individual genotypes were determined with an ABI Genetic Analyzer 3130xl and GeneMapper ver 4.0 (Applied Biosystems, Foster City, CA, USA). Of the 30 microsatellite loci, 29 loci amplified successfully and produced definite banding patterns. Animals with less than 60 percent of amplified markers ($n = 20$) were dropped from the dataset (Table 1).

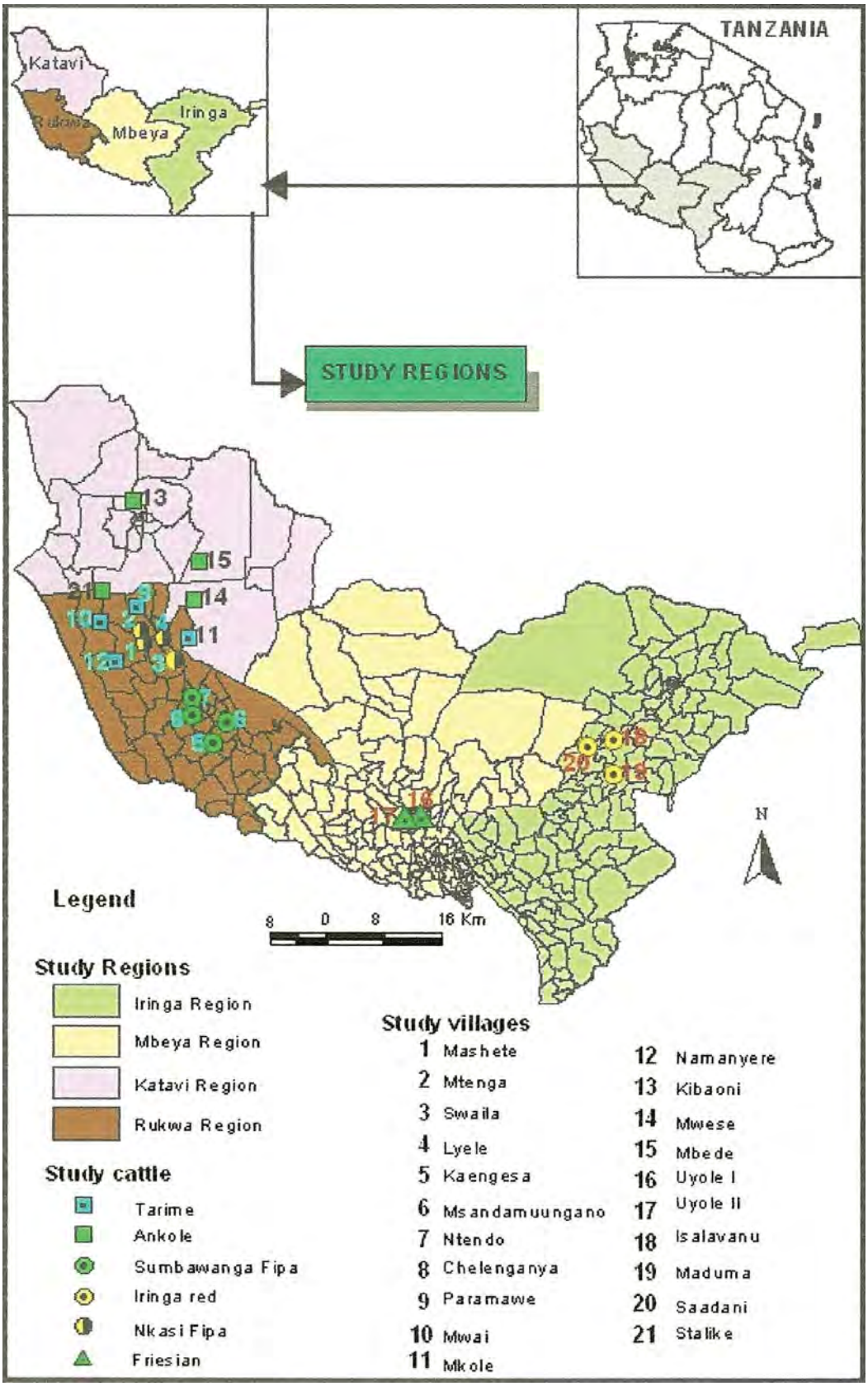

Figure 1. A map of Tanzania showing the study regions and villages where Fipa, Tarime, Ankole, Iringa red and Friesian cattle blood samples were collected.

Table 1. Number of alleles, in brackets number of private alleles, observed and unbiased expected heterozygosity, effective number of alleles, allelic richness, polymorphic information content and HWE at 29 microsatellite loci in 6 cattle populations.

Population (*N*)	TNA	Mean heterozygosity						Allele range	HWE[a] deviation
		MNA	Ho	UHe	Ae	Ar	PIC		
Sumbawanga Fipa (39)	206 (12)	7.10 ± 0.43	0.706 ± 0.025	0.725 ± 0.021	3.974 ± 0.252	6.301 ± 0.352	0.677 ± 0.002	4–12	5[b] (HAUT27, CSRM60, ILSTS005, HAUT24, HEL9)
Nkasi Fipa (38)	212 (13)	7.31 ± 0.38	0.683 ± 0.027	0.732 ± 0.018	4.035 ± 0.266	6.490 ± 0.326	0.685 ± 0.020	4–12	7[b] (HEL5, HAUT24, ETH10, ETH185, HAUT27, CSRM60, INRA37)
Tarime (35)	199 (5)	6.86 ± 0.32	0.694 ± 0.028	0.718 ± 0.017	3.769 ± 0.228	6.223 ± 0.262	0.671 ± 0.019	4–12	4[b] (TGLA53, HAUT27, HAUT24, ETH185)
Iringa red (38)	196 (4)	6.76 ± 0.36	0.643 ± 0.027	0.691 ± 0.021	3.198 ± 0.232	6.034 ± 0.294	0.641 ± 0.023	3–10	9[b] (HEL5, HAUT24, BM1824, ETH3, CSRM60, TGLA122, TGLA53, ILISTS005, INRA37)
Ankole (31)	187 (6)	6.45 ± 0.37	0.684 ± 0.026	0.700 ± 0.016	3.458 ± 0.187	5.953 ± 0.314	0.646 ± 0.019	4–12	5[b] (HEL5, MM12, INRA63, INRA35, HEL13)
Entire indigenous sample (181)	271 (40)	9.345 ± 0.474	0.682 ± 0.012	0.713 ± 0.008	3.753 ± 0.105	7.248 ± 0.314	0.729 ± 0.017	6–16	11[b] (HEL5, INRA37, HAUT24, ILSTS005, CSRM60, TGLA53, ETH185, ETH3, ETH10, TGLA227, HAUT27)
Friesian (39)	163 (27)	5.62 ± 0.39	0.677 ± 0.024	0.664 ± 0.021	3.527 ± 0.189	5.147 ± 0.336	0.603 ± 0.023	2–11	3[b] (MM12, INRA37, HAUT24)

Note: *N*, number of samples; TNA, total number of alleles; in brackets number of private alleles; MNA, mean number of alleles per locus; H, observed heterozygosity; UHe, unbiased expected heterozygosity; Ar, allelic richness; Ae, effective number of alleles; PIC, polymorphic information content; [a]Number and types of loci not in Hardy–Weinberg equilibrium (HWE; $P < 0.05$); [b]*Population not in Hardy–Weinberg equilibrium (HWE; $P < 0.05$).

Statistical analyses

Within-population genetic diversity

Allele frequencies (Af), allelic richness (Ar), private alleles (Ap), effective number of alleles (Ae), observed heterozygosity (Ho) and unbiased genetic diversity (UHe) were calculated using GenAlEx 6.41 software (Peakall and Smouse, 2006) per locus, for each population of cattle and for pooled sample. To eliminate the influence of different sample sizes from locus to locus and for each population on evaluation; genetic diversity, distance and allelic richness were calculated following rarefaction method in order to standardise them (Petit, El Mousadik and Pons, 1998). Polymorphic information content (PIC) was also assessed using the software Cervus 3.0.3 (Kalinowski, Taper and Marshall, 2007).

Test for conformity to Hardy–Weinberg equilibrium

Genepop v. 4.0 (Rousset, 2007) was used to perform the test for conformity to Hardy–Weinberg equilibrium (HWE) per locus and per breed, using the Exact test of Guo and Thompson (1992). Once a deviation from equilibrium was observed at some loci a more powerful test was applied to evaluate the heterozygote deficiency or excess following the suggestions of Raymond and Rousset (1995).

Genetic diversity among the strains

Genetic distances D_A (Nei, Tajima and Tateno, 1983) between the strains were assessed and based on allele frequencies using the GenAlEx 6.41 software. The extent of genetic differentiation among the strains was determined using F_{ST} statistics. The F_{STAT} v.2.9.3 software was used to estimate the F_{IS}, F_{IT} and F_{ST} statistics (Weir and Cockerham, 1984) and their significance was inferred by methods based on randomisation. A dendrogram showing the relationship of the strains was constructed based on the D_A distance by the neighbour-joining method (Saitou and Nei, 1987) using *MEGA* version 5 (Tamura *et al.*, 2011). The D_A genetic distance is better suited to obtain correct tree topology than other distances, regardless of a mutation model (Takezaki and Nei, 1996). The principal component analysis (PCA) was performed with the GenAlEx 6.41 software using allele frequencies observed at 29 microsatellite loci in order to asses genetic relationships among the strains based directly on allele frequencies. The structure software (Pritchard, Stephens and Donnelly, 2000; Falush, Stephens and Pritchard, 2003) was used to analyse possible genetic admixture. To choose the appropriate number of inferred clusters to model the data, one to six inferred clusters were performed with ten independent runs each. All analyses used a burn-in period of 50 000 and 100 000 iterations (MCMC) for data collection. Individual animals were assigned to their presumed population of origin using individual assignment tests using the GenAlEx 6.41 program, in order to ascertain genetic admixture.

Results

Within-population genetic diversity and conformity to HWE

A total of 271 alleles were generated among the indigenous strains. The number of alleles per locus ranged from 6 for INRA63, ETH3 and ETH152 to 16 for TGLA53, with an average of 9.345 alleles per locus (Table 1). All of the loci under investigation were polymorphic. The Nkasi Fipa strain had the highest mean number of alleles (7.31), followed by the Sumbawanga Fipa strain (7.10), while the Ankole cattle revealed the lowest mean (6.45). Likewise, the Nkasi Fipa strain had the highest allelic richness (6.49), whereas the Ankole breed had the lowest mean (5.953). Private alleles were detected in all the indigenous strains. The number of private alleles ranged from 13 for Nkasi Fipa to 4 for Iringa red. However, the frequencies of all private alleles from the indigenous strains were generally low (<0.1). The number of private alleles for the Friesian breed was 27, with some alleles having frequencies of more than 0.1.

The mean polymorphic information content (PIC) was 0.677 in the Nkasi Fipa, 0.685 in the Sumbwanga Fipa, 0.671 in the Tarime, 0.641 in the Iringa red and 0.646 in the Ankole cattle. For all indigenous strains, the PIC ranged from 0.474 for INRA35 to 0.871 for HEL9, with a mean of 0.729.

The mean observed (Ho) and expected (He) heterozygosities were 0.683 and 0.732 in Nkasi Fipa, 0.706 and 0.725 in Sumbawanga Fipa, 0.694 and 0.718 in Tarime, 0.643 and 0.691 in Iringa red and 0.684 and 0.700 in Ankole cattle, respectively. The average observed heterozygosity was lower than the average expected heterozygosity in all strains. The diversity analysis revealed considerable levels of genetic variation in all the strains, with the Nkasi Fipa and Sumbawanga Fipa subpopulations displaying somewhat higher levels of genetic polymorphism than the other strains (Table 1).

The test for conformity to HWE revealed that all strains exhibited significant ($P < 0.05$) deviations from the HWE at some of the loci. In the pooled indigenous strain samples, a total of 11 of 29 loci deviated from the HWE. The Iringa red cattle had the highest number of loci (9) that deviated from the HWE while Tarime cattle had the lowest (4) number of loci deviating from the HWE. Most of the loci that significantly deviated from the HWE exhibited deficiency of heterozygotes, except for CSRM60 in Sumbawanga Fipa; INRA37 in Nkasi Fipa; BM1824, CSRM60, ETH3 and TGLA122 in the Iringa red; and MM12 and HEL13 in Ankole cattle which showed heterozygote excess.

F-statistics

Table 2 shows Wright's *F*-statistics in the entire sample and per strain, revealing that the homozygote excess in the whole population was moderate ($F_{IT} = 0.061$). The F_{IT} values per locus ranged from −0.002 for HEL13 to 0.341 for ETH185. The F_{IS} values within the entire population ranged from −0.002 for BM1818 to 0.309 for ETH185, with a mean of 0.030, which was not significantly different ($P > 0.05$) from zero. Of the 29 markers, 17 had negative F_{IS} values while the rest had positive F_{IS} values. The F_{ST} values ranged from 0.014 for BM1824 to 0.073 for INRA32, with an overall mean of 0.032 which was highly significant ($P < 0.01$).

Within each strain, the F_{IS} values ranged from −0.010 for BM1818 and ETH10 in Sumbawanga Fipa and Tarime cattle to 0.530 for HAUT24 in Tarime cattle. The average F_{IS} values across microsatellite loci ranged from 0.023 for the Ankole to 0.070 for the Iringa red. The mean F_{IS} values for Sumbawanga Fipa and Ankole cattle were not significantly different ($P > 0.05$) from zero, while these estimates were significant ($P < 0.05$) in Tarime, Nkasi Fipa and Iringa red cattle.

Genetic relationships among strains

Table 3 summarises genetic distances (D_A) and gene differentiation (F_{ST}) indices between all pairs of cattle strains/breeds. The closet D_A genetic distance (0.032) was obtained between Sumbawanga Fipa and Nkasi Fipa, whereas the largest D_A (0.095) was obtained between Iringa red and Ankole. These results were as expected as they correspond well to the distances between the geographical locations inhabited by these strains in Tanzania. The smallest F_{ST} value (0.013) was observed between the Sumbawanga Fipa and the Nkasi Fipa, while the largest (0.027) was between Iringa red and Ankole. This corresponds well to the D_A values obtained in the study. The pair-wise F_{ST} values obtained showed that the strains/breeds were highly significantly ($P < 0.01$) different from each other.

The NJ tree based on D_A genetic distance is represented in Figure 2. The tree shows the existing relationships among the indigenous strains according to loci considered in the study. As it would be expected, the Sumbawanga Fipa and Nkasi Fipa are close to each other, whereas the Nkasi Fipa cattle are closer to the Tarime, and then to the Iringa red than to the Ankole cattle as shown in Figure 2. The Friesian breed is well separated from the indigenous strains.

Assessment of genetic relationships between breeds/strains using PCA is represented in Figure 3. The first three principal components accounted for 91.54 percent of the total genetic variation. The first PC explained 74.4 percent of the variation and clearly separated Friesian cattle from the indigenous strains. The second PC explained an additional 9.14 percent of diversity and separated the Ankole from the other four indigenous strains. The grouping in this PCA almost supports the clustering in the NJ tree (Figure 2).

Table 2. Wright's *F*-statistics values for each strain/breed and for the entire indigenous sample.

Locus	F_{IS} values for individual strains/breeds						F_{STAT} values for entire indigenous sample		
	Sumbawanga Fipa	Nkasi Fipa	Tarime	Iringa red	Ankole	Friesian	F_{IS}	F_{IT}	F_{ST}
ETH225	−0.131	−0.037	0.115	0.248[a,*]	−0.168	−0.147	−0.020	0.014	0.034
HEL5	0.123	0.351[a,***]	0.185[a,*]	0.340[a,***]	0.417[a,***]	−0.019	0.269[a,**]	0.287[a,**]	0.025
HEL9	0.035	−0.104	−0.043	0.055	0.006	0.102	−0.026	0.014	0.039
INRA23	−0.060	0.136	−0.181	0.054	−0.023	−0.068	−0.029	−0.002	0.026
BM1824	0.090	0.112	−0.048	−0.070	0.072	0.006	0.016	0.029	0.014
INRA35	0.147	0.063	0.226[a,*]	0.101	0.227[a,*]	−0.064	0.141	0.163	0.025
MM12	0.011	0.023	−0.055	0.101	−0.071	0.086	−0.014	0.008	0.021
INRA32	−0.072	0.016	−0.121	0.188[a,*]	−0.141	−0.120	−0.037	0.039	0.073
INRA37	−0.040	−0.048	−0.088	0.027	−0.003	−0.196	−0.045	0.010	0.053
HAUT24	0.187[a,*]	0.215[a,*]	0.530[a,***]	0.204[a,*]	0.126	0.273[a,**]	0.235[b,**]	0.267[a,**]	0.041
ILSTS005	0.031	−0.034	−0.075	0.165	−0.064	0.084	−0.010	0.011	0.021
TGLA126	0.053	−0.074	0.253[a,**]	−0.150	−0.089	−0.142	−0.014	0.005	0.019
HEL1	0.022	0.046	0.240[a,*]	0.006	−0.111	−0.057	0.025	0.065	0.041
BM1818	−0.010	0.119	0.022	0.041	−0.113	−0.065	−0.002	0.023	0.026
CSRM60	−0.129	0.137	0.001	−0.056	−0.170	−0.005	−0.054	−0.021	0.031
SPS115	−0.152	−0.094	0.058	−0.063	0.246[a,*]	0.037	−0.020	0.008	0.027
TGLA53	0.007	−0.044	0.050	0.009	0.084	−0.021	0.005	0.036	0.031
ETH185	0.255[a,**]	0.378[a,***]	0.181	0.417[a,***]	0.374[a,***]	−0.014	0.309[a,**]	0.341[a,**]	0.047
BM2113	0.065	−0.085	0.012	0.109	−0.076	0.143	−0.006	0.023	0.028
ILSTS006	−0.013	−0.021	−0.140	−0.049	−0.141	−0.158	−0.088	−0.048	0.037
INRA63	0.005	−0.021	0.103	0.252	0.179	0.009	0.082	0.103	0.023
ETH3	−0.077	−0.186	0.028	−0.064	−0.038	−0.185	−0.080	−0.046	0.032
CSSM66	−0.072	−0.056	−0.019	0.034	−0.023	−0.002	−0.041	−0.016	0.025
ETH152	0.120	0.307[a,**]	−0.055	0.086	0.193	0.048	0.119	0.156	0.043
HEL13	−0.105	0.027	0.014	−0.081	−0.025	0.071	−0.048	0.002	0.048
ETH10	0.025	0.013	−0.010	−0.115	0.050	−0.160	−0.020	−0.002	0.018
TGLA227	−0.031	0.152[a,*]	−0.092	0.202[a,*]	−0.144	−0.150	0.010	0.029	0.019
TGLA122	0.106	0.058	0.011	−0.015	−0.051	0.008	0.005	0.025	0.020
HAUT27	0.326[a,***]	0.538[a,***]	0.006	0.079	0.155	0.066	0.211[a,**]	0.239[a,**]	0.035
Mean ± SE	0.027 ± 0.021	0.067[a,***] ± 0.027	0.034[a,*] ± 0.030	0.070[a,***] ± 0.026	0.023 ± 0.016	−0.021 ± 0.020	0.030 ± 0.020	0.061 ± 0.019	0.032** ± 0.002

Note: F_{IS}, inbreeding coefficient of an individual relative to its subpopulation; F_{IT}, inbreeding coefficient of an individual relative to the whole set of indigenous populations; F_{ST}, inbreeding coefficient of the subpopulation relative to the entire indigenous population; SE, standard error; [a]Deficit of heterozygote; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 3. Pair-wise Nei unbiased genetic distances (D_A below diagonal) and fixation indices (F_{ST} above diagonal) between cattle populations.

Sumbawanga Fipa	Nkasi Fipa	Tarime	Iringa red	Ankole	Friesian	
–	0.013**	0.021***	0.022***	0.024***	0.095***	Sumbawanga Fipa
0.032	–	0.014***	0.021***	0.022***	0.104***	Nkasi Fipa
0.073	0.038	–	0.015***	0.022***	0.110***	Tarime
0.076	0.067	0.037	–	0.027***	0.116***	Iringa red
0.086	0.078	0.075	0.095	–	0.113***	Ankole
0.585	0.689	0.730	0.730	0.721	–	Friesian

Note: **F_{ST} values highly significantly different from zero ($P < 0.01$), ***F_{ST} values very highly significantly different from zero ($P < 0.001$).

Individual animals' assignment to their population of origin

The results of the analyses for individual animal assignment and population structure are shown in Table 4 and Figure 4, respectively. The proportion of animals from each group correctly assigned to their source population ranged from 55.3 percent for Nkasi Fipa to 81.6 percent for Iringa red, with an average of about 73.7 percent for the entire indigenous cattle population. Considerable proportions of Nkasi Fipa animals were assigned to other clusters, such as Sumbawanga Fipa (21.1 percent) and Tarime (18.4 percent). This further demonstrates the close relationship of the Nkasi Fipa cattle to both the Sumbawanga Fipa and the Tarime cattle. A similar feature was apparent for the proportions of Sumbawanga Fipa (17.9 percent) and Tarime (17.1 percent) individual animals assigned to the Nkasi Fipa cluster. Few Ankole (6.5 percent) and Iringa red (7.9 percent) individuals were found in the Sumbawanga Fipa cluster, Nkasi Fipa (12.9 and 2.6 percent) and Tarime (3.2 and 7.9 percent) clusters. The misassignments of some of the indigenous animals could also be clearly illustrated by the structure analysis (Figure 4). As it would be expected, all individual animals from the Friesian breed were correctly assigned to their source population.

The genetic relationship of the strains was also assessed using the phylogenetic analysis of individual animals. The NJ dendrogram in which each individual animal is treated as a taxonomic unit showed that the animals from each indigenous strain did not separate into specific clusters while the animals from the Friesian breed formed a distinct cluster (Figure 5).

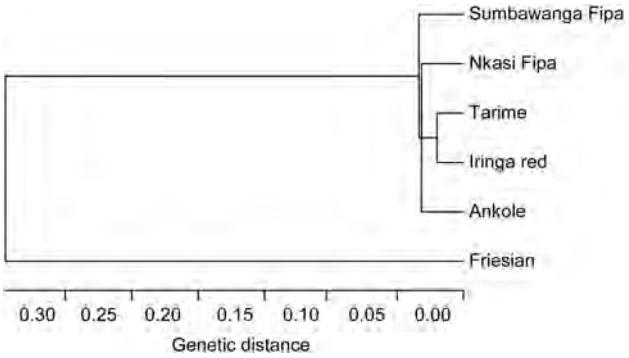

Figure 2. Unrooted neighbour-joining tree showing genetic relationships of five Tanzanian cattle strains and the Friesian breed using D_A genetic distances from 29 microsatellite loci.

Discussion

Within-strain genetic variability and compliance to HWE

The estimates of genetic diversity were based on a set of markers showing relatively high levels of polymorphism. The total number of alleles per locus in all the studied indigenous cattle ranged from 6 to 16, with an average of 9.345. This level is considered sufficient and above the recommended number of alleles (>4) to reduce the

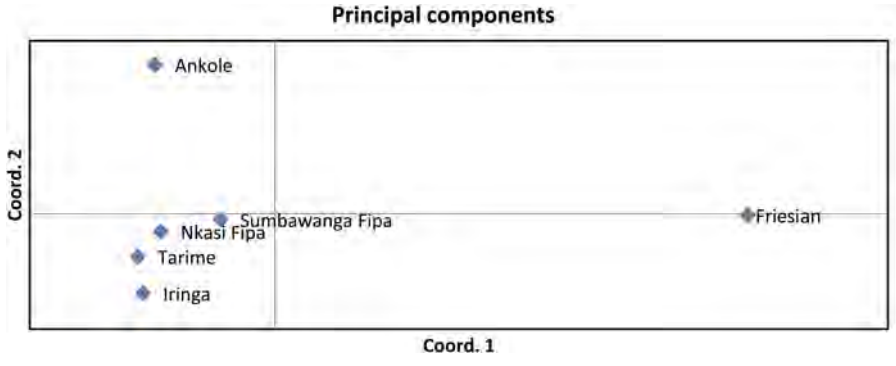

Figure 3. Principal components graph of the first three principal components from six populations.

Table 4. Percentages of individual animals from each population correctly and incorrectly assigned to source and other populations (with leave one out option).

Source population	Correctly assigned (%)	Assigned to (%)					
		Sumbawanga Fipa	Nkasi Fipa	Tarime	Iringa red	Ankole	Friesian
Sumbawanga Fipa	76.9	–	17.9	2.6	0	2.6	0
Nkasi Fipa	55.3	21.1	–	18.4	5.3	0	0
Tarime	77.1	0	17.1	–	5.8	0	0
Iringa red	81.6	7.9	2.6	7.9	–	0	0
Ankole	77.4	6.5	12.9	3.2	0	–	0
Friesian	100	0	0	0	0	0	–
Total	78.1	5.9	9.3	5.4	1.9	0.4	0

standard error estimates of genetic distances (FAO, 2004). The total numbers of alleles per locus and high PIC values that were observed in this study suggest that these markers are informative for genetic diversity in Tanzanian cattle and that Tanzanian cattle possess a wide genetic base that allows for adaptation to a wide variety of ecological environments. This is also an indication of heterogeneity of individual animals that were sampled in all the strains/breeds. However, the Nkasi Fipa cattle had the highest number of alleles per locus while the Ankole cattle had the lowest. The mean number of alleles per locus found in the present study is lower than the 12.5 alleles per microsatellite locus observed by Okomo-Adhiambo (2002) in Kenyan Zebu strains and 11.5 alleles per microsatellite locus observed by Ibeagha-Awemu *et al.* (2004) in West/Central African cattle breeds.

All the indigenous strains exhibited significant deviations from HWE at some of the loci. Although, it is difficult to envisage the exact basis of this deviation, yet the presence of heterozygote deficiencies at some of the loci studied may suggest inbreeding to be a possible reason. However, it should be noted that the deficiency of heterozygotes within indigenous strains is not only an indicator of inbreeding, but also non-random mating or population subdivision.

The mean gene diversity as indicated by UHe had a range of 69.1 percent for the Iringa red to 73.2 percent for the Nkasi Fipa cattle. This is within the range of 60–75 percent reported by Ibeagha-Awemu *et al.* (2004) and Dalvit *et al.* (2008) in both native and commercial cattle breeds. These values are also within the range of 70.7–75.4 percent reported by Okomo-Adhiambo (2002) in Kenyan Zebu cattle. However, the UHe values in the present study are slightly higher than the value of 64.1 percent reported by Okomo-Adhiambo (2002) in Sahiwal cattle.

The Fipa cattle are kept by a considerable number of rural farmers, who practice uncontrolled (random) mating (Mwambene *et al.*, 2012). This might explain why the within Fipa cattle population genetic diversity was rather high. Toro and Maki-Tanila (2007) also suggested that the high genetic diversity observed within strains could arise from overlapping generations and population mixtures from different geographical locations, with natural selection favouring heterozygosity. A similar notion was expressed by Machado *et al.* (2003) to explain the high diversity within the local Brazilian Gyr cattle breed. Normally, high levels of gene flows among different populations maintain high genetic diversity within each population and therefore, make them little susceptible to genetic drift (Falconer and Mackay, 1996).

The high gene diversity observed in the Fipa and other indigenous strains suggests the existence of a high underlying genetic diversity within the strains that can be utilised to improve desirable traits. This result is coherent with the great phenotypic diversity that was previously reported in the Fipa cattle population (Mwambene *et al.*, 2012), which is also an indication of a great functional genetic diversity in the strain. Functional diversity is

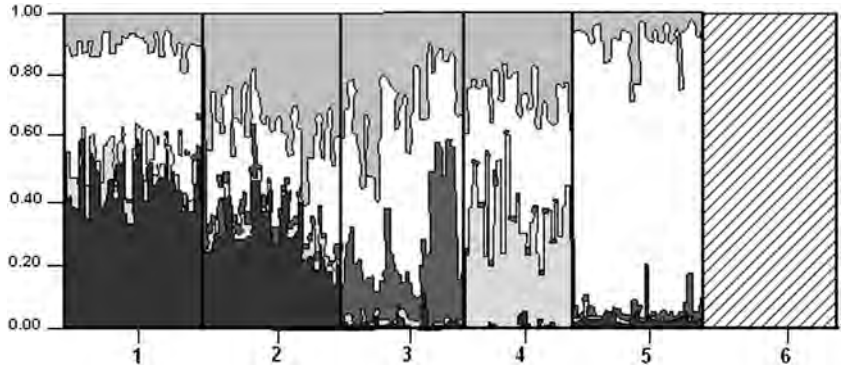

Figure 4. Structure analysis of six cattle populations (1 – Sumbawanga Fipa, 2 – Nkasi Fipa, 3 – Tarime, 4 – Ankole, 5 – Iringa red and 6 – Friesian).

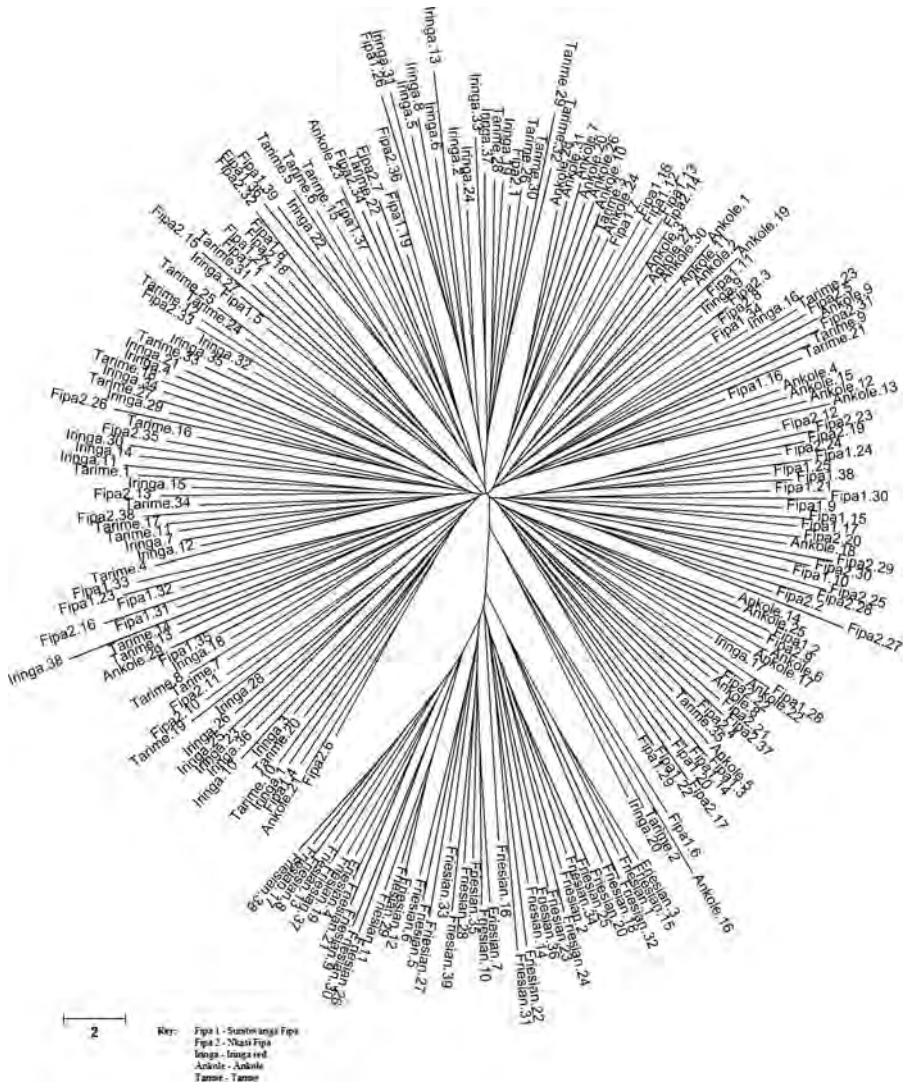

Figure 5. A radiation neighbour-joining dendrogram constructed from allele-sharing distances among 220 individual animals from four Tanzanian strains and one exotic breed.

valuable for achieving present or future breeding objectives and, therefore, strains with high functional diversity (i.e. measured by neutral genetic markers) coupled with other physical and socio-economical attributes should receive a high priority for conservation. According to Notter (1999), the high diversity of native strains which are usually subjected to traditional husbandry practices enhances adaptation ability of the strains to changing environment, market demand and breeding goals.

The levels of gene diversity in five indigenous strains did not differ significantly. The lack of significant differences between strains observed in this study with respect to within-strain gene diversity might have been caused by a recent differentiation of the strains from a common ancestral population, coupled with the continuous mixing and interbreeding between geographically proximal strains. In the last four decades some agro-pastoral communities, particularly the Sukuma, have been migrating from one place to another in the South-Western Highlands of Tanzania in search of pastures. This has led to the coexistence of the Fipa with other indigenous strains in this area, thus leading to an admixture and interbreeding among the indigenous strains.

Never-the-less, all the strains had mean Ho values lower than He values and therefore, pointing to a possible departure from random mating. This is evidenced by the fact that of the 29 loci studied, 12 loci revealed heterozygote deficiency. This observation might have resulted from mating between relatives, similar to what has been reported by Rehman and Khan (2009) in Hariana and Hissar cattle populations.

Inbreeding coefficients of the strains

The total inbreeding coefficient (F_{IT} value) observed in this study was moderate and it could be accounted for by the observed mean within-heterozygote deficiency (F_{IS} value). Increasing F_{IT} values are an indication of some measure of homozygote excess or heterozygote deficit resulting from relatedness of individuals. The

presence of positive F_{IS} values for some loci suggests heterozygote deficiencies, as it has been reported in other studies on cattle breeds (MacHugh *et al.*, 1997; Ciampolini *et al.*, 2006; Dalvit *et al.*, 2008; Rehman and Khan, 2009). The heterozygote deficiencies might have been caused by pooling together different populations in the analysis which are actually subdivided. This is because the samples for each strain were collected from different areas.

The average F_{IS} values for most of the loci in Sumbawanga Fipa and Ankole cattle were positive but not significantly ($P > 0.05$) different from zero, thus indicating a very low rate of inbreeding within each strain. On the contrary, the Nkasi Fipa, Tarime and Iringa red cattle had positive F_{IS} values that were significant ($P < 0.05$). This observation suggests some degree of inbreeding or non-random mating within each strain. It is not clear how such a result could come about for the Nkasi cattle as they do almost coexist with Tarime and Ankole cattle unlike the Sumbawanga Fipa cattle. These results could also explain the deviation from HWE observed in some loci, both in the whole sample and in each strain. Generally, the F_{IS} values per strain observed from this study were still low in comparison with those reported from the other studies on local breeds. Moioli, Napolitano and Catillo (2004) reported values ranging from 0.102 to 0.138 in their study on three indigenous Italian cattle breeds and Rendo *et al.* (2004) reported an F_{IS} estimate of 0.108 in the Betizu cattle, a native breed in Spain. However, it is important to note that the F_{IS} values observed in the present study might have been based on different markers, sample sizes and sampling procedures from those obtained from other studies.

Distinctiveness and relationships of the Fipa with other strains

One of the main objectives of this study was to evaluate the genetic distinctiveness of the Fipa cattle strain in reference to other indigenous strains in order to determine if it merits to be considered for conservation, promotion and improvement. The evaluation was based on coefficients of genetic differentiation (F_{ST}), genetic distances (D_A), Neighbour-joining (NJ) tree, population structure and principal component (PC) analyses. The mean coefficients of genetic differentiation observed in this study demonstrated that only about 3.2 percent of the total genetic variation was accounted for by between-indigenous strain differences, while the rest (96.8 percent) was attributed to differences among individuals within indigenous strains. Molecular genetic variation was therefore observed to be higher within strains than among strains, which suggest high heterogeneity within the strains sampled. The observed overall level of differentiation among indigenous strains was lower than that reported (9 percent) by Okomo *et al.* (1998) in East African cattle, 11 percent reported by MacHugh *et al.* (1997) in European cattle and 6.8 percent reported by Jordana *et al.* (2003) in South European beef breeds. The pair-wise F_{ST} values were relatively small, indicating low levels of genetic differentiation between the indigenous strains. Low levels of genetic differentiation between indigenous strains are attributed to high gene flows, admixture and interbreeding in the study area as well as sharing a common ancestry among the strains. According to Laval *et al.* (2000), migration and admixture may exert a greater effect than mutation or drift on the reduction of genetic differentiation between populations.

The Ankole breed was relatively distantly related from the other indigenous strains. This finding can be attributed to the different ancestral origin of the Ankole cattle (which is a Sanga), from that of the Fipa and Tarime (which are Zebu × Sanga crosses), and the Iringa red (which is a Zebu). The Fipa cattle were more closely related to the Tarime than to the Iringa red cattle. This is because both Tarime and Fipa cattle are Sanga × Zebu crosses. They are also kept in the proximity with each other in the area, particularly in Nkasi district. Although the Iringa red strain is far more isolated by distance from the Fipa population than the Ankole subpopulation sampled in the current study, the genetic analysis results showed that the Fipa cattle are more closely related to the Iringa red than to the Ankole cattle. This observation suggests that the Fipa cattle have more Zebuine than Sanga inheritance in their genetic constitution. The genetic distance between the Sumbawanga Fipa and Nkasi Fipa cattle was the smallest. This finding confirms a recent separation of the strains from a common ancestry. Accordingly, the two Fipa subpopulations showed a significant genetic divergence between them. The divergence might be attributed to genetic introgression from either the Tarime or Ankole in the Nkasi subpopulation. The Fipa cattle population subdivision leading to independent genetic drift in each subpopulation, as well as limited gene flow between them because of being isolated by a large physical distance might also be the additional causes of observed divergence. The existence of substantial genetic differentiation between cattle populations has been considered by many scholars to be advantageous for conservation purpose (Talle, 2004).

Genetic structure of indigenous strains

The cluster, breed assignment and dendrogram analyses using individual animals as operational taxonomic units showed an intermixing of the indigenous strains. Some individuals from different strains appeared in the other groups and therefore lacking very specific population subclusters. The analyses revealed that the five indigenous strains are closely related. These results confirmed further the lack of genetic distinctiveness of the Fipa population from the other indigenous strains.

The results for principal component analysis supported the close relationships among the indigenous strains, except the Ankole breed. These observations signify further that the indigenous strains share a common ancestry and that

their separation is only recent. The mis-assignments of the animals were also probably caused by admixture and interbreeding of the strain as a result of coexisting in the same geographical areas, as well as by the movement of animals in search for pastures. The findings of the present study are consistent with the results that have been reported by Moioli, Napolitano and Catillo (2004) in the Italian cattle breeds. These authors observed that individual animals from breeds that had no gene-flow between them were clearly coherent in their respective clusters. But, breeds that had been admixed had some of their members mis-assigned away from their respective clusters.

Even if the Fipa population is not at risk of extinction (Mwambene *et al.*, 2012), the results of this study point to the merit of considering an immediate conservation programme for the Fipa cattle, with the aim of conserving the genetic purity of the strain and slowing down its rate of admixture/introgression with other indigenous strains. Conservation measures would aim at maintaining the desirable traits of the Fipa cattle that are preferred by the Fipa community. Despite the genetic indistinctiveness of the Fipa population from the other indigenous strains, the Sumbawanga Fipa germplasm deserves to be conserved based on its within-population genetic diversity, very low inbreeding coefficient and threat emanating from population admixture with other indigenous strains. However, these results need also to be complemented by detailed phenotypic, desirable (adaptive and productive) attributes, socio-economic roles, ecological, cultural values and population status (degree of endangerment) information for development of rational conservation and improvement strategies.

Conclusion and recommendations

On the basis of the findings of the current study, it is concluded that:

1. The Fipa and other indigenous strains have considerably high within-population genetic diversity, as measured by MNA, observed and expected heterozygosities.
2. The Sumbawanga Fipa and Ankole cattle have very low inbreeding coefficients, not significantly different from zero, while the Nkasi Fipa, Tarime and Iringa red cattle strains show significant inbreeding levels.
3. Indigenous cattle strains are genetically more closely related, as shown by low F_{ST} and D_A values among them.
4. The Fipa cattle population is genetically indistinct from the other indigenous strains, as indicated by the NJ, PC, individual animal assignment and structure analyses.
5. It is recommended that further genetic analyses on the Fipa cattle strain be undertaken using mitochondrial DNA analyses in order to better understand the origins and uniqueness of the Fipa population.

Ethical clearance statement: Research protocols followed the guidelines stated in the Guide for the Care and Use of Agricultural Animals in Research and Teaching (FASS, 2010).

Statement of interest: The authors strongly declare that there are no conflicts of interest.

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Fipa cattle in the southwestern highlands of Tanzania: desired attributes, breeding practices and productive performance

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Summary
Farmers in different cattle production systems have different trait preferences and breeding strategies that need an investigation before designing any sustainable breeding plan. The present study was undertaken to assess characteristics deemed desirable, breeding practices and productive performance of Fipa cattle in three districts of southwestern highlands of Tanzania, using a structured questionnaire. The majority of farmers perceived body size (91.7 percent), body conformation (85 percent), body colours (85 percent), disease resistance (87.5 percent), heat/drought tolerance (82.5 percent), draught power (87.5 percent), better carcass (84.2 percent) and fertility (70.8 percent) as the most important attributes of the Fipa cattle. Most (91.6 percent) farmers preferred pure breeding to cross-breeding in order to maintain the genetic purity of the strain. Mating practice was random among the majority (95.8 percent) of the farmsteads owing to non-availability of breeding bulls for each individual farmstead (43.3 percent) and also owing to grazing on communal rangelands (52.5 percent). Selection of breeding bulls was rarely rationally done. Age at first calving was 50 ± 1.3 months, while lactation length and calving interval were 7.1 ± 2.8 and 15.5 ± 0.6 months, respectively. Mean daily milk yield at peak was 3.35 ± 0.15 litres, while longevity was 10.78 ± 0.59, 14.56 ± 0.50 and 15.48 ± 0.55 years for bulls, cows and castrates, respectively. The farmers' preference for certain attributes and the inherent performance variability should be deployed as the entry point for participatory establishment of improvement and sustainable utilization strategies of the strain.

Keywords: *breeding practices, desirable traits, Fipa cattle, performance*

Résumé
Les agriculteurs des divers systèmes de production de bovins ont des préférences pour certains caractères et des stratégies d'amélioration génétique différentes qu'il faudrait analyser avant de concevoir tout programme de sélection durable. Cette étude a été réalisée pour évaluer les caractéristiques souhaitables, les pratiques d'élevage et les performances de production des bovins Fipa dans trois districts des hautes terres sud-occidentales de la Tanzanie, en utilisant un questionnaire structuré. La majorité des agriculteurs considèrent la taille (91,7 pour cent), la conformation (85 pour cent) et les couleurs (85 pour cent) du corps, la résistance aux maladies (87,5 pour cent), la tolérance à la chaleur/à la sécheresse (82,5 pour cent), la traction (87,5 pour cent), la meilleure qualité de la carcasse (84,2 pour cent) et la fécondité (70,8 pour cent) comme les caractères les plus importants des bovins Fipa. La plupart (91,6 pour cent) des agriculteurs préfèrent l'élevage en race pure au croisement pour conserver la pureté génétique de la souche. La pratique d'accouplement est aléatoire dans la majorité (95,8 pour cent) des fermes en raison du manque de disponibilité de taureaux reproducteurs pour chaque ferme (43,3 pour cent) et également en raison du pâturage sur les parcours communaux (52,5 pour cent). La sélection des taureaux reproducteurs est rarement réalisée de façon rationnelle. L'âge au premier vêlage est de 50 ± 1,3 mois tandis que la période de lactation et l'intervalle entre vêlages sont respectivement de 7,1 ± 2.8 et de 15.5 ± 0,6 mois. Le rendement journalier moyen en lait au maximum est de 3,35 ± 0,15 litres, tandis que la longévité est respectivement de 10,78 ± 0,59, 14,56 ± 0,50 et 15,48 ± 0,55 ans pour les taureaux, pour les vaches et pour les animaux châtrés. La préférence des agriculteurs pour certains caractères et la variabilité intrinsèque des performances devraient constituer le point de départ pour la mise en place participative des stratégies d'amélioration et d'utilisation durable de cette souche.

Mots-clés: *pratiques d'élevage, caractères souhaitables, bovins Fipa, performance*

Resumen
Ganaderos que siguen diferentes sistemas de producción tienen también preferencias por distintas características y estrategias de mejora, necesitándose, por tanto, de un análisis previo antes de diseñar un programa de mejora sostenible. El presente estudio se llevó a cabo para evaluar las características que se consideraban más oportunas, así como las actuaciones de mejora y el rendimiento productivo del ganado vacuno Fipa en tres distritos del suroeste de las zonas montañosas de Tanzania, utilizando un cuestionario estructurado. La mayoría de los ganaderos tenían en cuenta el tamaño corporal (91,7%), la conformación corporal (85%), el color de la capa

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(85%), la resistencia a enfermedades (87,5%), la tolerancia al calor y a la sequía (82,5%), la fuerza de tiro (87,5%), la mejor conformación de la canal (84,2%) y la fertilidad (70,8%) como las cualidades más importantes del ganado Fipa. La mayoría de los ganaderos (91,6%) preferían reproductores de raza pura en lugar de los cruzados con objeto de mantener la pureza genética de la población. Los apareamientos tenían lugar al azar en la mayoría de las de las explotaciones (95,8%) debido a la falta de toros reproductores en cada explotación a nivel individual (43,3%) y también debido a que pastan en pastos comunales (52,5%). La selección de toros para cría rara vez se lleva a cabo de una forma muy pensada. La edad al primer parto era de 50 ± 1,3 meses, mientras que la duración de la lactación y el intervalo entre partos era de 7,1 ± 2,8 y 15,5 ± 0,6 meses, respectivamente. La media de producción diaria de leche en el punto más alto de la curva de lactación era de 3,35 ± 0,15 litros, mientras que la longevidad era de 10,78 ± 0,59, 14,56 ± 0,50 y 15,48 ± 0,55 años para los toros, vacas y los bueyes, respectivamente. Se deben utilizar las preferencias de los ganaderos por determinadas características de los animales, así como la variabilidad de éstos en cuanto a su rendimiento productivo, como punto de partida para el establecimiento participativo de un programa mejora y estrategias sostenibles de utilización de esta raza.

Palabras clave: *prácticas de mejora, caracteres deseables, ganado vacuno Fipa, rendimiento*

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Introduction

Indigenous cattle are the predominant breeds kept in Tanzania. These indigenous cattle are grouped into distinct breeds/strains such as the humped Tanganyika Shorthorn Zebu (TSZ), Ankole, Tarime and Fipa cattle. These breeds/strains play multiple roles with respect to production environments and farming systems of the country, particularly in the agropastoral and pastoral production systems. Their contribution to household food security and income as well as their socio-cultural roles are well known (Bwire, Mkonyi and Masao, 2005).

The Fipa cattle form an important strain kept in the Fipa plateau of Rukwa region in the southwestern highlands of Tanzania. They are also kept in the northeastern part of Zambia where they are named differently. They contribute significantly to the livelihood of the Fipa communities in which crop production is the principal occupation. The Fipa cattle population is estimated at about 269 890 heads (URT, 2010). The animals are said to be well adapted to the local environmental conditions and can survive well in various agro-ecological zones (AEZs) of Rukwa region (Mwakilembe *et al.*, 2007; URT, 2010). According to Rege and Tawah (1999), the Fipa cattle strain is a derivative of Sanga and Small East African Zebu (SEAZ). Similar to other indigenous cattle, the Fipa cattle are considered to have developed through artificial selection in challenging environments in order to suit the socio-economic characteristics and needs of the Fipa community. According to Mwambene *et al.* (2012), the Fipa cattle are the major source of draught power, manure and household income in Rukwa region. They also provide genetic resource materials for research and development in the country.

In Rukwa region, the Fipa cattle are preferred to other indigenous cattle strains because of their perceived draught capability, relatively large size, tasty meat and saleability (Mwambene, Katule and Chenyambuga, in press). They also provide a wide range of other products such as horns, skins and milk, as well as have various cultural functions (dowry, rituals and income) (URT, 2010). The Fipa cattle are also renowned for adaptive traits that enable them to be resilient to seasonal environmental stresses. They subsist on natural pastures, utilize crop residues and have positive environmental effects by being fully integrated into the nutrients recycling for sustainable agriculture (Mwambene, Katule and Chenyambuga, in press). Despite the immigration of other indigenous cattle, particularly Tarime and Ankole in some parts of Rukwa region, Fipa cattle still constitute the majority (>90 percent) of the cattle in the Fipa plateau AEZ where they are preferred to other indigenous cattle (URT, 2010).

Normally, the breeding strategies followed by livestock keepers are as diverse as the agro-environments in which they operate. Their breeding goals are often comprehensive (Köhler-Rollefson, 2000; Bebe *et al.*, 2003; Roessler *et al.*, 2008) and are mainly driven by the underlying production systems, trait preferences, socio-economic and cultural circumstances (Wollny, 2003; Ouma, Abdulai and Drucker, 2007). In order, therefore, to design a viable and sustainable breeding plan, farmers' preferences for the different traits need to be investigated and incorporated in the plan (Ngowi, Chenyambuga and Gwakisa, 2008). Investigations of this nature are aimed at determining special qualities of a breed/strain with the ultimate goal of optimizing the utilization of the breed/strain in their natural production systems (Schwartz, 1992; Ouma, Abdulai and Drucker, 2007). To date, there is scanty information on the unique qualities of the various cattle strains constituting the indigenous cattle population of Tanzania.

In Rukwa region, the human population is also increasing. This situation has led to the gradual decrease in the grazing rangelands. This, in turn, is threatening the long-term existence of the Fipa cattle population despite their apparent ecological and economic importance to the livelihoods of the Fipa community. Consequently, the identity of Fipa cattle population is likely to disappear before being

properly documented owing to admixing and interbreeding with other indigenous cattle. Information on desirable traits, traditional breeding practices, productive and reproductive performance is lacking. The present study was therefore, undertaken to determine Fipa cattle unique qualities, adaptive traits, traditional breeding practices and productive performance under their natural environment as a preliminary step towards the development of a sustainable conservation and improvement strategy of the strain.

Materials and methods

Study area

This study was conducted in three districts (Sumbawanga rural, Sumbawanga urban and Nkasi) of Rukwa region, in the southwestern highlands of Tanzania (Figure 1). Geographical location, altitude, AEZs, landscape, production systems, soil types, natural vegetation, farming systems, socio-economic activities and climatic conditions of the study area are described in detail in Mwambene *et al.* (2012).

Research design

A cross-sectional research approach was used in this study. To obtain desired data, purposive sampling was used to select six wards (two wards per district) and two villages were randomly selected per ward for the study. In each village, 10 households were randomly selected to make a sample size of 120 households, as described in Mwambene *et al.* (2012).

Data collection

A structured questionnaire was used to collect basic data on special attributes, adaptive traits, productive performance and breeding practices of the Fipa cattle, as well as data on preferences of Fipa cattle owners on certain attributes of the strain. Information gathered on the farmers' preferences of various traits of the Fipa cattle strain included body size, body conformation, body colours, disease and heat/drought tolerance, draught ability, meat taste, milk production, temperament and fertility. The information collected for adaptive qualities included ability to forage, resilience to environmental changes, draught ability and ability to walk for a long distance. Traditional breeding strategies commonly practiced by the Fipa community were also investigated. Information on productive attributes included age at first calving, calving interval, longevity, number of calves in a cow's lifetime, lactation length and daily milk yield at peak and end of lactation. All quantitative data depended on the farmer's memory as they usually did not keep any records. In case of milk yield, a 1 litre jug that was commonly used for measuring out local liquor was used for yield estimations. Data were collected during the onset of the dry season, in the months of June to August in 2010.

Data analysis

Qualitative data from the field survey were coded and analysed using the Statistical Package for Social Sciences (SPSS, 2008) computer software in order to generate frequencies and percentages. The chi-square tests for independence were run to compare proportions of respondents from different districts with respect to particular responses and variables studied. Quantitative data were also analysed using SPSS in order to generate and compare means between districts.

Results

Perceptions of farmers on the trait qualities of Fipa cattle

Table 1 shows the perceived evaluation by farmers on various traits of Fipa cattle. The body size, body shape, body colour, draught power, disease and drought tolerance, carcass quality and fertility of Fipa cattle were perceived to be good by most of the respondents, while milk yield and temperament were considered 'average' in the Sumbawanga rural district, but not in Nkasi district. The presence or absence of horns was not considered to be an important trait by most of the farmers. The levels of perceptions among the farmers on the trait qualities of the Fipa cattle were almost similar between the study districts, except for body shape, fertility, meat tasty, temperament and body colour.

Fipa cattle traits preferred by Farmers

Draught ability, saleability, body size, tolerance to diseases/parasites/drought and tasty meat were the most valued attributes by the farmers. On the other hand, milk yield and longevity were not regarded as important attributes (Table 2). The levels of preference among the respondents on the various traits of the Fipa cattle were different between the study districts, except for body size and longevity. A considerable proportion (53.3 percent) of farmers valued the temperament of Fipa cattle to be good, more in Sumbawanga urban (77.5 percent) than in Sumbawanga rural district (32.5 percent).

Breeding management strategies of Fipa cattle

Table 3 shows different approaches pertaining to breeding practices that are employed by the Fipa cattle farmers. Most (67.5 percent) of the farmers reported that they kept intact bulls for mating purpose, while a few (29.2 percent) of them kept intact bulls both for breeding and draught purposes. A considerable proportion (61.7 percent) of the farmers had their own breeding bulls. The

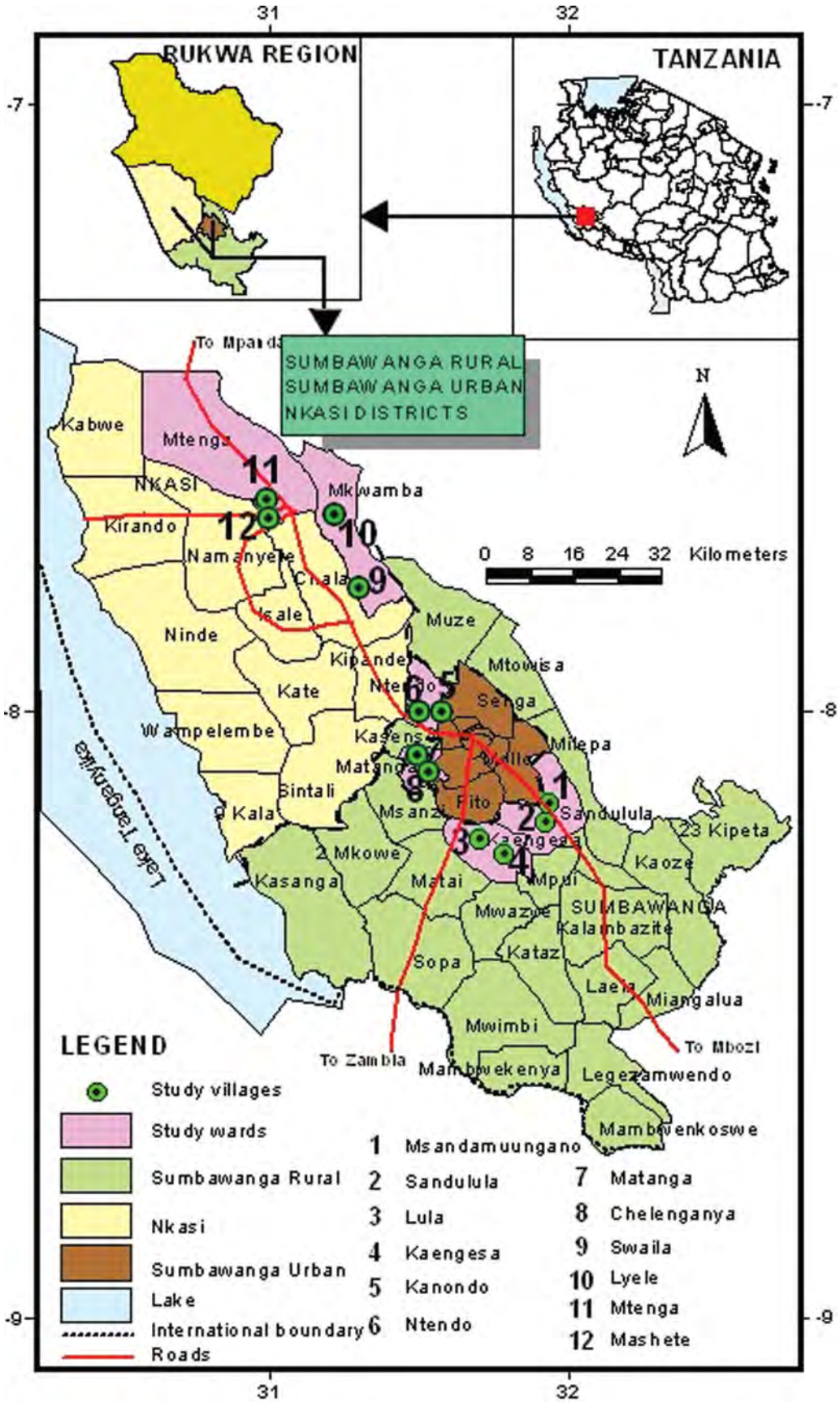

Figure 1. Map of Tanzania showing the study districts, wards and villages.

Table 1. Proportions (%) of farmers with different perceptions on various Fipa cattle attributes.

Traits	Perception	Sumbawanga rural ($n = 40$)	Sumbawanga urban ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	χ^2 test
Body size	Good	67.5	92.5	85	91.7	(df = 4), 1.215^{ns}
	Average	33.5	2.5	2.5	12.5	
	Poor	0	5	12.5	5.8	
Body shape	Good	72.5	95	87.5	85	(df = 4), 93.189***
	Average	15	2.5	2.5	6.7	
	Poor	12.5	2.5	10	8.3	
Body colour	Good	80	97.5	77.5	85	(df = 4), 94.838***
	Average	15	0	2.5	5.8	
	Poor	5	2.5	20	9.2	
Disease tolerance	Good	85	97.5	80	87.5	(df = 4), 1.093^{ns}
	Average	10	0	10	6.7	
	Poor	5	2.5	10	5.8	
Draught power	Good	70	97.5	95	87.5	(df = 4), 1.278^{ns}
	Average	20	2.5	2.5	8.3	
	Poor	10	0	2.5	4.2	
Heat/drought tolerance	Good	60	97.5	90	82.5	(df = 4), 1.352^{ns}
	Average	30	2.5	2.5	11.7	
	Poor	10	0	7.5	5.8	
Milk yield	Good	25	35	20	26.7	(df = 4), 1.450^{ns}
	Average	65	55	37.5	52.5	
	Poor	10	10	42.5	20.8	
Temperament	Good	32.5	77.5	50	53.3	(df = 4), 101.430***
	Average	60	20	17.5	32.5	
	Poor	7.5	2.5	32.5	14.2	
Meat tasty	Good	80	92.5	80	84.2	(df = 4), 93.265***
	Average	15	5	5	8.3	
	Poor	10	2.5	15	7.5	
Fertility	Good	77.5	80	57.5	70.8	(df = 4), 62.055***
	Average	10	10	10	10.9	
	Poor	12.5	10	32.5	18.3	
Horn status	Important	10	10	10	10	(df = 2), 1.897^{ns}
	Not important	90	90	90	90	

Note: N = number of respondents; ***very highly significant ($P < 0.001$), ^{ns}not significant ($P > 0.05$).

remaining (38.3 percent) farmers depended on the other farmers' bulls for mating their cows particularly in the communal grazing areas. There were more farmers keeping their own breeding bulls in Nkasi (70 percent) and Sumbawanga urban (62.5 percent) districts than in Sumbawanga rural district (47.5 percent). Selection of breeding bulls was reported to be not practised at all. About 60.8 percent of the farmers indicated that if they had to select a bull for breeding, they would base the selection on body size, while 59.2 percent said they would go for body conformation, 30.8 percent for body colour and 30 percent would go for the bull's own performance with respect to growth rate.

The majority (91.6 percent) of the respondents preferred pure breeding using Fipa bulls for mating. Random

Table 2. Proportion (%) of respondents indicating preference levels for various traits of Fipa cattle.

Traits[a]	Sumbawanga rural ($n = 40$)	Sumbawanga urban ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	Ranking position	χ^2-test
Draught ability	82.5	87.5	90	86.7	1	(df = 2), 66.015***
Better carcass tasty	55	60	27.5	47.5	6	(df = 2), 25.426***
Disease/parasites resistance	60	60	25	48.3	5	(df = 2), 29.194***
Heat/drought tolerance	60	97.5	90	82.5	2	(df = 2), 19.157***
Trek – ability	47.5	45	20	37.5		(df = 2), 22.591***
Milk production	37.5	42.5	20	33.3		(df = 2), 14.341**
Saleability	45	67.5	47.5	53.3	3	(df = 2), 66.278***
Body size	50	55	45	50	4	(df = 2), 5.303^{ns}
Longevity	5	0	0	1.7		(df = 2), 5.022^{ns}

Note: [a]Data were based on multiple responses; N = number of respondents; ***very highly significant ($P < 0.001$); **highly significant ($P < 0.01$); ^{ns}not significant ($P > 0.05$).

Table 3. Proportion (%) of respondents falling in indicated categories pertaining to utilization of Fipa bulls.

Utilization aspect	Sumbawanga rural ($n = 40$)	Sumbawanga urban ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	Chi-square (χ^2)
Reasons for keeping intact bulls					
Breeding	75	62.5	65	67.5	(df = 4), 44.733***
Draught power	5	2.5	2.5	3.3	
Breeding and draught power	20	35	32.5	29.2	
Selection criteria of breeding bulls					
Body size	85	62.5	45	60.8	(df = 2), 38.846***
Body conformation	75	62.5	50	59.2	(df = 2), 72.515***
Body colour	32.5	15	20	30.8	(df = 2), 9.459*
Dam performance	5	10	0	5	(df = 2), 5.835^{ns}
No option/choice	2.5	0	12.5	5	(df = 2), 15.259**
Bull performance	35	37.5	17.5	30	(df = 2), 12.642**
Preferred strain for breeding bulls					
Fipa (pure breeding)	90	95	90	91.6	(df = 4), 1.341^{ns}
Other cattle strains (interbreeding)	0	0	5	1.7	
No choice/option	10	5	5	6.7	
Sources of breeding bulls					
Own herd	47.5	62.5	70	61.7	(df = 2), 1.099^{ns}
Communal	52.5	37.5	30	38.3	
Mating practices					
Random (non-selective)	90	100	97.5	95.8	(df = 2), 1.223^{ns}
Controlled (selective)	10	0	2.5	4.2	
Reasons for using a particular practice					
Lack of own bulls	17.5	75	37.5	43.3	(df = 4), 130.987***
Grazing on communal land	75	25	57.5	52.5	
Both	7.5	0	5	4.2	
Ways of maintaining preferred traits					
Using pure breeding system	100	75	12.5	60.8	(df = 2), 58.501***
Better feeding	22.5	77.5	40	46.7	(df = 2), 47.996***
Unknown	0	7.5	47.5	18.3	(df = 2) 46.448***

Note: N = number of respondents; ***very highly significant at $P < 0.001$; **highly significant at $P < 0.01$; *significant at $P < 0.05$; ^{ns}not significant at $P > 0.05$; data on selection of breeding bulls and ways of maintaining preferred attributes were based on multiple responses.

(uncontrolled) mating was common in most (95.8 percent) of the Fipa cattle herds. This situation was attributed partly to lack of own breeding bulls (43.3 percent) for some of the households and partly (52.5 percent) because of the communal grazing and watering practices. Interbreeding with other cattle strains was not common in almost all the study districts. The proportions of respondents on the reasons given for keeping breeding bulls and selection criteria for breeding bulls were different between districts, whereas they were similar for bull strain preference, sources of breeding bulls and mating practices.

Table 3 shows also the farmers' responses with respect to ways of sustaining the preferred traits in Fipa cattle. The preferred traits of Fipa cattle were reported to be retained mainly through pure breeding system (60.8 percent), much more in Sumbawanga urban (100 percent) and Sumbawanga rural (75 percent) than in Nkasi district (12.5 percent). Better feeding was also mentioned to be the way of sustaining the preferred traits by some (46.7 percent) of the farmers, largely in Sumbawanga urban district (77.5 percent). On the other hand, a few (18.3 percent) farmers were not aware of the means for achieving the desirable traits of the Fipa cattle, particularly in Nkasi district (47.5 percent). The difference of proportions of respondents on the strategies reported to be used for maintenance of preferred traits between the study districts was highly statistically significant.

Castration of Fipa bulls

Table 4 summarizes the purposes and ages of castration of the Fipa bulls. The majority (97.5 percent) of respondents reported to castrate their bulls at different ages, mainly (94.2 percent) for attaining better draught animals with good temperament. The purposes for castration of bulls were almost similar across the study districts. Bulls were castrated at varied ages, mostly at the age of 2–4 years.

Culling of animals

The results further reveal that the decision to retain or dispose of an animal was based mainly on the animal's body condition for cows and castrates, and on changing behaviour (bad temperament or straying) for bulls. Other reasons for culling cows, bulls and castrates are indicated in Table 5. Unlike the castrates, the reasons for culling bulls and cows were almost similar across the study districts.

Entry and exit channels of Fipa cattle

Many farmers reported that they acquired different categories of animals through purchases, births, gifts and exchanges, in that order of significance. On the other hand, different categories of cattle exited from farmers' herds mainly through culling, deaths and theft. Most (95 percent) of the

Table 4. Proportion (%) of respondents falling in indicated categories pertaining to castration of Fipa male cattle.

Aspect	Sumbawanga rural ($n = 40$)	Sumbawanga urban ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	χ^2-test
Castration practice					
Undertaken (done)	95	97.5	100	97.5	(df = 2), 1.265^{ns}
Not done	5	2.5	0	2.5	
Purposes of castration					
Draught power	95	92.5	95	94.2	(df = 4), 1.305^{ns}
Good temperament	2.5	0	5	2.5	
Control breeding	2.5	7.5	0	3.3	
Castration age (years)					
1/2–1	20	10	10	13.3	(df = 8), 22.238**
11/2–2	22.5	27.5	32.5	27.5	
21/2–3	30	35	40	40	
4–5	25	27.5	15	22.5	
6–7	2.5	0	2.5	1.7	

Note: N = number of respondents; **highly significant ($P < 0.01$); ^{ns}not significant ($P > 0.05$).

respondents sold their animals that were culled to private customers at household levels, while very few (5 percent) of them sold at the livestock auction marts. Based on the overall mean of annual births and deaths of calves reported in the study areas, the annual mortality rate for calves was estimated at 1.79/3.68 = 48.6 percent (Table 6).

Productive performance of Fipa cattle

The estimated productive and reproductive performances of Fipa cattle are summarized in Table 7. The overall average age at first calving and calving intervals were about 50 and 15 months, respectively. The Fipa cattle from Nkasi district had significantly ($P < 0.05$) lower age at first calving than that of the other districts. The average longevity was 10.78 ± 0.59, 14.56 ± 0.50 and 15.5 ± 48 years for bulls, cows and castrates, respectively. The castrates and cows lived relatively longer than bulls. The average lifetime number of calves per cow was 9 and the lactation length was 7.1 months. The average number of calves was relatively larger in Nkasi than in the other districts while the lactation length was relatively shorter in Sumbawanga rural than in the other districts. The results further revealed that the average estimated milk yield at the peak and the end of lactation were 3.35 ± 0.15 and 0.92 ± 0.05 litres, respectively. The average milk yield per day was relatively lower in Nkasi than in the other districts.

Discussion

Perceptions of farmers on the trait qualities of Fipa cattle

The favourable impression the farmers had on the Fipa cattle with regard to body size, body conformation, draught power and meat taste implies that the strain is essential to the livelihoods of the Fipa communities. These attributes, coupled with the perceived adaptive traits

Table 5. Proportion (%) of respondents indicating different reasons for culling bulls, cows and castrates.

Culling reasons	Sumbawanga rural ($n = 40$)	Sumbawanga urban ($n = 40$)	Nkasi ($n = 40$)	Overall ($n = 120$)	χ^2-test
Cows					
Infertility	15	5	10	10	(df = 6), 1.192^{ns}
Old age	7.5	12.5	10	10	
Poor body condition	52.5	72.5	47.5	57.5	
Human family problems	12.5	10	30	17.5	
Bulls					
Change behaviour	72.5	77.5	50	66.7	(df = 8), 1.118^{ns}
Old age	5	5	2.5	4.2	
Poor body condition	5	0	12.5	5.8	
Human family problems	10	17.5	25	17.5	
Poor performance	7.5	0	10	5.8	
Castrates					
Poor performance	15	5	10	10	(df = 6), 97.015***
Old age	27.5	15	25	22.5	
Poor body condition	40	67.5	37.5	48.3	
Human family problems	7.5	12.5	27.5	15.8	

Note: N = number of respondents; ***very highly significant ($P < 0.001$); ^{ns}not significant ($P > 0.05$).

Table 6. Means of annual entries and exits of Fipa cattle per household in the last 12 months.

	Means ± SE			
	Sumbawanga rural (*n* = 40)	**Sumbawanga urban (*n* = 40)**	**Nkasi (*n* = 40)**	**Overall (*n* = 120)**
Annual entries				
Births (calves)	3.61 ± 0.567	3.19 ± 0.361	4.25 ± 0.634	3.68 ± 0.306
Purchases (castrates)	2.20 ± 0.583	1.00 ± 0.00	1.25 ± 0.250	1.58 ± 0.288
Purchases (bulls)	2.20 ± 0.490	1.40 ± 0.245	1.00 ± 0.00	1.73 ±0.273
Purchases (calves)	2.00 ± 0.00	0	0	2.00 ± 0.00
Purchases (weaners)	2.00 ± 0.00	3.00 ± 0.00	0	2.50 ± 0.500
Purchases (cows)	2.50 ± 1.50	1.00 ± 0.00	0	1.75 ± 0.750
Gifts (cows)	3.00 ± 2.00	0	1.00 ± 0.00	2.67 ± 1.667
Exchanges (bulls)	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00
Exchanges (cows)	1.00 ± 0.00	0	0	1.00 ± 0.00
Annual exits				
Deaths (calves)	1.64 ± 0.20	1.67 ± 0.162	2.07 ± 0.408	1.79 ± 0.155
Culls (bulls)	1.00 ± 0.00	0	1.33 ± 0.333	1.25 ± 0.250
Culls (cows)	2.00 ± 0.00	0	0	2.00 ±0.000
Deaths (cows)	1.50 ± 0.50	1.25 ± 0.250	1.33 ± 0.211	1.33 ± 0.142
Theft (castrate)	0	1.00 ± 0.00	0	1.00 ± 0.000
Selling points (%)				
At homesteads	97.5	92.5	95	95
At auction marts	2.5	7.5	5	5
	χ^2 (df = 2) = 1.742^{ns}			

Note: *N* = number of respondents, SE = standard error of the mean; means along the rows without superscripts are not significant ($P > 0.05$); ^{ns}not significant ($P > 0.05$).

such as tolerance to diseases, drought/heat, natural pastures and feed shortages, show the suitability of the strain to the Fipa community. The adaptive traits reported for Fipa cattle may also enable the strain to cope with the current global climate change coupled with nutrition fluctuations and shrinkage of grazing rangelands that are now experienced in Rukwa region because of increase in human population and expansion of cropping activities. These findings are consistent with those reported by Mwacharo and Drucker (2005) for SEAZ of southeastern Kenya and by Sungael (2005) for Iringa red cattle in Tanzania.

Fipa cattle traits preferred by farmers

The present study has also revealed that most farmers prefer Fipa cattle to other breeds mainly because of better draught ability, heat/drought tolerance, saleability and large body size. These observations are similar to those reported by Chenyambuga *et al.* (2008) for Tarime cattle, Oumam, Abdulai and Drucker (2005) for SEAZ cattle and Oseni and Bebe (2010) for pastoral communities of Kenya. Milk yield and temperament traits were considered to be average. The temperament of Fipa cattle, particularly for cows and bulls, was reported to be average perhaps because some of these animals were not used to be handled during milking or traction. Milking was reported to be not done by some of the households because of lack of traditions of milk drinking. These findings are inconsistent with those observed by Chenyambuga *et al.* (2008) on Tarime cattle and Sungael (2005) on Iringa red cattle where all the animals were docile and could be easily handled even by women during milking and draught activities.

Breeding management practices of Fipa cattle

The most common breeding system reported in the three districts surveyed was pure breeding. Pure breeding was mostly preferred to cross-breeding/interbreeding system in order to maintain the genetic purity of the Fipa cattle. Interbreeding of Fipa cattle with other indigenous cattle

Table 7. Productive and reproductive attributes of Fipa cattle.

Means of entry (Mean ± SE)	**Sumbawanga rural (*n* = 40)**	**Sumbawanga urban (*n* = 40)**	**Nkasi (*n* = 40)**	**Overall (*n* = 120)**
Bulls longevity (years)	11.58 ± 0.83	9.11 ± 1.054	10.88 ± 1.18	10.78 ± 0.59
Cows longevity (years)	13.87 ± 1.25	13.50 ± 2.30	15.75 ± 2.01	14.56 ± 0.50
Castrates longevity (years)	14.60 ± 1.27	15.63 ± 2.35	18.85 ± 2.05	15.48 ±0.55
Calves per cow lifetime	8.47 ± 0.407	8.19 ± 0.46	10.21 ± 0.60	8.92 ± 0.29
Age at first calving (years)	4.55 ± 0.22^{b}	4.09 ± 0.16^{ab}	3.86 ± 0.15^{a}	4.17 ± 0.11
Calving interval (years)	1.21 ± 0.07	1.33 ± 0.09	1.34 ± 0.10	1.29 ± 0.05
Lactation length (months)	6.26 ± 0.38	7.29 ± 0.38	7.67 ± 0.40	7.06 ± 0.23
Milk yield at peak (litres)	3.99 ± 0.26	3.53 ± 0.22	2.41 ± 0.20	3.35 ± 0.15
Milk yield at end (litres)	1.04 ± 0.09	0.94 ± 0.17	0.75 ± 0.15	0.92 ± 0.05

Note: *N* = number of respondents; SE = standard error of mean. Means along the rows without superscripts are not significantly different at $P > 0.05$.

was reported to be very rare perhaps because of low number of them in the Fipa plateau unlike in other AEZs of Rukwa region (Mwambene *et al.*, 2012). The mating system that was commonly in use was natural random. In communal grazing areas, herds of cattle from different households and areas were grazed together. As a result, only some (61.7 percent) farmers kept their own breeding bulls while a considerable proportion (38.3 percent) of them depended on bulls from the communal grazing areas. Dependence on bulls from the communal grazing areas was reported to be preferred as it was cheaper to farmers than keeping their own breeding bulls in addition to draught bulls which would have been castrated ones. Random mating in communal areas might also be advantageous for maintenance of genetic diversity of Fipa cattle as it minimizes an occurrence of inbreeding effects particularly in the households with small herd sizes.

It was, however, reported by the farmers that mostly mediocre, immature or stunted bulls of unknown history were left for breeding in the communal grazing land, while the strong and fast-growing bulls were castrated for draught activities, particularly in Sumbawanga rural and urban districts. This implies that systematic selective breeding was lacking in the Fipa community. In the long run, this tendency might have a serious genetic effect and thus, threaten the long-term existence of the strain. This habit might be attributed to the lack of awareness of the majority of farmers of the importance of selection and keeping superior bulls for breeding, and valuing traction (cropping) activities rather than the development of the Fipa strain. This scenario is quite different from that which has been reported for Kurya (Chenyambuga *et al.*, 2008), Sukuma (Msalale, 2007) and Kamba (Mwacharo and Drucker, 2005) communities where superior bulls were selected for breeding in every household and inferior bulls castrated for draught purposes. However, farmers indicated that if they have to make a choice of a superior bull for breeding, the emphasis would be mainly on physical features such as body size, body conformation, body colours and fertility. Black, red and a mixture of these colours with white were reported to be the most preferred coat colour patterns of the breeding bulls among the Fipa cattle herds. On the other hand, white colour alone was not preferred in the whole study area because it was believed to be associated with high tick infestations. The white colour was further reported to affect the salvage price of a bull unlike the bulls with other colours at the local markets. A similar observation has been reported for farmers keeping SEAZ in Makueni Kenya (Mwacharo and Rege, 2002) and for Iringa red cattle in Iringa region (Sungael, 2005).

The majority of farmers reported to castrate their bulls in order to attain better draught animals with good temperament. Castration was carried out when the bulls attained an age between 2 and 3 years. The reasons given by farmers for late castration of their cattle were that animals at 2–4 years of age and above would develop more muscle and eventually offer more traction power and higher meat yield than if the animals were castrated at a young age. Thus, castration of cattle at 2 or more years enabled farmers to balance between good working ability and high salvage value at the time of their disposal. These observations are also similar to those reported by McDonald (1989) and Sungael (2005) for other cattle breeds on different castration ages of intact bulls.

In general, from Rukwa region statistics, the population of Fipa cattle is over 0.26 m, indicating that this strain of cattle is still in large numbers. What puts the population at risk of genetic erosion is the breeding management practiced where the mating system is random without proper selection of breeding bulls. Furthermore, there are lots of other types of TSZ strains that are being introduced in the region particularly in some AEZs of Nkasi and Sumbawanga rural districts. Given these situations the risk status of Fipa cattle can be classified as need to monitor the breeding practices and control of cattle movements.

Entry and exit channels of Fipa cattle

Most of the acquisitions of Fipa cattle reported by farmers were through purchases, births, gifts and exchanges. The main channels of exit were culling (sales), deaths and theft. Female cattle were rarely disposed of, mainly because of old age, poor body condition and infertility, while breeding bulls were culled because of showing bad behaviours (fierce or straying) as they got old. This is a common phenomenon in traditional livestock-keeping communities who value the role of cows in raising calf crops for herds' growth. These findings are consistent with those reported by Mwacharo and Drucker (2005) in the southeast of Kenya and Ishag and Ahmed (2011) in Sudan where female cattle and female camels, respectively, were maintained in the herds up to the end of their reproductive life in order to ensure an adequate year-round supply of milk and growth of the herd size.

The majority of the farmers reported to be reluctant to dispose of their animals through sales, unless the animals were very old, poor in body condition or had a bad temperament. The high status of the Fipa cattle as a draught animal rather than commercial one may be the reason for this. The reluctance to dispose of cattle could also be attributed to the lack of formal livestock markets. According to Mwakilembe *et al.* (2007) the absence of effective marketing channels in the tropics is a major constraint to increasing cattle sales and off-takes. Informal market normally leads to exploitation of farmers by middlemen through lowering cattle prices. Furthermore, the Fipa cattle farmers might still be regarding livestock farming as a means of minimizing risks in the case of crop failures, as well as a capital reserve in the case of emergencies rather than considering it as a readily available source of cash income and food security (Franzen *et al.*, 1996).

The mortality rate of calves calculated from the reported number of calf births to deaths annually across the study area was observed to be very high. Many deaths were associated with tick-borne diseases, particularly East Coast fever. The practice of allowing calves to accompany their dams for grazing and during night at a young stage can be among the factors accounted for high calf mortality rate (Mwambene *et al.*, 2012). This finding is similar to that reported by Rwambo *et al.* (1998) on calf mortality rates in the agropastoral production system in Ngorongoro conservation area and Maeda-Machang'u *et al.* (2000) for other agropastoral communities in Tanzania.

Production performance of Fipa cattle

Females and castrates had greater longevity than males. Because of this, they play valued roles in producing replacement stocks for herd growth and providing draught services to the households, respectively. This finding is consistent with the herd life of most African domestic cattle (Mukasa-Mugerwa 1989; Mwacharo and Rege, 2002). The advanced culling ages of castrate and female animals suggest the ability of the animals to survive the tropical prevalent diseases/parasites, feed and climate fluctuations. This is an indication of their good adaptive qualities (Ouma, Abdulai and Drucker, 2007). The long reproductive life reported by farmers indicates the Fipa cattle to possess longevity trait. This trait can thus be tapped in the case of selection of animals for economic attributes that are well expressed at later stages. On the other hand, entire males were disposed of earlier since as they got old, they became fierce and sometimes strayed away from their herds chasing other cows on heat. This tendency forced many farmers to cull breeding bulls earlier to avoid risks of injury and permanent loss.

The average age at first calving of the Fipa cattle was about 4 years. This age was much longer compared with that of exotic breeds of around 2–3 years. Poor inherent genetic potential and absence of selection for high growth rate and early maturity as well as nutritional stress throughout the growth period could be the causes of this late age of attaining sexual maturity and hence advanced age at first calving. Similar observations have been reported by Payne and Wilson (1999) on the factors affecting delays of onset of sexual maturity, infertility and subfertility of cattle in the tropics. In this study, it was observed that the average age at fist calving of Nkasi cows was significantly less than that of Sumbawanga rural and urban districts. Early attainment of age at first calving for the animals from Nkasi district could be attributed to ready availability of enough feed all year-round in the district. There were more grazing rangelands with low stocking density, low human population and minimal cropping activities in Nkasi district than in the other districts (Mwambene *et al.*, 2012). Generally, the average age at first calving observed in the present study is almost similar to those reported for TSZ cattle (Mpiri, 1994), Africander, Ankole, Boran and Malawi zebu (Mukasa-Mugerwa, 1989) and SEAZ of Kenya (Mwacharo and Rege, 2002). However, it is lower than the age at first calving which have been reported for Tarime zebu (Chenyambuga *et al.*, 2008) and Iringa red cattle (Sungael, 2005).

The average calving interval of Fipa cattle (1.3 years) was considered to be good as it was within the range of some African shorthorn cattle (Mpiri, 1994). Normally, estimates of calving interval in zebu cattle range from 1.01 to 2.22 years and most are therefore, unsatisfactory (Mukasa-Mugerwa, 1989). The good calving interval observed in Fipa cattle might have been influenced by low milk yield, which facilitates early return to oestrous and conception (Sungael, 2005). Normally, the short calving interval is useful in case of the rate of genetic progress and reproductive efficiency of any breed/strain.

However, the number of calves born during the life time of a Fipa cow is slightly smaller than that reported in the survey for Tarime cattle (Chenyambuga *et al.*, 2008) but larger than that reported for Kenana cattle (Saeed *et al.*, 1987). The lactation length of 7.1 months reported in this study is slightly lower than that reported for SEAZ (Mwacharo and Rege, 2002), but compares well with that of Ankole cattle in pastoral areas of Uganda (Kugonza *et al.*, 2011) and TSZ (Mpiri, 1994; Sungael, 2005). The average milk yield estimated in this study is similar to the values reported by Mwacharo and Rege (2002) for SEAZ (1–3.1 litre/day), but is slightly higher than that of Iringa red (0.7–2.34 litres/day) (Sungael, 2005) and Tarime cattle (1.9 litres/day) (Chenyambuga *et al.*, 2008). Generally, the low lactation performance observed in the Fipa cattle reflects their low genetic potential for milk production, although other factors such as poor and fluctuating nutrition, breeding and other management practices may also contribute to the observed low milk yields. The yields of milk observed in this study might also have been underestimated as the milking was done once a day. Similarly, farmers did not take into account the milk that was consumed by the calf. Nevertheless, the observed variation of milk yields and lactation length between and within Fipa cattle subpopulations may suggest the influence of differences in availability of feed resources and management practices among the districts (Mwambene *et al.*, 2012). These variations might also suggest the existence of inherent genetic differences in milk production potential among individual animals in the population. Inherent genetic variations can also be used as a resource for choosing better animals on the basis of milk yields and lactation length. Consequently, as some Fipa farmers do neither milk their animals nor keep records, selection of Fipa individuals based on an optimum index of lactation yield and length as recommended by many scholars (Rege *et al.*, 2001) may not be practical.

Conclusion and recommendations

Based on the findings of this study it is concluded that:

1. The Fipa community considers adaptive traits (disease resistance, heat/drought/nutrition tolerance) and productive traits (draught ability, body size, fertility, meat taste and saleability) as essential attributes of Fipa cattle.
2. The Fipa cattle farmers prefer pure breeding to cross-breeding/interbreeding in order to maintain the genetic purity of the strain.
3. Random (non-selective) mating is commonly practised among the Fipa cattle herds owing to shortage of breeding bulls in some households, and also because of the grazing of animals in communal land.
4. The variation in the performance levels of Fipa cattle within and between districts is an indication of differences in feed availability, management practices or inherent individual animal differences. The inherent animal differences can be tapped for improvement through selection.

In order to improve the Fipa herd productivity, a sustainable conservation and improvement strategy that incorporates farmer preferences of the important, adaptive and productive traits of the strain is needed.

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Morphological characterization of indigenous chickens of Sikkim and West Bengal, India

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Summary
The study was conducted to characterize the variations in physical characters and some important feather and skin mutations observed in different populations of native chickens of West Bengal and Sikkim, India. The data encompassing eight different phenotypes such as, naked neck chicken, frizzled chicken, muffed/bearded chicken, creeper chicken, crested chicken, rumpless chicken, feathered shank chicken and fibromelanosis chicken, were collected from six districts of West Bengal and two districts of Sikkim. Seven qualitative traits such as colour of the egg shell, feather, skin, shank, comb and earlobe as well as the type of feather, and three quantitative traits such as shank length, egg weight and body weight, were assessed in a total of 2 170 fowls of both sexes. The data were analysed statistically using descriptive statistics, the differences in means were compared using Duncan's multiple range test and χ^2 was used for non-parametric characters. Each of the populations had multiple variants and mixed feather colours were seen in most of the chickens while the feather, skin and shank colours were all black in fibromelanosis chickens. The shank colour was predominantly blue, followed by yellow and white. The skin colour in most of the chickens was white. Most of the chickens had a single comb (except for the crested chicken). The highest body weight was observed in the desi chicken while the rumpless chicken weighed the least. The egg-shell colour varied between cream and light brown in all the flocks except for the fibromelanosis chicken whose egg-shell colour was tinted bluish. The highest recorded egg weight was observed in the naked neck chicken, whereas the hatchability and egg weight were the lowest for the rumpless chicken. In the recent years, it has been observed that there is a significant reduction in the population of native chickens. This may be attributed to the restocking with Rhode Island Red and synthetic Kruilor chickens following the avian influenza outbreaks in the region. Hence, immediate steps need to be taken to preserve whatever is left in the native chicken ecotypes in the region.

Keywords: *native chicken, morphological characterization, West Bengal, Sikkim, India*

Résumé
L'étude a été dirigée pour caractériser les variations dans les caractères physiques et les aspects utiles de quelque plume important et de mutations de peau a observé dans la population différente de poulets natals de Bengale et de Sikkim d'ouest (l'Inde). L'étude a été dirigée à six quartiers de Bengale d'ouest et deux emplacements d'entourer de Sikkim huit mutations différentes dans les poulets. Sept quantitatif et deux traits qualitatifs ont été évalués dans une population de 2 170 volailles des deux les sexes. Les données ont été statistiquement ana - lysées utilisant la statistique descriptive, les différences dans les moyens ont été évaluées utiliser Duncan le test de Gamme Multiples et le carré de chi ont été utilisés pour non les caractères paramétriques. Chacune des populations ont eu des variantes multiples et la couleur de plume mélangée a été vue dans la plupart des poulets pendant que la plume, la couleur de peau et jambe était noire dans les poulets avec fibromelanin. La couleur de jambe était d'une manière prédominante bleue, suivie par le jaune et le blanc. La couleur de peau dans la plupart des poulets était blanche, le peigne, blanc seul et des lobes le. Le plus haut poids a été observé dans le poulet de desi pendant que le chiffonne a pesé le moins. La couleur de coquille d'oeuf a varié entre la crème pour allumer le marron dans tous les troupeaux sauf l'une de fibromelanin où la couleur de coquille a été teintée bleuâtre. Le plus haut poids d'oeuf enregistré a été observé dans les poulets de cou nus où comme le poids de hatchability et oeuf était le plus bas pour le chiffonne des poulets. Il a été observé qu'il y a une réduction significative dans la population de poulets natals. Ceci pourrait être attribué au regarnir avec Rhode Island poulets Rouges et la tache de Kruilor synthétique qui suivent la grippe d'avian dans la région. Donc, les étapes immédiates ont besoin d'être pris pour conserver quoi qu'est parti de l'ecotypes natal actuel dans la région.

Mots-clés: *poules indigènes, caractérisation morphologique, Bengale occidental, Sikkim, Inde*

Resumen
El presente estudio fue realizado para caracterizar las variaciones en caracteres físicos y aspectos útiles de algunas mutaciones importantes de pluma y piel que se observaron en diferentes poblaciones de gallinas nativas de Bengala Occidental y Sikkim (India). El estudio fue realizado en seis distritos de Bengala Occidental y dos localidades de Sikkim abarcando ocho mutaciones diferentes. Siete caracteres cuantitativos y dos cualitativos fueron valorados en una población de 2 170 aves de ambos los sexos. Los datos fueron analizados estadísticamente utilizando la estadística descriptiva, las diferencias de medias fueron valoradas utilizando la prueba de

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Rangos Múltiples de Duncan, utilizando el ji cuadrado para los caracteres no paramétricos. Cada una de las poblaciones mostró múltiples variantes de color de pluma, mientras que la mayor parte de los colores de pluma, color de piel y patas fue negro en los pollos con fibromelanina. El color de las patas fue predominantemente azul, seguido de amarillo y blanco. El color de la piel en la mayor parte de las aves fue blanco, combinado, y orejillas blancas. El color de la cáscara del huevo varió entre nata y marrón en todas las poblaciones menos los que poseían fibromelanina, en los que el color de la cáscara estaba teñido de azulado. El peso registrado más alto del huevo fue observado en los pollos de cuello pelado, mientras que el peso del huevo fue más bajo para los pollos de arrugas. Se ha observado que hay una reducción significativa en la población de pollos nativos. Esto puede ser atribuido a la reposición con Rhode Island Roja y con la población sintética Kruilor, que siguió a la epidemia de gripe aviar en la región. De ahí, que pasos inmediatos deben ser dados para preservar lo que ha quedado de los ecotipos nativos existentes en la región.

Palabras clave: *pollo autóctono, caracterización morfológica, Bengala Occidental, Sikkim, India*

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Introduction

Mutations along with recombination are the major factors affecting the genetic differences between breeds and populations of chicken (Weigend, Romanov and Rath, 2004). Lush (1994) reported that in the course of domestication of livestock, humans have isolated and selected animals for favourable traits. These resulted in the development of breeds and also strains within a breed. The chicken breeds in the developing countries comprise mostly of indigenous breeds and in many countries they make up around 70–80 percent of the total chicken population (Guéye, 2005; Pym, Guerne Bleich and Hoffmann, 2006). Hoffmann, Siewerdt and Manzella (2004) further reported that the hobby/fancy breeds of chickens look very different from one another, but do not necessarily mean that they are genetically quite diverse. The same is true even for indigenous breeds in the developing countries (Pym, Guerne Bleich and Hoffmann, 2006).

However, in the recent times it has been of concern that there is a loss in farm animal biodiversity at a global scale. In Latin America and the Caribbean, it is estimated that 81 percent of avian breeds are classified as being of unknown risk status, while the assessment for Africa was 60 percent (FAO, 2007). Reduction in the local avian populations may be attributed to panmectic nature of breeding of the native chickens with various exotic chicken breeds, which have been introduced in the region by different agencies under poverty alleviation schemes. Similar observations have also been reported by Bhuiyan, Bhuiyan and Deb (2005), Nidup *et al.* (2005) and Hussein *et al*. (2000), Fathi and Galal (2000). Thus, in order to initiate an efficient conservation programme, reliable data pertaining to the genetic differences between individuals, populations and breeds are required. Phenotypic variation within a species can provide a baseline data for the assessment of genetic diversity of the species (Moiseyeva *et al.*, 1984). Weigend, Romanov and Rath (2004) observed that the identification and characterization of any livestock species require the assessment of its population structure and traits that have evolved due to specific genotype by environmental interactions.

The phenotypic variation can be further divided into discrete/qualitative (e.g. morphological traits) and continuous/quantitative (e.g. production traits and body measurements) characters that are helpful in assessing genetic characters and phylogenetic relationship between breeds/ecotypes. The preliminary results so obtained can then be further validated using modern molecular tools.

Horst (1987) observed that the native chickens are able to adapt to adverse conditions, hence, they can be used for further development under small holder farming conditions. The phenotypic variations in the chickens reared in the States of West Bengal and Sikkim indicate a wide range of genetic variations among the fowl genotypes, which can be a potential source for the development of new breeds suitable for tropical regions of Asia and Africa.

The genetic characterization of the fowls can be ascribed due to both qualitative and quantitative genes. The former can be in the form of comb-type, skin and shank colour, while the latter can be in the form of body weight and other economically important traits. The agrarian societies in the developing world are also concerned about the cultural significance of the livestock. The Bhutia, Lepcha and Nepali communities of North and West districts of Sikkim and Darjeeling district of West Bengal consider that the chickens with fibromelanin wade away evil eye, hence they are in high demand by the sorcerers, locally known as “Jhakris”. Nanukan chickens are used for religious rituals by the people living in Tarakan islands of Indonesia (Sartika *et al.*, 2007), while Kapung chickens are sacrificed in religious ceremonies by the members of ethnic groups from Jawa islands (Sidadolog, 2007). Surono (1997) reported that Cemani chickens of Indonesia are specifically reared for mystic purposes and the meat is not liked by the people; hence it is not sold in the supermarkets. It has also been observed that in certain regions of West Bengal people purposively rear the rumpless birds as they are believed to escape predators

easily and perform better under scavenging conditions, while some farmers prefer birds with creeper gene as they look unique, can fend for themselves under the granaries which cannot be reached by the chickens with normal (long) shank. The spilled grains otherwise would have attracted rodents around the granaries.

The indigenous fowls of India by and large have a panmectic existence. However, some fanciers in the past have developed breeds such as Aseel (used for cock fighting). There also have been instances were further selection within the Aseel breed itself and mating with local ecotypes have given rise to specific strains e.g. Hyderabad, Lucknow and Rampur Aseel's. These strains can be identified by their feather colours and body sizes. It is unfortunate that most of the ecotypes described (in this paper) are yet to find their place in the Domestic Animal Diversity Information System (DAD-IS) of the FAO (derived from FAO, 2008a), in which only a few ecotypes of native fowls from India have been mentioned, indicating that there is scanty data available on native chicken genetic resources of the region and there is a wide gap between what is there in the country and what is known to the scientific community. The States of West Bengal (21°38′ to 27°10′N, latitude and 85°50′ to 89°50′E, longitude) and Sikkim (27°4′ to 28°7′N, latitude and 88°00′58″ to 88°55′25″E, longitude) are located on the eastern region of India. The study area of West Bengal and Sikkim is situated within the breeding tract of red jungle fowl (*Gallus gallus*) (Crawford, 1990; Banglapedia, 2006; Anonymous, 2011). Dastagiri (2004) reported that the State of West Bengal has the highest number of native fowls in India ($33\,984 \times 10^3$ during 2003 census) with an annual growth rate between 1997 and 2003 as 28.67 percent, while the number of native fowls in Sikkim was estimated to be 214×10^3, with an annual growth of 4.05 percent between 1997 and 2003. The forests of West Bengal and Sikkim still abound with red jungle fowls. However, recent data pertaining to district level on the number of native fowls are unavailable, as large-scale culling occurred in the study area because of repeated outbreaks of avian influenza in the past few years.

The present study was carried out to describe the phenotypic attributes and zoometric variations in different populations of the native fowls in West Bengal and Sikkim.

Materials and methods

The study included some potentially useful qualitative and quantitative traits of the chickens. Purposive sampling was carried out to identify households rearing only native fowls. The owners of the flocks were interviewed regarding the status of their flocks. In West Bengal, majority of the owners belonged to the minority community and/or Hindus with lower socio-economic strata. In case where there was history of exotic birds being reared in the immediate neighbouring households, the family was dropped from the survey; this was done because of panmectic mating among the village fowls. However, this grossly limited the number of households surveyed; hence, additional villages were accommodated to get a sizable flock recording. Although in Sikkim, the survey indicated that majority of the rearers had native fowls and exotic breeds were rarely distributed in the area, thus sampling was carried out in all the households of the villages selected.

There are specific names by which the fowls can be easily identified in their localities, for example the frizzled fowl is commonly called as "dum chi" in Sikkim, whereas the same is known by the name "Dum Shay" in Bhutan (Nidup *et al.*, 2005) or Sojaru murgi in West Bengal (Banerjee, 2007; Banerjee *et al.*, 2008). In this paper local names have been used as were provided by the rearers of the ecotypes and their possible English names have been derived.

Description of the study area

The study locations are situated at various agro-climates, such as 2 m above the mean sea level (mamsl) (Joynagar Mazilpur) to 3 000 mamsl (Lachung). The study area comprised rearers from various ethnicities and cultures, each having their own preferences and selection criteria. The study was conducted in six districts of West Bengal, namely Midnapur (East), 24 Parganas (South), 24 Parganas (North), Nadia, Murshidabad and Jalpaiguri as well as two districts of Sikkim (North and West).

The villages within the districts were selected in a way that there was homogeneity in production system. The samplings of the households were carried out using the stepwise selection method. The districts were purposively selected taking into account their elevations. The locations within a district were also selected purposively keeping in mind the proximity from the all weather road and also the information received from the key informants of the area. Although the villages within a location were selected purposively taking into account the population of native birds within the villages. The villages were selected based on the rapid survey conducted in all the villages within the vicinity of the location, only those villages with maximum native birds were finally selected. The ecological and demographic features of the locations from where the samplings were carried out are presented in Table 1.

Data collection and analysis

The morphological data distribution were based on colour of egg shell, skin, shank, comb, earlobe and feather as well as the presence of feathers on the neck, shank and tail. The data pertains to 2170 fowls of both sexes. The comb types of the birds were recorded according to the description provided by Somes (1990). The morphological traits were recorded as threshold binary numbers (0 as absent and 1

Table 1. The location, latitude, longitude, fowl number and the ethnicity of the rearers within the study area.

	District	Name of the panchayat	Number of fowls	Temperature	Latitude	Longitude	Altitude	Number of native fowls	Reference
West Bengal	**Midnapur (East)**								
	1. Mahishadal	Itamogra-2, Lakshya-1, Amritberia, Betkundu and Natshal-2	177	7–39.0°C	22°11′N	87°59′E	4 mamsl	784, 442[a] (48.02%)	DARAH (2006b)
				Highly humid				29, 788[b]	
	24 Parganas (S)								
	1. Joynagar. Mazilpur	Thakurchak, Baharu and Bhagabanpur	259	10–37.5°C	22°10′33″N	88°25′4″E	24 mamsl	1, 913, 040[a] (66.67%)	DARAH (2006f)
	2. Basanti	Basanti town	242	Highly humid	22°11′21″N	88°40′14″E	1 mamsl	72, 314[b]	
								88, 508[b]	
	24 Parganas (N)								
	1. Jaguli	Amdanga, Kampa, Cakla and Maricha	277	18–37.5°C	22°55′58″N	88°32′18″E	10 mamsl	2, 016, 202[a] (47.99%)	DARAH (2006e)
				Highly humid				90, 717[b]	
	Nadia								
	1. Haringhata	Birohi-1, Fatehpur, Mollaberia and Nagurukhra-1	175	18–37.5°C	22°58′60″N	88°28′60″E	10 mamsl	1, 740, 736[a] (84.82%)	DARAH (2006d)
	2. Chakdah	Madanpur-1, Simurali-2		Highly humid	23°4′60″N	88°31′E	10 mamsl	114, 451[b]	
								123, 202[b]	
	Murshidabad								
	1. Beldanga	Andulberia-1, Begunbari, Mohula-2, Dadpur and Debkundu	315	18–38.5°C	23°55′60″N	88°32′18″E	19 mamsl	3, 790, 574[a] (94.41%)	DARAH (2006c)
				Highly humid				355, 554[b]	
	Jalpaiguri								
	1. Maynaguri	Amguri, Curabhandar and Saptimari	187	12.8–32.3°C	26°34′N	88°53′E	74 mamsl	1, 465, 579[a] (84.66%)	DARAH (2006a)
	2. Dhupguri	Banarhat and Chamurchi	152	Humid	26°36′N	89°1′E	79 mamsl	149, 336[b]	
								126, 329[b]	
Sikkim	**West**								
	1. Rinchingpong	Kaluk, Mangalbaria and Rinchingpong Heeyangthang and Dentam	219	−5 to 33.5°C	27°28′N	88°27′E	823 mamsl	53, 570[a] (71.89%)	DAHVS (1997)
	2. Hee Gaon 3. Soreng	Soreng, Chakung and Burikhop		Sub-temperate				31, 633[b]	
	North								
	1. Mangan	Mangan, Heegyathang	167	−20 to 31.5°C	27°52′ N	88°53′ E	956 mamsl	17, 874[a] (82.44%)	DAHVS (1997)
	2. Lachung	Bitchu and Lachung			27°61′66″ N	88°65′ E	3 000 mamsl	13, 338[b]	
								4 536[b]	

Note: [a]Number of native fowls in the district. The values in parenthesis indicate the percentage of the native fowl's vis-à-vis total chicken population in the study area. [b]Estimated native chickens in the panchayats studied; Mamsl: metres above mean sea level; DARAH: Directorate of Animal Resources and Animal Health, Government of West Bengal; DAHVS: Department of Animal husbandry and Veterinary Sciences, Government of Sikkim.

as present). The shank length of a bird was assessed using the methodology as suggested by Maciejowski and Zieba (1982). The body weight of a bird was taken individually on a digital balance with an error margin of ±5 g. The egg shell colour was recorded by visual observation and individual eggs were weighed on a digital balance with an error margin of ±0.5 g.

The data obtained were analysed statistically using SPSS v-12 for Windows (SPSS, 2003), non-parametric test (χ^2) was used for analysing the data of the qualitative traits (colour of feather, shank, comb, skin, ear lobe and egg, type of comb), whereas Duncan's multiple range test was used to compare the means of the quantitative variables, i.e. body or egg weight. The variables were compared between locations; the effect of sex was also taken as a variable. However, the effect of age was not considered as a variable due to lack of reliable recording.

Results and discussion

The special features of chicken phenotypes reared in each of the districts along with production and marketing systems are presented in the following sections.

General husbandry practices

The backyard system of rearing is more or less similar to what is practiced in other developing countries. Chickens usually fend for themselves but are sometimes provided with broken rice and other kitchen leftovers. The average flock structure was estimated to be 3.5 adult hens and 1.25 cocks per household. The fowls are mostly kept indoors during the night either under a bamboo basket or on the bare floor or sometimes with old rags to protect them against cold or damp. Jute bags are mostly used to protect the birds against cold (83 percent). Sometimes wooden houses are also made for chickens (8 percent) and only some of the respondents (4 percent) had specially constructed brick houses for chickens. It was observed that 5 percent of the respondents (in West Bengal) protect chicks against predators and harmful insects by rearing them under mosquito nets. The broody hen and hens with chicks are reared separately. The grains (for the chickens) are usually scattered on the floor. Some farmers, however, provide feeders made of clay pot or hollow of a bamboo/tree. Chickens are provided water in discarded clay or metallic pots. The feeders and waterers are usually dirty and hence potential sources of disease transmission.

Chickens and eggs are mostly traded by local collectors; money obtained by the sale of eggs is usually retained by the women to procure items for day to day kitchen activities. These observations are similar to the findings of Iqbal and Pampori (2008). It is estimated that on average the price of one egg received by the rearers is Rs 1.25–1.75 (US$2 = Rs 51.00), while it is sold at Rs 4.50 ± 0.5 to consumers. The price of the eggs from native chickens is usually higher by Re 1 ± 0.5 compared with those from commercial layers. The cocks fetch a higher price than the hens primarily because of their larger body size. Hens with chicks are usually not sold by the rearers except under a highly distress condition or when there is an outbreak of diseases. Due to high mortality of the chicks, their sale is highly restricted and the replacement stock at times may even not be available. Farmers may have to borrow some chicks from their neighbours/relatives/friends to replenish their stock. Sometimes the chickens are sold by the rearers directly in the weekly local livestock market known as "haat" (Figure 1). The chickens are traded by their size with only visual estimation to fix their price followed by bargaining between the seller and the buyer. The external appearance, agility and plumage colour are the major criteria selected in accordance to the preference for both sexes. In some parts of West Bengal, especially in tracts where the majority of the residents are followers of Islam religion, caponization of the cocks is practiced. The castrated males are locally known as "khasi murgi". Thus, selection for economic attributes such as egg and body weights within the native chickens can help the economically challenged members of the society to catapult out of the vicious cycle of poverty.

The results for the number of eggs laid per hen did not give a consistent figure, however, the estimates obtained through questionnaires indicated that it varied between 50 and 80 eggs per hen on an annual basis, averaging around 57 ± 5.3 eggs. The observations are in agreement with the reports of Yoshimura *et al.* (1997), Haque and Assaduzzaman (1990) and Iqbal and Pampori (2008). Reports from Government of India (GOI, 2006) indicate that the average annual egg production of a native fowl in India to be 98.34 eggs.

The mortality pattern indicates that only around 29.75 percent of the chicks attained adulthood. The predominant causes of losses in the flock as indicated by the respondents

Figure 1. An old woman selling her chickens at the village market.

Figure 2. Naked neck fowls.

are due to outbreaks of Newcastle disease (80 percent), predators (7 percent), theft (5 percent) and other causes such as internal parasites, snakes and other diseases (8 percent). These findings are in consonance with the results obtained by Bhuiyan, Bhuiyan and Deb (2005). Outbreak of avian influenza in the recent past has led to mass culling among all the reared avian species in the region, thus adding to the woes of the farming communities.

Morphological traits of the different phenotypes of chickens reared in West Bengal and Sikkim

Naked neck fowl

The naked neck fowls (Figure 2), locally known as Gola kata murgi (Bengali) or Khurley (Nepali), are found in all the locations studied. The results from Table 2 indicate that the population of naked neck chickens ranks the second only to the desi chickens (native feathered chicken) in the study area. The presence of these birds in middle altitude regions of Sikkim may indicate its ability to adapt to moderately cold conditions. The findings are in consonance with the observations of Grobbelaar, Sutherland and Molalakgotla (2010). The mixed feather colours predominate over any single feather colour. The feather colours occur in similar frequencies among both sexes. Similar observations were reported by Bhuiyan, Bhuiyan and Deb (2005) and Faruque *et al.* (2010) from Bangladesh, Nidup *et al.* (2005) from Bhutan, Rajkumar *et al.* (2009) from India and Dana *et al.* (2010) from Ethiopia. The body weight of the naked neck chickens (Table 3) is higher than that of the feathered chickens; similar results were also presented by Galal (2000), Patra *et al.* (2002), Bhuiyan, Bhuiyan and Deb (2005) and Nidup *et al.* (2005), supporting their adaptation to the hot and humid climate of the region. The results of Banerjee and Banerjee (2000) indicated that the dressing percentage of the naked neck chickens was higher than the feathered chickens; similar observations were also obtained by Bordas, Monnet and Mérat (1980), Mérat (1990) and Deeb and Cahaner (1994). The exposed skin colour of the neck in these fowls varies from pink to bright red. The shank length (irrespective of the feather colours and sexes) was 9.50 ± 0.50 cm. Most of these chickens (83 percent) had a yellow skin colour and a single comb. The earlobe colour was predominantly white (83 percent) (Tables 4 and 5). The sexual dimorphism was also observed with the cocks having a higher body weight compared with the hens, the observations being in harmony with the observations of Yakubu, Kuje and Okpeku (2009). The body weight of the naked neck fowls reared in West Bengal is higher than those in Sikkim, which may be attributed to loss of body heat in the hilly climate of the region; the observations are in accordance with the

Table 2. Percentages of different phenotypes of chickens in the study area of West Bengal and Sikkim.

Districts	Different types of fowls (%) with respect to total population															
	Naked neck		Frizzled		Muffed/ Bearded		Creeper		Crested		Rumpless		Fibromelanosis		Feathered shank	
	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen
Midnapur (East)	6.7	5.4	5.3	4.1	3.5	2.9	3.9	3.7	5.4	4.2	2.5	1.8	0.0	0.0	0.0	0.0
Murshidabad	9.2	7.7	5.8	5.1	3.7	2.3	4.5	3.2	6.2	4.7	5.5	4.7	0.0	0.0	0.0	0.0
24 Parganas (South)	9.5	8.1	6.8	4.9	4.3	2.7	4.2	3.6	5.7	4.9	3.9	3.2	0.0	0.0	0.0	0.0
24 Parganas (North)	9.5	6.9	5.7	3.6	4.1	3.2	4.7	3.9	4.9	4.8	5.2	4.5	0.0	0.0	0.0	0.0
Nadia	8.2	7.5	5.2	3.9	4.2	3.7	5.3	4.8	6.1	5.9	5.7	5.1	0.0	0.0	0.0	0.0
Jalpaiguri	7.9	6.8	2.7	2.5	2.6	2.5	3.5	1.9	5.9	3.5	3.3	2.5	2.7	2.3	3.2	3.1
West (Sikkim)	7.2	6.9	4.8	4.6	1.6	1.5	4.7	3.9	2.3	1.9	1.9	2.1	3.7	3.5	8.6	8.2
North (Sikkim)	3.2	2.9	1.7	1.5	2.6	3.1	3.3	2.0	1.3	1.2	1.2	1.0	3.9	4.2	5.7	4.9
Average (West Bengal)	8.5	7.1	5.3	4.0	3.7	2.9	4.5	3.5	5.7	4.7	4.4	3.6	2.7	2.3	3.2	3.1
Average (Sikkim)	5.2	4.9	3.3	3.1	2.1	2.3	4.0	3.0	1.8	1.6	1.6	1.6	3.8	3.9	7.2	6.6
Total average	7.7	6.5	4.8	3.8	3.3	2.7	4.3	3.4	4.7	3.9	3.7	3.1	3.4	3.3	5.8	5.4

Table 3. Body weight of different phenotypes observed in the districts in West Bengal and Sikkim.

District	Desi fowl		Naked neck		Frizzled		Muffed/Bearded		Creeper		Crested		Rumpless		Fibromelanosis		Feathered shank	
	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen
Body weight (g)	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.
Midnapur (East)	1 550 ± 102^{a}	1 225 ± 118^{a}	1 575 ± 105^{a}	1 195 ± 56	1 496 ± 112^{a}	1 236 ± 112^{a}	1 426 ± 70^{a}	1 079 ± 135^{b}	1 354 ± 167^{a}	1 077 ± 45^{a}	1 254 ± 79^{a}	970 ± 102^{b}	983 ± 45^{b}	865 ± 75^{b}	0	0	0	0
Murshidabad	1 395 ± 96^{a}	1 050 ± 98^{b}	1 275 ± 98^{b}	1 058 ± 24	1 354 ± 210^{a}	1 065 ± 102^{b}	1 556 ± 90^{a}	1 220 ± 96^{a}	1 078 ± 97^{c}	986 ± 63^{b}	1 196 ± 112^{a}	964 ± 74^{b}	963 ± 122^{b}	850 ± 54^{b}	0	0	0	0
24 Parganas (South)	1 179 ± 221^{b}	995 ± 125^{b}	1 195 ± 112^{b}	1 052 ± 113	1 289 ± 105^{b}	1 022 ± 65^{b}	1 358 ± 122^{b}	1 032 ± 87^{b}	1 187 ± 107^{b}	1 065 ± 56^{a}	1 080 ± 59^{b}	918 ± 95^{b}	993 ± 86^{a}	779 ± 54^{c}	0	0	0	0
24 Parganas (North)	1 010 ± 115^{b}	1 010 ± 220^{b}	1 185 ± 125^{b}	1 092 ± 104	1 129 ± 177^{b}	1 089 ± 75^{b}	1 386 ± 107^{b}	1 074 ± 76^{b}	1 245 ± 96^{a}	1 096 ± 59^{a}	1 042 ± 96^{b}	977 ± 122^{b}	1 010 ± 59^{a}	907 ± 64^{a}	0	0	0	0
Nadia	1 259 ± 98^{c}	1 122 ± 189^{a}	1 156 ± 106^{b}	1 069 ± 122	1 196 ± 102^{b}	1 010 ± 96^{b}	1 224 ± 78^{b}	1 067 ± 57^{b}	1 298 ± 103^{a}	1 097 ± 41^{a}	1 097 ± 82^{b}	862 ± 68^{c}	996 ± 112^{a}	885 ± 34^{b}	0	0	0	0
Jalpaiguri	1 115 ± 112^{b}	965 ± 110^{c}	1 189 ± 135^{b}	1 098 ± 69	1 105 ± 225^{b}	1 070 ± 45^{b}	1 354 ± 88^{b}	1 107 ± 104^{b}	1 153 ± 87^{b}	945 ± 49^{b}	1 022 ± 107^{b}	988 ± 47^{b}	1 007 ± 75^{a}	876 ± 39^{b}	1 186 ± 67^{b}	987 ± 76^{b}	1 120 ± 102^{b}	1 065 ± 105^{a}
West (Sikkim)	1 858 ± 228^{a}	1 062 ± 115^{b}	1 185 ± 159^{b}	1 025 ± 85	1 188 ± 129^{b}	1 005 ± 100^{b}	1 490 ± 105^{a}	1 209 ± 95^{a}	1 375 ± 106^{a}	1 023 ± 45^{a}	1 107 ± 104^{a}	1 056 ± 122^{a}	0.0	0.0	1 404 ± 25^{a}	907 ± 67^{a}	1 258 ± 128^{a}	962 ± 85^{b}
North (Sikkim)	1 661 ± 118^{a}	1 098 ± 89^{b}	1 276 ± 114^{b}	1 082 ± 116	1 292 ± 86^{b}	1 066 ± 144^{b}	1 635 ± 87^{a}	1 235 ± 106^{a}	1 265 ± 95^{a}	1 053 ± 75^{a}	1 150 ± 86^{a}	976 ± 47^{b}	0.0	0.0	1 611 ± 34^{a}	887 ± 45^{a}	1 161 ± 101^{b}	998 ± 89^{b}
Average (West Bengal)	1 251 ± 143^{b}	1 062 ± 123^{b}	1 263 ± 116	1 094 ± 89	1 261 ± 112	1 082 ± 89	1 384 ± 94^{b}	1 096 ± 89^{b}	1 219 ± 98^{a}	1 044 ± 51^{a}	1 115 ± 95^{a}	947 ± 98^{b}	992 ± 79^{a}	860 ± 64^{b}	1 186 ± 67^{b}	987 ± 76^{b}	1 120 ± 102^{b}	1 065 ± 105^{a}
Average (Sikkim)	1 760 ± 132^{a}	1 080 ± 112 ^{c}	1 231 ± 225	1 054 ± 92	1 240 ± 101	1 038 ± 212	1 563 ± 109^{a}	1 222 ± 124^{a}	1 320 ± 177^{a}	1 038 ± 108^{a}	1 129 ± 102^{a}	1 016 ± 95^{a}	N/A	N/A	1 508 ± 106^{a}	897 ± 89^{a}	1 210 ± 114^{a}	980 ± 87^{b}

Note: ^{a,b,c,d}Values with different subscripts across rows differ significantly at $P < 0.05$.

study of Hussein, Fathi and Galal (2000) and Galal (2000). The egg-shell colour was brown (Table 6), which is similar to the observation of Bhuiyan, Bhuiyan and Deb (2005). The average egg weight (Table 6) was higher than those of the desi chicken, which may be attributed to their better adaptability and heat dissipation, the findings are in agreement with the assessment of Yoshimura *et al.* (1997) and Mathur (2003). The study also revealed that the naked neck chickens are not favoured by many of the consumers for chicken meat because of the red skin colour in its bare neck; hence there is an indirect selection against the trait. The observations are in accordance with the findings of Aklilu (2007).

Frizzled fowl

The frizzled fowls (Figure 3) are observed in all the districts studied. These birds are locally known as Sojaru murgi (in Bengali), while the same is known as Pulom and also Dum-shay in Bhutan (Nidup *et al.*, 2005) or as Dum Chi in Sikkim. The results from Table 2 indicate that the population of frizzled fowl is higher in West Bengal compared with Sikkim. This may be attributed to the feather pattern, which provides poor insulation in the cold climate of the region. It has been reported by Yunis and Cahaner (1999), Garcês, Casey and Horst (2001) and Sharifi, Horst and Simianer (2010) that under a high ambient temperature the frizzled genes provide an advantage by dissipating the body heat, whereas under cold climate the reverse is true, hence the birds have disadvantages over the normal feathered chickens. Most of the chickens had mixed feather colours. The shank colour is similar to that of the naked neck fowls, i.e. yellow and blue colours in equal proportions followed by white-coloured shank. The average shank length of these chickens was 10.20 ± 1.50 cm. White colour of skin, single comb and white ear lobe were predominant among the population studied. The egg weight of the frizzled fowl was higher than that of the normal feathered chicken but lower than that of the naked neck fowl (in West Bengal). These findings are in consonance with that of Garcês, Casey and Horst (2001). However, in Sikkim the egg weight of the frizzled fowl was lower than that of both normal feathered and naked neck chickens. Oke (2011) reported a slightly higher egg weight in frizzled fowls compared with the naked neck chickens in Nigeria. During the present study chickens with both frizzled and naked neck genotypes (double heterozygous genotype as reported by Horst, 1987; Manner, 1992; Pech-Waffenschmidt, 1992) were observed only in west Sikkim (Figure 4).

Muffed/bearded fowl

The muffed/bearded feathering conditions in fowls (Figure 5) have not been reported so far from India. They are locally known as Dariwala murgi (in Bengali). The results indicated that muffed/bearded chickens were distributed in West Bengal and Sikkim (Table 2). The

Table 4. Plumage colour of the fowls in the study area.

Phenotype	Feather colour (%)									
	Mahogany		Black		Brown		White		Mixed	
	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen	Cock	Hen
Midnapur (East)	17^{b}	12^{b}	5^{c}	4^{c}	15^{b}	13^{b}	4^{c}	7^{c}	59^{a}	64^{a}
Murshidabad	12^{c}	10^{c}	18^{b}	12^{c}	20^{b}	14^{c}	3^{e}	6^{d}	47^{a}	58^{a}
24 Parganas (South)	16^{b}	12^{c}	8^{c}	6^{c}	15^{b}	18^{b}	0	0	61^{a}	63^{a}
24 Parganas (North)	10^{c}	12^{c}	37^{a}	30^{b}	15^{c}	17^{c}	0	0	38^{a}	41^{a}
Nadia	18^{b}	20^{b}	3^{d}	2^{d}	23^{b}	20^{b}	7^{c}	9^{c}	49^{a}	49^{a}
Jalpaiguri	16^{b}	15^{b}	20^{b}	16^{b}	16^{b}	14^{b}	0	0	48^{a}	55^{a}
West (Sikkim)	0	0	100	100	0	0	0	0	0	0
North (Sikkim)	12^{c}	9^{c}	16^{b}	17^{b}	17^{b}	20^{b}	2^{d}	1^{d}	49^{a}	53^{a}
Feather colours between sexes	12.6	11.3	25.9	23.4	15.1	14.5	2	2.9	43.9	47.9
Variation between colours	11.9^{c}		24.6^{b}		14.8^{c}		2.5^{d}		45.9^{a}	

Note: ^{a,b,c,d}Values with different subscripts across rows differ significantly at $P < 0.05$.

feather colour was mixed in most of the chickens; however, the colour of the muff/beard was mostly black (92.5 percent) but some of them had also mixed colours of the beard/muff. The size of the wattles was reduced in the muffed/bearded chickens. The shank colour was predominantly blue followed by yellow and white, while the white skin was observed in most of the birds studied. Almost all the birds were single combed and the ear lobe colour was white. The body weight of the muffed/bearded fowl (Table 3) was higher than that of the normal feathered, naked neck and frizzled chickens, while the egg weight (Table 6) was lower than that of the other abovementioned phenotypes of fowls. The average shank length of the muffed/bearded chicken was 9.75 ± 0.25 cm.

Creeper fowl

Creeper chickens (Figure 6), locally known as Bête murgi (in Bengali), were observed in all the locations (Table 2). The existence of creeper fowls have also been reported from Bangladesh by Uddin *et al.* (2011) and Bhutan by Nidup *et al.* (2005). In Bhutan, they are locally known as "Baylaitey". The results of the study indicate that predominant feather colour is mixed followed by black and mahogany colour of the feathers, similar to the observations of Nidup *et al.* (2005). The shank colour of most of the creeper chickens was blue followed by yellow, while the skin colour was observed to be mostly white with a few chickens having yellow colour. Almost all the birds surveyed were single combed, the earlobe colour was observed to be mostly white (76.3 percent), while the rest being red. The average shank length varied from 3.25 to 4.47 cm with an average of 3.75 ± 0.75 cm. The cocks had longer shanks than the hens. The average body weight of the creeper cocks was lower in West Bengal when compared with those reared in Sikkim, whereas the reverse was true for the hens. The average body weight of the creeper fowls was higher than that of the naked neck and frizzled fowls but lower than that of the desi fowls. The results from Table 6 were indicative that the average weight of the eggs from these fowls was similar to that of the desi fowls. Due to their short shank length the creeper fowl was unable to escape easily from the predators, they were therefore mostly reared under confinement and were allowed to scavenge under the granaries to eat any fallen grains, thus preventing the attraction of rodents.

Crested fowls

Crested fowls (Figure 7), locally known as Khopa murgi, were also observed in all the locations, with a higher number in West Bengal when compared with Sikkim (Table 2). However, in most cases the crest was slight to moderate which was indicated by the presence of comb, whereas only 25.7 percent of the chickens were fully crested (indicated by rudimentary comb), similar to the results obtained by Somes (1990). The presence of crested fowls has also been reported by Nidup *et al.* (2005) from Bhutan where these chickens are commonly known as "Belochem". These chickens also have varied feather colours; the mixed feather colour predominated in the studied population followed by brown, mahogany, white and black feather colours. The shank colour in the studied birds was predominantly blue followed by yellow and white. The colours of the skin and earlobe were white in majority of the crested chickens. These findings were in agreement with the assessment of Nidup *et al.* (2005). The average shank length of the crested chickens was 8.79 ± 1.20 cm for both sexes, with higher values observed in the cocks than hens. The body weight of the crested chickens (for both sexes) was lower than that of the creeper, normal desi, naked neck, bearded and frizzled fowls. Similar trend was also observed for the egg weight (Table 6).

Rumpless fowl

The rumpless fowls (Figure 8) were locally known as Bocha murgi and characterized by the absence of sickle feathers in both sexes. The rumpless chickens were mostly localized in Nadia district and adjoining regions of Murshidabad district; however, true rumpless fowls were quite rare, and the study did not find the presence

Table 5. Morphological variations in fowls (%) as observed in the study.

Phenotype	Shank colour			Skin colour			Comb type			Earlobe				
	Yellow	White	Blue	Yellow	White	Slate	Single	Crested	Rose	White	Red	Mixed[d1]	Yellow	Black
Midnapur (East)	40[a]	27[b]	33[b]	17[b]	83[a]	0.0	96.7[a]	1.8[b]	1.5[b]	77[a]	10.0[b]	7.5[c]	5.5[c]	0.0
Murshidabad	38[a]	24[b]	38[a]	21[b]	79[a]	0.0	97[a]	1.1[b]	1.9[b]	71.0[a]	16.4[b]	6.0[c]	6.6[c]	0.0
24 Parganas (South)	37[b]	19.5[c]	43.5[a]	18[b]	82[a]	0.0	98.5[a]	0	1.5[b]	70.0[a]	18.0[b]	5.7[c]	6.3[c]	0.0
24 Parganas (North)	38.7[a]	19.7[b]	41.6[a]	15.3[b]	84.7[a]	0.0	97.2[a]	1.0[b]	1.8[b]	70.8[a]	10.0[b]	7.2[c]	12.0[d]	0.0
Nadia	35[b]	22.5[c]	42.5[a]	20.5[b]	79.5[a]	0.0	0	100	0	70.0[a]	11.7[b]	7.7[c]	11.3[d]	0.0
Jalpaiguri	31[b]	24.5[c]	44.5[a]	23[b]	77.0	2.3[c]	97.3[a]	1.7	1.0	77.5[a]	12.0[b]	5.3[c]	5.2[c]	0
West (Sikkim)	0	0	100	0	0	100	100	0	0	0	0	0	0	100
North (Sikkim)	37.5[a]	22.3[b]	40.2[a]	25.1[b]	74.9[a]	0	98.0[a]	1.0[b]	1.0[b]	76.2[a]	15.0[b]	5.2[c]	3.6[c]	0
Overall	32.1[b]	19.9[c]	47.9[a]	17.5[b]	70.0[a]	12.8[c]	85.6[a]	13.3[b]	1.08[c]	64.1[a]	11.6[b]	5.6[c]	6.3[c]	12.5[c]

Note: [a,b,c,d]Values with different subscripts across rows differ significantly at $P < 0.05$. [1]Red and white or red and yellow colour or vice versa.

Table 6. Egg weight and egg shell colour of different phenotypes of fowls in different districts of West Bengal and Sikkim.

District	Mean egg weight ± S.E. (in g) and shell colour of different fowl types																	
	Desi fowl (187)		Naked neck (165)		Frizzle (147)		Muffed/Bearded (133)		Creeper (137)		Crested (159)		Rumpless (132)		Fibromelanosis (121)		Feathered shank (132)	
	Colour	Weight	Colour	Weight	Colour	Weight	Colour	Weight	Colour	Weight	Colour	Weight	Colour	Weight	Colour	Weight	Colour	Weight
Midnapur (East)	CLB	40 ± 2.3[b]	CLB	44.2 ± 1.2[b]	CLB	39.5 ± 2.2[b]	CLB	36.7 ± 1.4[c]	CLB	40.6 ± 1.6[b]	CLB	33.2 ± 2.6[c]	Cream	32.7 ± 0.8[b]	N/A	0.0	N/A	0.0
Murshidabad	CLB	42.6 ± 1.3[b]	CLB	42.5 ± 1.7[b]	CLB	40.2 ± 2.1[b]	CLB	37.3 ± 1.5[c]	CLB	42.2 ± 0.9[a]	CLB	33.5 ± 1.7[c]	Cream	33.7 ± 1.9[b]	N/A	0.0	N/A	0.0
24 Parganas (South)	CLB	40.7 ± 2.9[b]	CLB	45.2 ± 1.4[b]	CLB	42.6 ± 1.2[a]	CLB	41.4 ± 1.5[a]	CLB	40.3 ± 0.8[b]	CLB	41.4 ± 0.6[a]	Cream	35.3 ± 0.8[b]	N/A	0.0	N/A	0.0
24 Parganas (North)	CLB	39.4 ± 1.6[b]	CLB	45.7 ± 1.3[b]	CLB	41.1 ± 1.4[a]	CLB	40.8 ± 1.2[b]	CLB	35.8 ± 1.6[c]	CLB	40.4 ± 2.7[a]	Cream	32.1 ± 1.7[b]	N/A	0.0	N/A	0.0
Nadia	CLB	39.7 ± 2.9[b]	CLB	42.3 ± 2.7[b]	CLB	41.8 ± 2.1[a]	CLB	41.4 ± 1.6[a]	CLB	40.7 ± 1.3[b]	CLB	39.2 ± 1.6[b]	Cream	33.6 ± 1.5[b]	N/A	0.0	N/A	0.0
Jalpaiguri	CLB	40.3 ± 1.7[b]	CLB	44.5 ± 3.2[b]	CLB	41.4 ± 1.6[a]	CLB	40.4 ± 1.8[b]	CLB	41.5 ± 2.0[b]	CLB	40.9 ± 0.7[a]	Cream	35.5 ± 0.8[b]	Bluish	40.6 ± 1.3[c]	CLB	40.2 ± 2.5
West (Sikkim)	CLB	42.9 ± 2.4[a]	CLB	46.7 ± 2.6[a]	CLB	40.3 ± 2.4[b]	CLB	40.1 ± 2.1[b]	CLB	42.5 ± 1.6[a]	CLB	41.2 ± 2.8[a]	N/A	0.0	Bluish	41.1 ± 1.2[b]	CLB	39.6 ± 1.7
North (Sikkim)	CLB	44.2 ± 1.3[a]	CLB	44.6 ± 2.1[b]	CLB	39.1 ± 2.3[b]	CLB	42.4 ± 1.3[a]	CLB	44.1 ± 0.7[a]	CLB	42.1 ± 1.4[a]	N/A	0.0	Bluish	42.8 ± 0.7[a]	CLB	40.1 ± 1.25
Average (West Bengal)		40.4 ± 1.8[b]		44.1 ± 1.5[b]		41.1 ± 2.2[a]		39.6 ± 1.6[c]		40.3 ± 1.9[b]		38.1 ± 1.1[b]		33.8 ± 1.3[b]		40.6 ± 1.3[b]		40.2 ± 2.5
Average (Sikkim)		43.6 ± 2.5[a]		45.6 ± 2.2[a]		39.7 ± 1.7[b]		41.2 ± 2.1[b]		43.8 ± 2.5[a]		41.6 ± 1.8[a]		0.0		43.4 ± 2.1[a]		40.15 ± 1.7

[a,b,c,d] Values with different subscripts across rows differ significantly at $P < 0.05$.

Note: Shell colour: cream to light brown (CLB), values in parenthesis indicate the number of eggs examined.

Figure 3. Chicks of frizzled fowls.

Figure 4. Fowl showing both naked neck and fizzled genes.

Figure 5. Muffed/bearded fowl.

Figure 6. Creeper fowl.

of the rumpless chickens in Jalpaiguri district and in Sikkim State. However, there is lack of information about the presence of such chickens in India. The presence of rumpless chickens has been reported by Badubi, Rakereng and Marumo (2006) from Botswana. The common feather colour was observed to be of mixed type followed by black, mahogany and brown. Most of these chickens had blue shank colour followed by yellow and white, while the skin colour and earlobe colour in most of the rumpless chickens were white. The average shank length was 8.25 ± 0.25 cm. The average body weight of the rumpless chickens (irrespective of sexes) was the lowest among all the phenotypes observed in the present study. The egg weight (Table 6) was also the least when compared with all other phenotypes. Low egg weight may lead to low hatchability (34 percent) as reported by the rearers of this type of chickens. The observations were similar with the assessment of Landauer (1945). This type of chickens, however, is able to escape predators easily because of the lack of tail feathers and small body size.

Feathered shank fowl

The fowls with feathered shank were quite common in Sikkim (Figure 9) and were also found in some parts of Jalpaiguri district of West Bengal, especially in regions adjacent to Bhutan. However, true feathered shank chickens were seldom seen in other studied areas. Some chickens with a few strands of hair have been encountered in all the locations but they were not included in the feathered shank category. Mixed feather colours were observed in most of these chickens, followed by brown, black, mahogany and white. The predominant shank colour was blue followed by yellow and white, while the skin colour was mostly white. Majority of the chickens were single combed and had a white ear lobe. The body and egg weights of the feathered shank chickens were higher only than the rumpless fowls. It was also observed that the pattern of the shank feathering was not consistent with some chickens

Figure 7. Crested fowl.

having feathers in the inner toes (15.6 percent), while the rest of them feathering in the outer toes. The average shank length was 9.25 ± 1.50 cm, being higher in cocks than hens.

Fibromelanosis fowl

The presence of fibromelanin in chickens has been reported in Kadaknath breed of chickens in Jhabua and Dhar districts of Madhya Pradesh and adjoining region or Gujarat and Rajasthan States in India (Chatterjee *et al.*, 2010). Thakur, Parmar and Pillai (2006) reported that the pure Kadaknath fowls are rare in the breeding tract due to indiscriminate introduction of exotic chicken breeds, especially the Rhode Island Red. The reports pertaining to the presence of fowl ecotypes having fibromelanosis is by and large lacking from other parts of India. This study indicated that the fibromelanosis fowls were reared by the members of the Bhutia ethnicity in the West and North districts of Sikkim (Figure 10). These fowls are locally known as "Phia naku", whereas individual cocks are called "Phiaku naku" and hens are called "Phia niam". The word "niam" denotes the black colour of the fowl. Similar variants were also found in Bhutan and they were locally prized for the medicinal value of meat, known as "Yubjha naap" (Nidup *et al.*, 2005). These fowls were used for religious ceremonies and hence demanded a very high price. Bhasin (2002) reported that majority of the Bhutia inhabitants of Sikkim are immigrants from Tibet and Bhutan during the 17th century. It is probable that these fowls were brought to Sikkim with them. Sarkar and Ray (2006) reported that during the 19th century caravans from Tibet carried merchandise through Bhutan to plains of Bengal; large-scale trading of commodities including livestock took place in the region. This possibly explained the existence of similar chickens in areas adjoining the Bhutan in Jalpaiguri district of West Bengal. Gao *et al.* (2008) also reported the presence of several such chicken breeds in China, where these chickens were an important part of the traditional faunal medicine. The cultural/religious significance of black-coloured chickens among different tribal societies of central India (the breeding tract of Kadaknath chicken) has been reported by Crooke (1896) and among people of Nepali ethnicity by Subba (2009). Smyth (1990) reported that the levels of melanin in the skin and even in the feathers were responsible for the difference in feather colours of the fowls. The presence of melanin in certain breeds also leads to dark colour of combs in certain types of chickens. Variation in the skin colour may also be a resultant of the presence or absence of xanthophylls in the feed consumed by the birds; however, the assimilation of the pigments in the skin was also a genetic trait as reported by Eriksson *et al.* (2007). The colours of skin, shank, earlobe and feather of these chickens were greyish to black; all the birds had a single comb. Some birds which were crosses of Phia naku had varying degrees of black coloration. Average body weight of the Phia naku was lower than the desi fowls. The eggshell colour was bluish black, while the weight was similar to that of the desi chickens. The average shank length was 9.15 ± 1.75 cm, being higher in cocks than hens.

Figure 8. Rumpless fowl.

Morphological variations between sexes and in different regions

The results from Table 2 indicate that the naked neck was the most common phenotype followed by feathered shank, frizzled, crested, creeper, rumpless, muffed/bearded and fibromelanosis in cocks. In case of the hens the most common phenotype observed was the naked neck, followed by feathered shank, crested, frizzled, creeper, fibromelanosis, rumpless and muffed/bearded. The study further indicates that some phenotypes were localized in specific agroclimates such as feathered shank and fibromelanosis chickens were localized in Sikkim and Jalpaiguri district of West Bengal, while most of the rumpless chickens were found in Nadia and Murshidabad districts of West Bengal.

Figure 9. Feathered shank fowl.

The results from Table 4 indicate the distribution of different feather colours in the chicken populations of the different regions. The results as tabulated indicate that the chickens in the populations studied had multiple variants in their feather colours, similar to the observations of Badubi, Rakereng and Marumo (2006), Bhuiyan, Bhuiyan and Deb (2005), Mandal, Khandekar and Khandekar (2006), Halima *et al.* (2007), Nidup *et al.* (2005), Faruque *et al.* (2010), Dana *et al.* (2010) and Uddin *et al.* (2011). The observed variation in feather colour as assessed by Bhuiyan, Bhuiyan and Deb (2005) may be attributed to genetic dilutions in native chickens. Mixed feather colour was the most common in all the locations and sexes except for Phia naku, which had a characteristic black plumage in both sexes. Halima *et al.* (2007) and Dana *et al.* (2010) reported that the variations in feather colour may also be attributed to selection by the rearers for cultural purposes and faunal medicine. The results of this study indicated that the white feather colour was the least preferred among the rearers, due to the fact that chickens with such feather colour were easily spotted by predators as they were unable to blend with natural vegetation. The findings are in consonance with the assessment of Ayele (2011) who observed that the farmers in Amhara region of Ethiopia did not prefer white-feathered chickens because of their inability to camouflage in the surroundings. Al-Yousef (2007) also reported that white feather colour was the least preferred in Baladi chickens of Saudi Arabia. There are also reports that certain feather colours are associated with aggressiveness of the cocks and such birds fetch higher prices, especially among the fanciers of cock fighting. The results from Table 5 denote that the most common shank colour was blue, followed by yellow and white. The results are in accordance with the observations of Bhuiyan, Bhuiyan and Deb (2005), Ahmed and Ali (2007) and Iqbal and Pampori (2008), but differed from the observations of Faruque *et al.* (2010). The predominant skin colour was white. It is distantly in accordance with the observations of Bhuiyan, Bhuiyan and Deb (2005), Iqbal and Pampori (2008) and Faruque *et al.* (2010). Smyth (1990) and Eriksson *et al.* (2007) indicated that the yellow pigmentation of the skin is a genetic trait correlated with carotenoid pigments in the skin of the birds and also associated with its nutrition, adaptive fitness and health. The average body weights of the cocks and hens vary between populations (Table 3), which may be attributed to both genotype and environment in which the chickens are reared. The body weight for cocks varied between 963 g (rumpless in Murshidabad) and 1 575 g (naked neck in Midnapur), while the values

Figure 10. Fowls with fibromelanosis.

for hens ranged between 885 g (rumpless in Nadia) and 1 236 g (frizzled in Midnapur). These differences in body weight can also be attributed to the nutrition available to the birds and also to the age, similar to the observations of Dana *et al.* (2010). The results from Table 6 indicate that the egg-shell colour varied from cream to light brown with various intermediate shades, which are in consonance with the reports of Bhuiyan, Bhuiyan and Deb (2005), Faruque *et al.* (2010) and Uddin *et al.* (2011). However, Parmar *et al.* (2006) reported that the egg-shell colour of Kadaknath breed varied from brown to light brown, whereas the egg-shell colour of Phia naku was bluish black tinge. Nidup *et al.* (2005) also reported similar colour of egg shell in Yubjha naap chickens of Bhutan. The feathers of the cocks were shiny when compared with the hens.

Population and conservation efforts

The outbreaks of avian influenza in West Bengal and Sikkim during 2007 and 2008 and again in 2011 (in Nadia district) had led to culling of all the domesticated avian species in the area of West Bengal included in this study (Ahuja *et al.*, 2009). The official figures of culled birds in the studied districts were 1 532 464 heads and 77 830 eggs (Ahuja *et al.*, 2009). The majority of the culled flocks were native fowls. The restocking in the region was carried out by distributing the chicks of Kruilor (a synthetic strain developed from several exotic chicken breeds) and also Rhode Island Red. The purposeful introduction of such stock has severely minimized the population of the indigenous fowls in the region and the resultant effect would lead to elimination and dilution of the native breeds of fowls in the region. Hence, it is feared that the potentially useful genotypes of the fowls as mentioned in the study may be lost forever if immediate steps are not taken for the conservation.

Conclusions

The present study indicates that the chickens in West Bengal and Sikkim had multiple variations in feather colour and physical traits. Certain physical features that were common among the phenotypes studied were yet divergent in some of the other physical characters, e.g. naked neck chickens, rumpless chickens, etc., while some phenotypes were localized in certain areas only such as the feathered shank and fibromelanosis chickens in Sikkim and Jalpaiguri district of West Bengal. Some phenotypes are known to have a better adaptability to tropical climates such as naked neck and frizzled fowls. Similarly, some interesting criteria of selection by the farmers were documented such as those for creeper and rumpless fowls. The present study is one of the first steps taken to document the chicken genotypes in the region. However, conservation efforts need to be immediately undertaken especially when restocking was carried out by introducing the exotic and synthetic strains of chickens.

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Distinct morphological features of traditional chickens (*Gallus gallus domesticus* L.) in Western Visayas, Philippines

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Summary

The local or traditional types of chicken found in the Philippines are not well described and no comprehensive information is available and as yet not described as breeds. Among the regions in the Philippines, Western Visayas has the largest population of chickens with limited information on their distinct morphological characteristics. Eight hundred and ten chickens from 270 flocks were divided equally into six areas representing the provinces of Aklan, Antique, Capiz, Guimaras, Iloilo and Negros Occidental. Data collected were qualitative and morphometric traits the former were analysed using non-parametric test and general linear model (GLM) for the latter. Results showed that red-lace and brown-pencilled plumage dominated in roosters and hens, respectively. The local types from Guimaras were the heaviest and dominantly possess amber-coloured iris, yellow skin and shank, snake-like head and have a pea comb, whereas those from Aklan had the lightest live weight and having single comb ($p < 0.01$). Chickens from Antique were known for its wedge-shaped body. Those from other provinces were found to be comparable.

Keywords: *native chickens, Philippines, distinct morphological features, poultry genetic resources*

Résumé

Le poulet traditionnel de résumé est un groupe de poulet sans des informations complètes sur sa race. Parmi les régions aux Philippines, Visayas occidental a la plus grande population des poulets avec l'information limitée sur leurs caractéristiques morphologiques distinctes. Ainsi, cette étude a été entreprise. Huit cents et dix (810) poulets de 270 bandes ont été divisés également parmi les provinces d'Aklan, antiquité, de Capiz, de Guimaras, d'Iloilo, et de Negros occidental. Les données rassemblées étaient des traits qualitatifs et morphométriques l'ancien a été analysé en utilisant l'essai non paramétrique et le GLM pour le dernier. Les résultats ont prouvé que des coqs et les poules ont été dominés par le plumage rouge-lacé et brun-penciled, respectivement. Les poulets traditionnels de Guimaras étaient les plus lourds et possèdent principalement l'iris ambre-coloré, la peau jaune et la jambe, serpent-comme la tête, et le peigne de pois; considérant que, ceux d'Aklan ont eu le poids vif le plus léger et avoir la crête unique ($p < 0.01$). Des poulets de l'antiquité ont été connus pour son corps triangulaire. Ceux d'autres provinces sont avérés comparables.

Mots-clés: *Poulets indigènes, Philippines, dispositifs morphologiques distincts, ressources génétiques de volaille*

Resumen

El pollo tradicional sumario es un grupo del pollo sin la información comprensiva sobre su casta. Entre las regiones en las Filipinas, Visayas occidental tiene la población más grande de pollos con la información limitada sobre sus características morfológicas distintas. Así, este estudio fue conducido. Ochocientos y diez (810) pollos a partir de 270 multitudes fueron divididos igualmente entre las provincias de Aklan, antigüedad, de Capiz, de Guimaras, de Iloilo, y de Negros Occidental. Los datos recogidos eran rasgos cualitativos y morphometric el anterior era analizado usando la prueba no paramétrica y GLM para el último. Los resultados demostraron que los gallos y las gallinas fueron dominados por el plumaje rojo-atado y marrón-penciled, respectivamente. Los pollos tradicionales de Guimaras eran los más pesados y poseen dominante el diafragma ambarino-coloreado, la piel amarilla y la caña, serpiente-como la cabeza, y el peine del guisante; mientras que, ésos de Aklan tenían el peso vivo más ligero y tener solo peine ($p < 0.01$). Los pollos de la antigüedad eran sabidos para su cuerpo acuncado. Ésos de otras provincias son encontrados para ser comparables.

Palabras clave: *Pollos nativos, Filipinos, características morfológicas distintas, recursos genéticos de las aves de corral*

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Introduction

Traditional chicken belong to a population of chickens with no comprehensive information about the breeds. These are the local chickens raised by farmers and often show large phenotypic diversity (FAO, 2012). The diversity of these animal genetic resources is important to the livelihood and food security of marginal farmers/raisers. A genetic reservoir of breeding stocks to meet the changing environmental conditions are potential sources of genes pertaining to resistance or tolerance among emerging diseases, could thrive in locally available resources, and fit with consumer preferences for meat and egg products (Boettcher *et al.*, 2010; Hoffmann, 2010). However, such a diversity is threatened by changes in the production system (Reges and Gibson, 2003), indiscriminate crossing of breeds (Hiemstra *et al.*, 2006), occurrence of catastrophe and degradation of environment (FAO 1998, 2007). This is manifested by 38 percent of the reported poultry breeds in the world at risk with some already extinct (Hoffmann, 2010). Furthermore, reports showed that in Asia, more need to be characterized, while most are of unknown risk status (FAO, 2007).

In the Philippines, the population of traditional chicken or popularly known as native chicken decreased from 62 to 47 percent of the total chicken inventory from 2001 to 2010 or about 1.5 percent decrease per annum. Among the 16 regions of the country, the highest population inventory of native chickens is in Western Visayas (BAS, 2011). Few places in this region served as pilot areas for *in situ* conservation (MASIPAG, 2010). The existing research undertakings focus on standardization of Darag[1] chickens among research institutions (Cocjin *et al.*, 1999, 2001, 2004, 2007; Patricio and Cabarles, 2007; Lopez, 2008; Tomambo *et al.*, 2010). This implies scarcity of data on other groups of traditional chickens. Information on the phenotypic and molecular characteristics of these chickens is important for intelligent decision-making about conservation and/or improvement (Davila *et al.*, 2009; Boettcher *et al.*, 2010; FAO, 2012; Zanetti *et al.*, 2010). These are some available information crucial for phenotypic characterization (Avante and del Fierro, 1991; Lambio, Bondoc and Grecia, 1998, 2000; Escobin *et al.*, 2005), molecular characterization (Roxas *et al.*, 1996; Lambio and Barrion, 1998) and description of production environment (Guevara, Lambio and Peñalba, 1991; Oñate, 1991; Roxas and Escarlos, 2000; Magpantay *et al.*, 2006), but are limited to traditional chickens in other regions. In Western Visayas, only few studies dealt with the production environment (Sulinthone, 2006; Lingaya, Oliveros and Magpantay, 2007) and molecular characterization of traditional chicken (Roxas *et al.*, 1996). The limited migration of people who brought chickens, the presence of higher mountains, poor road network and socio-cultural differences might have led to morphological divergence of these genetic resources (Roxas *et al.*, 1996). There is, therefore, a need to identify distinct morphological characteristics of traditional chicken, which are crucial in Western Visayas, Philippines. These are vital inputs to the existing activities and future chicken breed development utilizing local chicken genetic resources as source of stocks.

The role of traditional chicken is crucial to the economy of the country and region. It is a cheap source of animal protein and provides extra income among families in rural areas (Lambio, Bondoc and Grecia, 1998; Lingaya, Oliveros and Magpantay, 2007). More than 6 million smallholder or marginal farmers keep this fowl as an integral part of their farming system (NSO, 2005; Bagiou, 2010). The annual need in Western Visayas alone is 64 million heads of dressed traditional chicken (Belleza, 2010). A niche exists for this chicken because it is organically grown and is leaner and its meat has a distinctive taste. However, with exponential human population growth, there is high probability that the increasing demand cannot be met. This is seen as opportunity by would-be raiser-entrepreneurs, but the availability of information on source of breeding stocks is limited (Belleza, 2010; Bagiou, 2010). Hence, this study was conducted to identify the distinct morphological traits of traditional chicken groups from the different provinces of Western Visayas, Philippines. The findings will serve as inputs to the development of this industry.

Materials and methods

Sampling sites and number of chickens characterized

The provinces of Aklan, Antique, Capiz, Guimaras, Iloilo and Negros Occidental in Western Visayas were included as sampling sites. The number was determined using the equation suggested by Israel (1992). Forty-five raisers of traditional chickens were purposely identified in three municipalities of each province considered (Dana *et al.*, 2010a). This was done to minimize taking data from closely related flocks (Mwacharo *et al.*, 2007). One rooster and two hens possessing dominant plumage colour and pattern were borrowed from each identified raiser for characterization. Guidance from the personnel of the municipal agriculture office and the farmer technician of Magsasaka at Siyentipiko para sa Pag-unlad ng Agrikultura (MASIPAG) in some areas with allied people organizations (PO's) prior to and during the visit for data collection were sought.

Data collected

The data gathered were based on the guidelines set by FAO (2012), Cuesta (2008) and FAO and UNEP (1986). The data collected were the following.

[1] A traditional or native chickens standardized as to its plumage and shank colour, comb, and some of its productive performance under the leadership of Dr Bernabe B. Cocjin of West Visayas State University

Qualitative traits

These data included plumage colour and pattern; feather distribution and morphology; colours of the earlobes, skin and shank; shapes of the head, breast and body; comb type and skeletal variants (Supplementary Figure S1). These were determined by an actual examination of one rooster and two hens from the identified flock of traditional chickens of each raiser. Only those chickens ageing more than 10-months-old with dominant plumage colour and pattern were considered for characterization.

Morphometric traits

The morphometric traits were determined by a direct measurement including body length, circumference and height; wingspan and primary feather length; and tail length, and were all taken using a tape measure. Lengths of beak, drumstick shank and middle toes; and diameter of drumstick and shank were determined using a digital calliper (Supplementary Figure S1). Centimetre was used as a unit of measurement. Live weight was also determined using a 5 kg capacity digital weighing scale.

Statistical analysis

Qualitative traits

Data on plumage colour and pattern, earlobe colour, skin colour, iris colour, shank colour, feather morphology and distribution, head shape, breast shape, body shape, comb types and skeletal variants were analysed using Kruskal–Wallis test (Dana *et al.*, 2010b). Significant differences in the frequency of occurrences among provinces were analysed using the least significant differences (LSD) for ranks.

Morphometric traits

The data were analysed using univariate general linear model (GLM). Live weight was considered as the dependent variable, whereas the beak length, body length, body circumference, body height, wingspan, primary feather length, drumstick length, midlength diameter of drumstick, shank length, midlength diameter of shank, tail length, middle toe length and fixed effects of traditional chicken sex were the independent variables. These data were used to derive the different coefficients in the model generated from univariate GLM. The statistical model used was

$$Y = -2.793 + 0.115X_1 + 0.015X_2 + 0.032X_3 + 0.006X_4 + 0.004X_5 + 0.005X_6 + 0.034X_7 + 0.090X_8 + 0.024X_9 + 0.750X_{10} + 0.025X_{11} + 0.002X_{12} - 0.099X_{13} \pm 0.123$$

where Y is the live weight (kg) of traditional chickens. $-2.793 = (\alpha)$ intercept of the model; X_1 = beak length; X_2 = body length; X_3 = body circumference; X_4 = body height; X_5 = wingspan; X_6 = primary feather length; X_7 = drumstick length; X_8 = midlength diameter of drumstick; X_9 = shank length; X_{10} = midlength diameter of shank; X_{11} = tail length; X_{12} = middle toe length; X_{13} = fixed effects of chicken sex (1 = male; 2 = male); 0.123 = standard error (S.E.).

The model indicates any change in live weight of traditional chickens owing to accumulated linear effects of the above-mentioned independent variables. Live weight was further analysed using the univariate analysis of variance (ANOVA). The Duncan multiple range test (DMRT) was used to determine significant differences between and among means.

Results and discussions

Plumage colour

Results show that 23.70 percent of the 810 traditional chickens in Western Visayas had brown plumage. This was followed by 17.41 percent having black plumage; red, 12.35 percent; wheaten, 9.88 percent; slate, 7.78 percent; white, 7.53 percent; barred, 5.80 percent; splash, 5.68 percent; silver, 5.43 percent; and, red-pyle and gold plumage as remaining percentages.

Among the roosters, 37.04 percent of 270 characterized chickens possessed red plumage (Figure 1; Table 1). It ranged from 29 to 49 percent with those from Negros Occidental having the highest and those from Guimaras, the least. About 24 percent of the roosters in Aklan were observed to have white; the same percentages (18 percent) were recorded for barring in Aklan and Capiz; 16 percent had slate in Guimaras and 13 percent had black-coloured plumages in Iloilo. In hens, the findings revealed that 35 percent of the 540 characterized had brown plumage (Figure 1). Hens from Iloilo had appeared to have the highest percentages (47 percent) and those from Guimaras had the least (20 percent) for this colour. Greater percentages of hens from the latter province were prominently having black (29 percent) and slate plumages (27 percent). Those from Negros Occidental were noted to have wheaten plumages. Hens in Aklan had a larger distribution for white (17 percent) and barred (11 percent) plumages. However, statistical analysis revealed that the distribution of occurrences of each plumage colour across provinces were not significantly different ($p > 0.05$).

The higher occurrences of red plumage among roosters and brown plumage in hens may be inherited from their progenitor – the red junglefowl and through natural selection. These colours enable them to mimic dry leaves and debris when threatened by dangers. This is the same with the chickens in Guimaras having black and slate plumages which make it easy for them to hide, when threatened, in the grey to black bark of mango trees. The preferences of raisers for other colours further increase diversity in plumage colours.

Figure 1. Dominant features of traditional chickens from different provinces of Western Visayas, Philippines. Roosters had laced-red plumage and red earlobes, whereas hens had pencilled-brown plumage except for those in Guimaras that had laced-black plumage and red with white earlobes; both had normal feather morphology, feather distribution and skeletal variants; equally had wedge-shaped breast. (a) Chickens from Aklan had single comb, white shank and skin, amber-coloured iris, wedge-shaped body, flat head, whereas roosters had snake-like and hens had flat-shaped head. (b) Chickens from Antique had wedge-shaped body, white skin, and roosters had single comb, amber-coloured iris, yellow shank and snake-like head, whereas hens had pea comb, golden brown-coloured iris, slate shank and flat head. (c) Chickens from Capiz had single comb, white skin and shank, amber-coloured iris, snake-like head; whereas males had blocky-shaped and hens had wedge-shaped body. (d) Chickens from Guimaras had pea comb, yellow skin and shank, amber-coloured iris and snake-like head, whereas roosters had blocky-shaped and hens had wedge-shaped body. (e) Chickens from Iloilo had single comb, white skin, snake-like head and wedge-shaped body, whereas roosters had yellow and hens had slate shank. (f) Chickens from Negros Occidental had white skin, wedge-shaped body; roosters had single comb, amber-coloured iris, yellow shank and snake-like head, whereas hens had pea comb, golden brown-coloured iris, slate shank and flat head.

The findings on the description of dominant plumage colours are similar to the observations of Avante and del Fierro (1991) on Philippine red junglefowl and Banaba chickens of Batangas. Other variants are the same as those described by Lambio, Grecia and Amado. (2000) among other genetic groups of Philippine native chickens. Studies conducted in Maison District of Sonla Province in Northwest Vietnam on the H'mong chickens showed that 70.66 percent had brown, 14.78 percent had black and 14.56 percent had white plumages (Cuc *et al.*, 2006). The trends in brown and black plumage occurrences among these chickens are similar to the present findings. The observed differences in the magnitude of plumage colour occurrences are probably because of limited colour variations among chickens and selection preferences of its raisers.

Plumage colour pattern

As found, 39.88 percent of the 810 characterized chickens had laced-plumage colour patterns (Table 2; Figures 2b and 2c). This was followed by 28.02 percent of chickens with pencilled (Figures 2a and 2d), 19.63 percent with plain, 5.80 percent with barred (Figure 3), 4.69 percent with spangled, and chickens with the mottled plumage colour were the least. The majority of the roosters had laced-plumage colour pattern. Those from Negros Occidental had the highest ($p < 0.05$) occurrence, but comparable to those in Guimaras. The same proportion (62 percent) of roosters in Antique and Capiz had this colour pattern. The occurrences of plain and spangled colour pattern were comparable across provinces except for those in Negros Occidental which had the lowest ($p < 0.05$). The distribution of roosters with barred and mottled plumage colour pattern from the various provinces were not significantly ($p > 0.05$) different. The occurrences of different plumage colour patterns except for the pencilled among hens in different provinces were not different ($p > 0.05$). The distribution of pencilled colour patterns ranged from 11 to 61 percent with hens from Iloilo having the highest ($p < 0.05$) occurrences and those from Guimaras having the lowest.

Table 1. Distribution as to plumage colour of traditional chickens from different provinces of Western Visayas, Philippines.

Colour	Chickens from											
	Aklan		Antique		Capiz		Guimaras		Iloilo		Negros Occidental	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Males[1]												
Barred	8	18	4	9	8	18	3	7	2	4	4	9
Black	1	2	4	9	5	11	5	11	6	13	1	2
Brown	1	2	1	2	0	0	0	0	1	3	0	0
Red	14	31	19	42	15	33	13	29	17	38	22	49
Slate	1	3	5	11	5	11	7	16	2	4	2	4
Wheaten	0	0	0	0	0	0	0	0	0	0	0	0
White	11	24	3	7	2	5	2	4	4	9	1	3
Others	9	20	9	20	10	22	15	33	13	29	15	33
Females[1]												
Barred	10	11	0	0	6	7	2	2	0	0	0	0
Black	18	20	18	20	19	21	26	29	22	24	16	18
Brown	31	34	39	43	25	28	18	20	42	47	34	38
Red	0	0	0	0	0	0	0	0	0	0	0	0
Slate	0	0	7	8	3	2	24	27	3	4	4	3
Wheaten	12	13	12	13	15	17	7	8	9	10	25	28
White	15	17	5	6	5	6	4	4	3	3	6	7
Others	4	5	9	10	17	19	9	10	11	12	5	6

[1]The occurrences of each plumage colour within the row are not different ($p > 0.05$).

Diversities in plumage colour patterns can be attributed to feather developmental mechanisms, genes of chickens and raisers selection practices. According to Smyth (1990), the colour patterns were owing to the distribution of eumelanin and the presence or absence of pheomelanin at feather developmental stage. The kind and concentration may vary among cells because of molecular gradients at feather follicles. The position of feather in the body may also affect the expression of colour pattern because of differences in intensity of melanin pigmentation in the skin (Yu *et al.*, 2004). These are also governed by different gene action as added by Smyth (1990). Probably, raisers retained the chickens with attractive colour patterns as their replacement stocks.

The results of this study on the different types of plumage colour patterns are similar to the portrayal of Philippine red junglefowl and other native chicken genetic groups as described by Avante and del Fierro (1991) and Lambio, Grecia and Amado (2000).

Table 2. Distribution of traditional chickens from different provinces of Western Visayas, Philippines as to their plumage colour pattern.

Patterns	Chickens from											
	Aklan		Antique		Capiz		Guimaras		Iloilo		Negros Occidental	
	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%
Males[1]												
Barred	8	18	4	9	8	18	3	7	2	5	4	9
Laced	20	44^{c}	28	62^{b}	28	62^{b}	33	73^{a}	22	49^{c}	40	89^{a}
Pencilled	0	0	1	3	1	2	0	0	0	0	0	0
Plain	11	24^{a}	6	13^{a}	6	13^{a}	5	11^{a}	6	13^{a}	1	2^{b}
Mottled	0	0	2	4	1	2	1	2	0	0	0	0
Spangled	6	14^{a}	4	9^{a}	1	3^{a}	3	7^{a}	15	33^{a}	0	0^{b}
Females[1]												
Barred	10	11	0	0	6	7	2	2	0	0	0	0
Laced	21	23	20	22	19	21	50	56	13	14	29	32
Pencilled	33	37^{b}	47	52^{ab}	40	44^{b}	10	11^{b}	55	61^{a}	40	44^{b}
Plain	25	28	20	22	17	19	25	28	19	21	18	20
Mottled	1	1	1	2	5	6	2	2	1	2	2	2
Spangled	0	0	2	2	3	3	1	1	2	2	1	2

[1]The occurrences of plumage colour patterns within the row with no common superscript are different ($p < 0.05$); those with no superscript are not different ($p > 0.05$).

Figure 2. Plumage colour patterns among the traditional chickens in Western Visayas, Philippines: (a) silver-pencilled hen, (b) silver-laced rooster, (c) red-laced rooster and (d) brown-pencilled hen.

Iris colour

Results showed that 35.19 percent of the 810 characterized chickens had amber-coloured iris (Table 3 and Figure 4a). This was followed by 162 chickens with golden brown (Figure 4b), 120 for sunburst (Figure 4c), 94 for flame (Figure 4d), 35 for popsicle, 32 for gold, 27 for bronze and 21 for straw coloured iris. The light brown, chocolate, light bronze, fog, peach, silver, light gold, rich red, bronze with gold and brown comprised the other colours with less than ten chickens each possessing such colour. Among the roosters, those from Capiz had the highest ($p < 0.05$) occurrences of amber-coloured iris but comparable to those in Antique and Guimaras. The majority (49 percent) of roosters found in Iloilo had flame-coloured iris. Those in Negros Occidental had the highest ($p < 0.05$) occurrences of popsicle-coloured iris. The occurrences of amber coloured iris in hens ranged from 16 to 49 percent with those from Capiz having the highest ($p < 0.05$) and those from Iloilo having the lowest. Hens from Antique had prominently golden brown-coloured iris. Gold-coloured iris was somewhat higher among the hens found in Aklan.

The results on diversities of iris colour may be attributed to the interactions of melanin and carotenoids, ingestion and utilization of xanthophylls, and its correlation with other genes expressing colours to other parts of the chicken body. According to Smyth (1990), the iris colour was owing to the presence of melanin and carotenoids, such as the xanthophylls. Interactions during eye development brought changes in eye colour. The diversity in iris colour of hens can be attributed to the presence of carotenoids in ingested feeds and its utilization for egg yolk production. The brighter coloured iris of roosters can be because of excess carotenoids reacting with the melanin. In addition, eye colour was closely correlated with shank colour and can be modified by genes associated with plumage colour.

Similar studies conducted in the provinces of Seam Reap, Rattanakiri, Kampong Cham, Kampot and Odar Meanchey in Cambodia showed that 70.74 percent of the chickens had orange; brown, 10.20 percent; pearl, 15.42 percent and red, 3.48 percent iris colour (FAO, 2009). The findings of Duguma (2006) in Ethiopia showed that all their chickens had black-coloured eye. The observed differences were probably owing to the absence of standardized

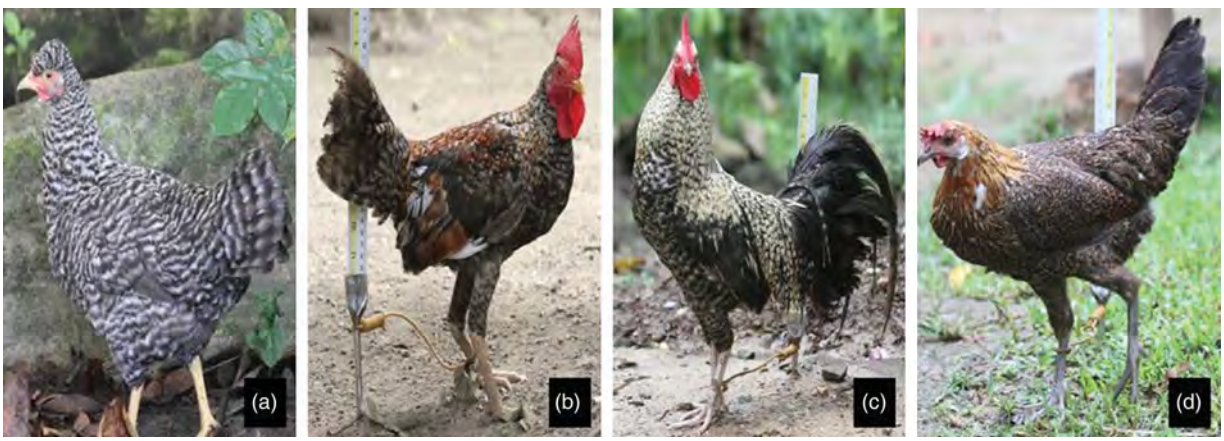

Figure 3. Variants of barred plumage colour pattern among traditional chickens: (a) female with white and black barred, (b) golden barred rooster, (c) silver barred rooster and (d) autosomal barring in pencilled-brown hen.

Table 3. Distribution of traditional chickens from different provinces of Western Visayas, Philippines as to their iris colour.

Colours	Chickens from											
	Aklan		Antique		Capiz		Guimaras		Iloilo		Negros Occidental	
	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%
Males[1]												
Amber	12	27^{c}	19	42^{ab}	25	56^{a}	22	49^{a}	6	13^{c}	13	29^{b}
Bronze	0	0	1	2	1	2	3	7	0	0	1	3
Flame	6	13^{c}	10	22^{b}	3	7^{c}	0	0^{c}	22	49^{a}	10	22^{b}
Gold	3	7	1	3	1	2	0	0	0	0	2	4
Golden brown	3	6^{c}	5	11^{b}	1	2^{d}	3	7^{c}	13	29^{a}	2	4^{d}
Popsicle	7	16^{b}	5	11^{c}	2	4^{c}	0	0^{e}	1	2^{d}	10	22^{a}
Straw	0	0^{b}	0	0^{b}	0	0^{b}	5	11^{a}	1	2^{b}	0	0^{b}
Sunburst	8	18^{a}	4	9^{b}	11	24^{a}	11	24^{a}	1	2^{c}	6	13^{a}
Others	6	13	0	0	1	3	1	2	1	3	1	3
Females[1]												
Amber	27	30^{b}	35	39^{b}	44	49^{a}	42	47^{a}	14	16^{c}	26	29^{b}
Bronze	5	6	0	0	6	7	5	6	0	0	5	6
Flame	4	4^{c}	10	11^{b}	2	2^{c}	3	3^{c}	21	23^{a}	3	3^{c}
Gold	10	11	0	0	5	6	1	1	6	7	3	3
Golden brown	24	27^{c}	37	41^{a}	8	9^{d}	7	8^{d}	33	37^{b}	26	29^{c}
Popsicle	3	3	2	3	1	1	0	0	2	2	2	2
Straw	0	0^{b}	0	0^{b}	2	2^{a}	8	9^{a}	2	2^{a}	3	3^{b}
Sunburst	16	18^{b}	3	3^{d}	18	20^{a}	18	20^{a}	9	10^{c}	15	17^{b}
Others	1	1	3	3	4	4	6	7	3	3	7	8

[1]The occurrences of iris colour across provinces with no common letter superscript are different ($p < 0.05$); those without letter superscript are not different ($p > 0.05$).

characterization guide for traditional chickens. The phenotypic characterization guide drafted by FAO was released only in November 2010 (FAO, 2012).

Earlobe and skin colours

Table 4 exhibits the distribution of traditional chickens from different provinces of Western Visayas, Philippines in terms of earlobe and skin colour.

Earlobe colours

As reported, 57.41 percent of the characterized chickens had red with white earlobes. About 37.53 percent had red, 2.22 percent had white and 1.85 percent had turquoise earlobes. The remaining percentages comprised chickens with black, black with red and yellow earlobes. The distribution of roosters with red earlobe ranged from 60 to 84 percent. Those from Guimaras had the highest ($p < 0.01$) occurrence, but is almost the same with those found in Antique and Negros Occidental. This was followed by those in Iloilo, Capiz and Aklan. The distribution of chickens possessing red with white earlobes was comparable across provinces except for those in Guimaras. Hens from Capiz had the highest ($p < 0.01$) distribution of red with white earlobes. However, this was almost similar to those observed in Aklan, Antique, Iloilo and Negros Occidental. Hens from Guimaras had the lowest (64 percent) distribution of red with white earlobes, but had the highest ($p < 0.01$) distribution of chickens with red earlobes.

Figure 4. The four iris colours of traditional chickens with larger occurrences: (a) rooster with amber, (b) hens with golden brown, (c) hen with sunburst and (d) hen with flame-coloured iris.

Table 4. Distribution of traditional chickens from different provinces of western Visayas, Philippines as to their earlobe and skin colour.

Parameters	Chickens from											
	Aklan		Antique		Capiz		Guimaras		Iloilo		Negros Occidental	
	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%
Males[1]												
Earlobe colour												
Red w/white	14	31[a]	9	20[a]	15	33[a]	7	16[b]	9	20[a]	9	20[a]
Red	27	60[d]	33	73[a]	28	62[c]	38	84[a]	32	71[b]	34	76[a]
Others	4	9	3	7	2	5	0	0	4	9	2	4
Skin colour												
White	30	67[a]	32	71[a]	24	53[a]	10	22[c]	24	53[a]	22	49[b]
Yellow	15	33[d]	13	29[e]	21	47[c]	35	78[a]	21	47[c]	22	49[b]
Black	0	0	0	0	0	0	0	0	0	0	1	2
Females[1]												
Earlobe colour												
Red w/white	67	74[a]	65	72[a]	76	84[a]	58	64[b]	68	76[a]	68	76[a]
Red	15	17[b]	23	26[a]	12	13[b]	31	34[a]	17	19[b]	14	16[b]
Others	8	9	2	2	2	3	1	2	5	5	8	8
Skin colour												
White	72	80[a]	74	82[a]	65	72[a]	38	42[c]	73	81[a]	64	71[b]
Yellow	16	18[c]	16	18[c]	25	28[b]	52	58[a]	17	19[c]	24	27[b]
Black	2	2	0	0	0	0	0	0	0	0	2	2

[1]The occurrences of earlobe and skin colours across provinces are different ($p < 0.01$); those with no superscript are not different ($p > 0.05$).

The variety of earlobe colours can be because of ancestral lineages and mutations. According to Ohta *et al.* (2000) and Nishida *et al.* (2000), there were possibilities of hybridization between the sub-species of *Gallus gallus* 1000 years ago. For example, *bankiva*, *murghi* and *gallus* which have white earlobes could have crossed with the *jabouillei* and *spadecius,* which had red earlobes. Smyth (1990) explained that the white pigment present in the earlobe was made of purine bases and not of melanin or carotenoid. It was inherited as a polygenic trait. The possibility of mutations on genes responsible for the expression of melanin and carotenoids were also considered given the occurrences of other earlobe colours.

In a similar study conducted in Cambodia, 82 percent of traditional chickens had red with white earlobes (FAO, 2009). This was followed by 12.16 percent having red with yellow, 2.82 percent having blue or turquoise, 2.26 percent having white and 0.2 percent having red coloured earlobes. The observation in Ethiopia showed that 67.0 percent had white, 17.9 percent had red with white, 18.6 percent had red and 0.7 percent had black earlobes (Duguma, 2006). The trends of red with white earlobes in Cambodia were similar to that of the present study. The findings on distributions of other earlobe colours were different from those in the cited studies. Probably, these differences were owing to adaptability of chickens with specific earlobe colour to local conditions. This pigmentation in the earlobes serves as thermoregulatory by absorbing or radiating solar radiation away from the body (Stettenheim, 2000; Egahi *et al.*, 2010). The occurrences of black and yellow earlobes indicate that this event is not only true in the Philippines but also in countries like Ethiopia and Cambodia.

Skin colour

Results showed that 65.19 percent of the 810 characterized chickens had white skin (Table 4). This was followed by 34.20 percent with yellow skin and the remaining percentages had black skin. The highest ($p < 0.01$) distribution of white skin was observed among the roosters in Aklan, Antique, Capiz and Iloilo. Those in Guimaras were top ($p < 0.01$) for having yellow skin. Equal distribution of white and yellow skin was detected in Negros Occidental. About 2 percent of the roosters in the said province had black skin. The distribution of white skin in hens ranged from 42 to 82 percent with those from Antique having the highest ($p < 0.01$) and those in Guimaras having the lowest. However, hens in the latter province were notable for having yellow skin. Equal proportion (2 percent) of hens in Aklan and Negros Occidental had black skin.

The diversity in skin colour may be owing to hybridization of parental lineages, mode of inheritance and mutations in genes responsible for colouration. Eriksson *et al.* (2008) found out that yellow skin did not originate from red junglefowl (*G. gallus*) for it had white skin. They pointed out that yellow skin was inherited from the grey junglefowl (*Gallus sonneratii*) and Ceylon junglefowl (*Gallus lafayettii*) which hybridized with red junglefowl. This hybridization took place in captivity mediated by man for certain purposes (Collias and Collias, 1967; Morejohn, 1968; Ohta *et al.*, 2000; Nishibori *et al.*, 2005; Pointer and Mundy, 2008; Silva *et al.*, 2008). The deposition of xanthophylls in the skin was governed by autosomal dominant white (W^+) and recessive yellow (w) alleles (Smyth, 1990). This may explain the dominant distribution of chicken with white skin in the region. The mechanism in the expression of white skin was because of beta-carotene dioxygenase 2 (*BCDO2*)

enzymes, which prevent the transfer of xanthophylls by converting it into colourless apocarotenoids in skin but not in other tissues (Eriksson *et al.*, 2008). Smyth (1990) added that the white and yellow skin phenotypes can be accurately determined when chickens reached the age of 12-weeks-old and beyond. This was because of the delayed deposition of xanthophylls in the skin after hatching. Moreover, molecular studies showed that the skin colouration was because of mutations in tyrosinase (*TRY*) genes. According to Chang *et al.* (2006), mutation in intron 4 of *TRY* gene was the cause of recessive white mutation in chickens. Zhang *et al.* (2009) added that exon-1 and 5′ flanking region of *TYR* gene can be responsible for the different flesh colours among chickens.

In a similar study conducted in Sonla province of Northwest Vietnam and Ethiopia, the proportions of skin colours were different from the present observations. It showed that 94.71 percent of the local chickens in Vietnam had yellow skin, whereas 5.29 percent had black skin (Cuc *et al.*, 2006). The trending for yellow skin was similar to those recorded in Ethiopia. Dana *et al.* (2010b) reported that 52 percent of the indigenous chickens had yellow skin and 48 percent had white skin. The observed differences in the distribution of occurrences is probably because of the fitness of chicken with yellow skin in the place; proximity of these places to areas where the *G. sonneratii* (India) and *G. lafayettii* (Sri Lanka) were believed to have originated (Eriksson *et al.*, 2008), and abundance of naturally occurring feedstuffs rich in carotenoids (Smyth, 1990).

Shank colour

Table 5 presents the distribution of traditional chicken from different provinces of Western Visayas, Philippines as to shank colour. Out of 810 characterized chickens, 265 had yellow shank. This was followed by 200 with white, 186 with slate, 116 with willow, and the remaining had black, black with yellow, yellow with red and dark orange-coloured shank. The roosters in Guimaras had the highest ($p < 0.05$) proportion of yellow shank, but comparable to those in Antique and Negros Occidental. Those in Aklan had the highest proportion of white-coloured shank. The same percentage (38 percent) of roosters in Capiz had yellow and white shank. About 22 percent of roosters in Iloilo possessed a willow-coloured shank. Occurrences of slate shanks in hens were comparable across provinces. The highest ($p < 0.05$) percentages of those with yellow and willow shank were observed in Guimaras. Hens from Aklan were prominent for having white-coloured shanks.

The diversity in shank colour can be owing to interactions of major and modifier genes as pointed out by Smyth (1990). This was controlled by *dermal melanin* (id^+) *inhibition of dermal melanin* (*Id*), *black extension factor* (*E*) and *autosomal white* (W^+) genes located in the Z chromosome. *Id* and id^+ expression were confined in the dermis, whereas *E* and W^+ in the epidermis. He added that homozygosity to *E* in chickens will express black shank. The interactions of id^+ and *E* with dominant white (*I*) chickens will express slate or willow shank. The presence of sex-linked barring, mottling and wheaten genes will inhibit the expression of id^+. Barring makes the pigmentation of shank lighter in rooster than hen, whereas mottling expressed small black spots in white shank. The presence of W^+ interacting with melanin will appear as blue or slate shank and the *w* for green or willow. Yellow shank was because of the interaction of homozygous recessive for *w* and e^+ with homozygous *Id*, whereas white shank was brought about by the accumulated effects of W^+/W^+ *Id/Id* e^+/e^+. According to Onibi, Folorunso and Elumelu (2008), the addition of carotene-rich feedstuffs to chicken ration further enhanced yellow pigmentation of the shank.

The trend in occurrences of shank colour was closer to the findings of similar studies conducted in Cambodia where

Table 5. Distribution of traditional chickens from different provinces of Western Visayas, Philippines as to their shank colour.

Colour	Chickens from											
	Aklan		Antique		Capiz		Guimaras		Iloilo		Negros Occidental	
	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%
Males[1]												
Willow	3	6^c	6	13^a	5	11^b	4	9^c	10	22^a	6	13^a
Slate	8	18	7	16	3	6	3	7	5	11	8	18
Yellow	13	29^c	21	47^a	17	38^b	29	64^a	17	38^b	18	40^a
White	17	38^a	10	22^b	17	38^a	7	16^c	13	29^a	13	29^a
Others	4	9	1	2	3	7	2	4	0	0	0	0
Females[1]												
Willow	7	7^c	16	18^b	11	13^b	26	29^a	15	16^b	7	8^c
Slate	27	30	30	33	21	23	10	11	32	36	32	36
Yellow	14	16^c	28	31^a	21	23^b	40	44^a	25	28^a	22	24^a
White	32	36^a	16	18^c	24	27^a	12	13^d	18	20^b	21	23^a
Others	10	11	0	0	13	14	2	3	0	0	8	9

[1]The occurrences of earlobe and skin colours across provinces are different ($p < 0.05$); those with no superscript are not different ($p > 0.05$).

48.64 percent had yellow, 17.82 percent had grey-blue, 13.44 percent had white, 11.22 percent had green and 8.70 percent had black-coloured shank of their traditional chicken (FAO, 2009). Yellow-coloured shank also had the highest distribution in Dekina, Nigeria. Daikwo, Okpe and Ocheja (2011) reported that 40.50 percent of the local chickens in this place had yellow shank. This was followed by 37.25 percent having black with yellow, 13.75 percent having black and 8.50 percent having white-coloured shank. Unlike in Vietnam, it was reported that 95.59 percent of H'mong chickens had black and 4.41 percent had yellow shank (Cuc *et al.*, 2006). The observed differences in the distribution of yellow-coloured shank in the present study and those in Cambodia and Dekina, Nigeria with the H'mong chickens of Vietnam, is possibly because of genes and selection practices of raisers. According to Cuc *et al.* (2006), these local chickens were noted for having yellow skin and black meat and shank. Raisers deliberately select these characteristics because of their medicinal attribute. Those raisers in other mentioned countries focused more on the economic performance of traditional chickens and less regard on the colouration and pigmentation.

Head and body shapes

Table 6 highlights the distribution of traditional chickens from different provinces of Western Visayas, Philippines as to their head, breast and body shapes.

Head shape

Results show that 64.69 percent of the traditional chickens had snake-like heads, whereas 35.31 percent had flat-shape heads. Figure 5 shows the variations in head shapes of traditional chickens. The data further show that roosters from Guimaras had the highest proportion of snake-like head but comparable to those in Iloilo. This was followed by 87 percent in Capiz and same percentages (71 percent) in Aklan and Antique. The roosters in Negros Occidental had the highest percentage (38 percent) for flat head. Hens from Aklan, Antique and Negros had the highest ($p < 0.05$) percentages for flat head, whereas those in Guimaras and Iloilo had the highest for snake-like head. Those in Capiz had an equal distribution of flat and snake-like head. Variations in head shape were probably because of genes and their possible pleiotropic effects on the growth rate. It was observed that chicken with snake-like head were heavier than those with flat head. Only limited published information dealing with head shape are available and further studies should be conducted to verify its correlation with live weight.

In similar studies conducted in Amhara, Benshangul Gumuz, Oromia and southern regions of Ethiopia, 46 percent had flat, 34 percent had crest and 20 percent had snake-like head (Dana *et al.*, 2010b). The observed differences in distribution may be because of the classification of different head shapes. It was suggested by the FAO (2012) that head shapes should be either snake-like or flat shapes. Crested head was classified under the category of feather distribution which was adapted in the present study. The study of Dana *et al.* (2010b) was conducted before the release of draft guidelines.

Body shape

The findings reveal that 66 percent of the 810 characterized chickens had wedge-shaped bodies, whereas the remaining percentage had blocky bodies (Table 6). The highest ($p < 0.05$) distribution of roosters with wedge-shaped body was observed in Antique. This was followed by same percentage (69 percent) in Iloilo and Negros Occidental. Those

Table 6. Distribution of traditional chickens from different provinces of Western Visayas, Philippines as to their head and body shapes.

Parameters	Chickens from											
	Aklan		Antique		Capiz		Guimaras		Iloilo		Negros Occidental	
	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%
Males												
Head shape[1]												
Flat	13	29[a]	13	29[a]	6	13[b]	1	2[d]	5	11[c]	17	38[a]
Snake-like	32	71[c]	32	71[c]	39	87[b]	44	98[a]	40	89[a]	28	62[d]
Body shape[1]												
Blocky	17	38[a]	10	22[c]	24	53[a]	27	60[a]	14	31[b]	14	31[b]
Wedge	28	62[c]	35	78[a]	21	47[d]	18	40[e]	31	69[b]	31	69[b]
Females												
Head shape[1]												
Flat	64	71[a]	52	58[a]	45	50[b]	1	1[d]	15	17[c]	54	60[a]
Snake-like	26	29[e]	38	42[c]	45	50[b]	89	99[a]	75	83[a]	36	40[d]
Body shape[1]												
Blocky	31	34[a]	13	14[c]	42	47[a]	34	38[a]	29	32[b]	19	21[c]
Wedge	59	66[c]	77	86[a]	48	53[e]	56	62[d]	61	68[b]	71	79[a]

[1]The occurrences of head and body shapes with no common superscript are different ($p < 0.05$); those with no superscript are not different ($p > 0.05$).

Figure 5. The variations of head shape of traditional chickens: (a) single comb rooster with flat head, (b) single comb rooster with snake-like head, (c) single comb hen with flat head, (d) single comb hen with snake-like head, (e) pea comb rooster with snake-like head, (f) pea comb hen with snake-like head, (g) pea comb hen with flat head and (h) pea comb rooster with flat head.

in Guimaras had the highest distribution for blocky-shaped body but comparable to those in Capiz and Aklan. Hens from Antique and Negros Occidental had the highest ($p < 0.05$) proportion of wedge-shaped body. This was followed by 68 percent in Iloilo, 66 percent in Aklan, 62 percent in Guimaras and 53 percent in Capiz. Those in Capiz were prominent for hens having blocky body but comparable to those in Aklan and Guimaras.

Somes (1990a) reported that the variation in body conformation was because of the accumulated expression of body size genes, specific body part genes and genes responsible for the development of muscular tissues. He added that the wedge-shaped body was brought about by natural selection considering that raisers did not put emphasis on their selection. This shape reduces air friction when the bird is flying. Scarce information related to this phenotypic trait was observed.

The results of this study were different from the observations of Dana *et al.* (2010a) among the indigenous chickens in Ethiopia. They reported that 87 percent of their chickens had blocky, 9 percent had triangular and 4 percent had wedge-shaped body. These differences may be attributed to multigenes interactions, environmental conditions, available resources and management practices of raisers in each country.

Comb type and live weight

Table 7 shows the distribution of traditional chickens from different provinces of Western Visayas, Philippines as to comb type and live weight.

Comb type

Slightly more than half (50.49 percent) of the characterized chickens had single comb (Figure 6a). This was followed by 40.12 percent with pea comb (Figures 6b and 6c). The remaining percentages had rose (Figure. 6d), strawberry (Figure 6e and 6f), walnut (Figure 6g) and buttercup comb (Figure 6h). Roosters in Aklan and Capiz had the highest ($p < 0.05$) distribution of single comb. This was followed by same percentage (53 percent) of those found in Antique and Negros Occidental. Highest ($p < 0.05$) distribution of roosters with pea comb was in Guimaras. Those in Iloilo were prominent for occurrences of strawberry comb. Highest ($p < 0.05$) frequencies of hens with single comb was observed in Aklan and Capiz, whereas those in Guimaras and Antique top the distribution for pea comb. Hens found in Iloilo and Negros Occidental were intermediate for the occurrences of single and pea comb.

The dissimilarity in the occurrences of comb types may be attributed to interactions of different genes responsible for its expression. Somes (1990b) pointed out that single comb (p^+) was inherited by domesticated chickens from the *G. gallus*, *G. sonnerati* and *Gallus lafayettei*. Number of points in the comb was owing to the presence of genes for rugged rose comb (He^+). According to Duguma (2006) single comb was dominant among traditional chickens in tropical regions for it helps reduce 40 percent of body heat. These clarify as reason for its dominant occurrence in the region. On the other hand, the crosses between pea and rose comb chickens produce offsprings possessing walnut and strawberry combs. Chicken with buttercup

Table 7. Distribution of traditional chickens from different provinces of Western Visayas, Philippines as to comb type and live weight.

Parameters	Chickens from											
	Aklan		Antique		Capiz		Guimaras		Iloilo		Negros Occidental	
	freq	%	freq	%	freq	%	freq	%	freq	%	freq	%
Males[1]												
Comb type[1]												
Single	34	76^{a}	24	53^{b}	34	76^{a}	9	20^{d}	22	49^{c}	24	53^{b}
Pea	9	20^{c}	6	13^{d}	10	22^{b}	33	73^{a}	6	13^{d}	17	38^{b}
Strawberry	1	2^{b}	4	10^{a}	1	2^{b}	2	4^{b}	10	22^{a}	1	2^{b}
Others	1	2	11	24	0	0	1	3	7	16	3	7
Live weight (kg)[2]	1.54 ± 0.08^{d}		1.79 ± 0.08^{bc}		1.96 ± 0.10^{ab}		2.04 ± 0.06^{a}		1.74 ± 0.07^{bc}		1.67 ± 0.06^{cd}	
Females[1]												
Comb type[1]												
Single	66	73^{a}	27	30^{c}	63	70^{a}	15	17^{d}	48	53^{b}	43	48^{b}
Pea	18	20^{c}	52	58^{a}	25	28^{c}	70	78^{a}	35	39^{b}	44	49^{b}
Strawberry	3	4	2	2	0	0	4	4	4	4	3	3
Others	3	3	9	10	2	2	1	1	3	4	0	0
Live weight (kg)[2]	1.14 ± 0.03^{c}		1.22 ± 0.03^{bc}		1.31 ± 0.04^{ab}		1.41 ± 0.04^{a}		1.33 ± 0.03^{ab}		1.23 ± 0.03^{bc}	

[1]The occurrences of comb type across provinces are different ($p < 0.05$); those with no superscript are not different ($p > 0.05$).
[2]The differences in live weight across provinces with no common superscript are different ($p < 0.01$).

comb had wider nostril and was found to be incompletely dominant (Somes, 1990b; Wright *et al.*, 2009; Dorshorst, Okimoto and Ashwell, 2010). Other related information about walnut and buttercup comb is limited.

The results on the trends of distribution of single comb were quite similar to the findings of Egahi *et al.* (2010) in Markudi, Nigeria but different from those reported by Dana *et al.* (2010b) in Ethiopia. Previous researchers reported that 43.33 percent had single, 23.33 had pea, 15.56 percent had walnut and 17.78 percent had rose comb, whereas the latter claimed 53 percent had pea, 16 percent had rose, 13 percent had single, 13 percent had duplex and 6 percent had walnut. The observed differences may be because of the prevailing conditions in the place and the frequency of genes carrying such comb expression as elaborated above (Somes, 1990b; Duguma, 2006).

Figure 6. The variations of comb types among traditional chickens: (a) rooster with single comb, (b) hen with smaller pea comb, (c) rooster with larger pea comb, (d) rooster with rose comb, (e) rooster with strawberry comb, (f) rooster with inverted strawberry comb, (g) hen with walnut comb and (h) rooster with buttercup comb.

Live weight

Roosters from Gumaras have the highest ($p < 0.01$) mean live weight of 2.04 ± 0.06 kg but not significantly different ($p > 0.05$) from those in Capiz (Table 7). Those in Aklan weighing 1.54 ± 0.08 kg were the lightest. The mean live weights of rooster from Antique (1.79 ± 0.08 kg), Iloilo (1.74 ± 0.07 kg) and Negros Occidental (1.67 ± 0.06 kg) were comparable. Results also show that the mean live weight of hens from Guimaras (1.41 ± 0.04 kg) was the highest ($p < 0.01$); however, it is close in comparison with those in Capiz (1.31 ± 0.04 kg) and Iloilo (1.33 ± 0.03 kg). The lowest mean live weight of 1.14 ± 0.03 kg was observed among the hens in Aklan. Those in Antique (1.22 ± 0.03 kg) and Negros Occidental (1.23 ± 0.03 kg) were of comparable weight.

The dimorphism in chicken started at egg cells before fertilization given the heterozygosity (ZW) of hens as governed by different genes and hormones (Johnson, 1988; Henry and Burke, 1998; Bannister *et al.*, 2009; Smith *et al.*, 2009; Zhao *et al.*, 2010; Parchami and Dehkordi, 2011). Remes and Szekely (2010) pointed out that the domestic roosters were 21.50 ± 0.55 percent heavier than hens. Consequently, the overall phenotypic expression follows the Rensch's rule that states males are larger than female in larger species and females are larger than males in smaller species (Colwell, 2000).

In addition, the bigger size of traditional chicken in Guimaras is probably because of genes. According to Erlinda Azuela (personal communication, 2011), these bigger and barbarous looking chickens were brought by Muslim sailors from Jolo a long time ago. They were used for cockfights or locally known as "pauwak" with native cocks raised by people in the place. The proliferation of "pauwak" enabled their ancestors to acquire more of these chickens for such activity. Through time, these traditional chickens from Jolo evolved and became adapted to the environment in Guimaras. The smaller size of traditional chicken in Aklan may be owing to the presence of predators in its wide forested area. The smaller body size allows them to be more flighty when in danger.

The live weight of roosters was comparable to those of other genetic groups of native chicken in the country. Avante and del Fierro (1991) reported that Paraokan weighed 2.0–2.5 kg, and the Banaba, Camarines and Bolinao had 1.5–2.0 kg live weight. The weight of hens ranged from 1.4 to 1.6 kg that was slightly higher than those in Western Visayas. Observed differences were probably owing to the expression of genes associated with body weight.

Conclusions

Results show that traditional chicken from Guimaras had amber iris, yellow skin and shank, snake-like head, pea-comb and heaviest. Those from Antique had wedge-shaped body, whereas those from Aklan had the lightest live weight and possessing single-comb. Thus, the traditional chicken from the different provinces except for Iloilo, Capiz and Negros Occidental of western Visayas was morphologically distinct.

Supplementary material

Supplementary online material is available at http://cambridge.journals.org/AGR.

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Statement of interest

The authors hereby declare that there is no conflict of interest involved in this study.

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Caractérisation morphologique de la chèvre rousse du Niger

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Résumé
Cette étude a pour but de fournir des données sur les caractéristiques physiques de la chèvre rousse de Maradi. Elle a été effectuée au centre caprin et dans 4 départements de la région de Maradi selon la position géographique (Tessaoua à l'Est, Dakoro au Nord, Madarounfa au Sud, Guidan Roumdji à l'Ouest). Ce travail a été réalisé sur 339 animaux dont 77 au centre, 88 à l'Est, 69 au Nord, 50 au Sud et 55 à l'Ouest. Elle a porté sur les mesures corporelles suivantes: hauteur au garrot, longueur scapulo-ischiale, tour de poitrine, longueur du dos, longueur des cornes, des oreilles et de la tête, la présence de pendeloques et de barbiches, la couleur de la robe et la structure du poil. Les résultats ont mis en évidence, des différences entre les variables corporelles mesurées, liées à la position géographique. En effet, la position géographique a influencé significativement l'indice de gracilité sous sternal (IGS) et l'indice auriculaire thorax (IAT) ($P < 0{,}0001$). La dominance de la couleur rousse est considérée comme un caractère d'adaptation des caprins de Maradi. Enfin, notre contribution à la définition du standard des caprins roux de Maradi peut se résumer comme une population, de format moyen, avec des oreilles courtes et dressées, deux cornes (plus développées chez le mâle) inclinées vers l'arrière, le poils ras et une présence de barbiche (barbe développée chez le mâle) dans les deux sexes. Seulement 2,4% de la population porte des pendeloques, chez les deux sexes, surtout à l'Est de Maradi (Tessaoua).

Mots-clés: *chèvre rousse, Maradi, biométrie, phénotype, caractérisation*

Summary
This study aims to provide data on the physical profiles of the red goat of Maradi. It was conducted in the centre of the goat's main territory, and further comprised 4 departments of the Maradi area (Tessaoua in the east, Dakoro in the north, Madarounfa in the south and Guidan Roumdji in the west). This work was performed on 339 animals including 77 in the centre, 88 in the east, 69 in the north, 50 in the south and 55 in the west. It focused on the following measurements: height at withers, scapulo-ischial length, chest size, back length, length of the horns, ears and head, the presence of "pendeloques" and goatees, the coat color and structure of the hair. The results have shown differences between body variable measurements related to geographical position. In fact, the geographical position has significantly influenced body profiles, IGS and IAT indices ($P < 0.0001$). The dominant trend of the red color is probably an adaptation character of Maradi goats. Our contribution to define the standard of this breed of red goats should be summary as a population with medium size, short and erect ears, two horns (most developed in males) tilting back, short hair and the presence of a beard (beard developed in males) in both sexes. We also note the presence of "pendeloques" in some animals in the East of Maradi.

Keywords: *red goat, Maradi, biometrics, body profiles, characterization*

Resumen
Este estudio pretende aportar datos sobre los perfiles físicos del ganado caprino rojo de Maradi. El estudio fue llevado a cabo en el centro caprino y en 4 de los departamentos que conforman la región de Maradi (Tessaoua en el Este, Dakoro en el Norte, Madarounfa en el Sur y Guidan Roumdji en el Oeste). Este trabajo se realizó con 339 animales distribuidos de este modo: 77 en el centro de cría, 88 en el Este, 69 en el Norte, 50 en el Sur y 55 en el Oeste. El trabajo se centró en las siguientes medidas: altura a la cruz, longitud escápulo-isquial, perímetro torácico, longitud de la línea dorsal, longitud de los cuernos, orejas y cabeza, presencia de mamellas y perilla, color de la capa y estructura del pelo. Los resultados mostraron diferencias en las medidas corporales en relación con la localización geográfica de los animales. De hecho, la ubicación geográfica influyó de manera significativa sobre los perfiles corporales y los índices IGS e IAT ($P < 0{,}0001$). La tendencia dominante del color rojo es probablemente un rasgo adaptativo de las cabras Maradi. Nuestra contribución a la definición del estándar racial de la cabra roja de Maradi se puede resumir en que es una población de tipo eumétrico, con orejas pequeñas y erguidas, dos cuernos (más desarrollados en el macho) arqueados hacia atrás, pelo corto y presencia de barba en ambos sexos (barba desarrollada en el macho). Asimismo, hemos constatado la presencia de mamellas en algunos ejemplares del Este de Maradi.

Palabras clave: *cabra roja, Maradi, Biometría, perfiles corporales, caracterización*

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Introduction

Les espèces animales inventoriées au Niger sont nombreuses et les petits ruminants occupent la première place sur le plan numérique (Robinet, 1964). Selon Yénikoye (1986), on dénombre plus d'un petit ruminant par habitant alors que ce ratio est de 0,7 pour l'ensemble des pays africains au sud du Sahara, 0,4 pour l'ensemble du monde, et 0,6 pour toute l'Afrique. Les caprins occupent le premier rang en effectif dans le monde en général, et en Afrique en particulier. Au Niger, le cheptel caprin représente à lui seul 36,21% de l'effectif du cheptel nigérien qui se chiffre à 31,039,041 têtes (Ministère du Développement Agricole/Ministère des Ressources Animales, 2007).

L'étude sur les ressources génétiques caprines africaines n'a réellement commencé qu'au début du 20ème siècle alors que le processus de domestication date de 8,500 à 9,000 ans (Anonyme, 1999). Jusqu'à aujourd'hui, les animaux ne sont pas suffisamment caractérisés. Or, toute action d'amélioration des performances d'une population animale requière sa connaissance préalable; il importe donc de les caractériser sur le plan phénotypique, zootechnique et génétique.

Les travaux de certains auteurs (Bourzat *et al.*, 1992; Bourzat et Koussou, 1996) rapportés par le PROJET CHD/96/G31/B/IG/99 (1998) et portant sur la caractérisation de la race caprine au Tchad, ont été effectués à partir d'une typologie basée sur les critères suivants: les caractéristiques du pelage (laine ou poil long ou court), la taille de l'animal, la latitude géographique. Quant à Zeuh *et al.* (1997), ils se sont basés sur la hauteur au garrot, la profondeur du thorax et l'indice de gracilité sous sternale pour caractériser les caprins au Tchad. A ces paramètres, N'go Tama *et al.* 1994 ont ajouté l'indice auriculaire thorax pour caractériser les caprins au nord du Cameroun. S'inscrivant dans le cadre de la connaissance des caprins du Niger (Haumesser, 1975), la présente étude a pour but de fournir des données sur les caractéristiques physiques de la chèvre rousse de Maradi, en combinant ces différents critères.

Materiel et methodes

Présentation du milieu d'étude

La région de Maradi est située au centre du territoire du Niger (figure 1). Elle est comprise entre 13°02 de latitude Nord et 6°15 de longitude Est. La population a été estimée à 2,109,879 habitants en 1999, avec une densité de 50 habitants par km^2. Elle couvre une superficie de 38,500 km^2, soit 3% du territoire national, répartie en terres agricoles (71,5%) au Sud, pastorales (25%) au Nord et forestières (3,5%). Maradi dispose d'un effectif de 1,005,113 caprins toutes races confondues, dont la valeur monétaire est estimée à 11,191,933,255 francs CFA et la production laitière de l'ordre de 21,107.340 litres/an (DDRA Maradi, 2007).

Le climat de Maradi est du type sahélien au Nord et soudano sahélien au Sud. Les températures sont très élevées avec une moyenne de 27°C et la moyenne annuelle des précipitations est de 490 mm avec un minima de 4 mm en avril et un maxima de 172 mm en août (le voyageur.net). Trois saisons sont observées au cours de l'année : une saison sèche et chaude de mars à juin, une saison de pluie de juillet à octobre, une saison froide de novembre à février.

La végétation est composée essentiellement d'une strate herbacée de graminées annuelles avec prédominance de *Cenchrus biflorus* et présence d'espèces comme *Aristidia mutabilis, Eragrostis tremula*, et *Brachiara ramosa*. La

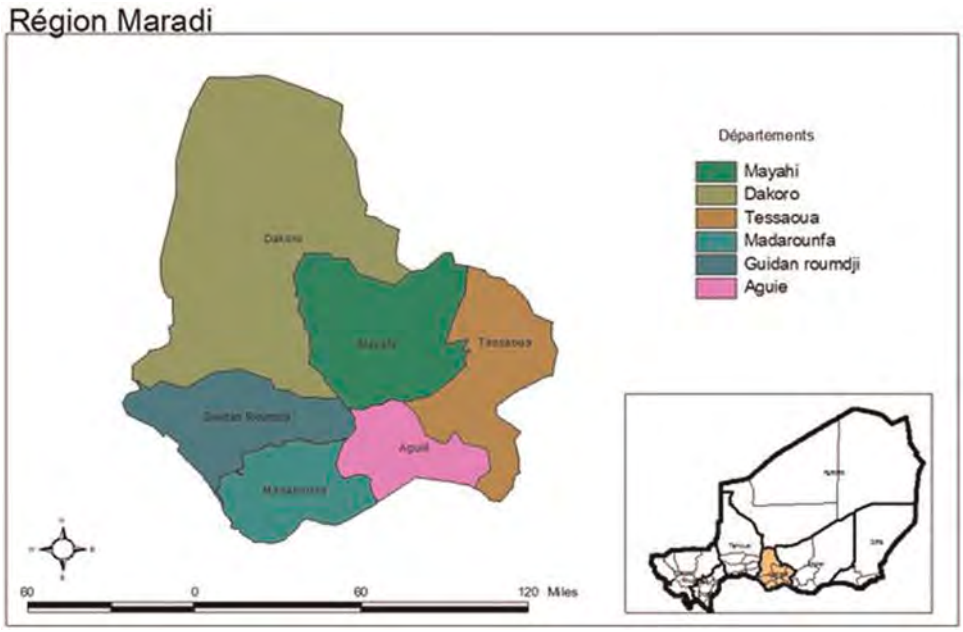

Figure 1. Les départements de la région de Maradi (une des 7 régions du Niger). Source: Chatelain (1987).

strate ligneuse, importante dans l'alimentation des caprins et camelins, est constituée de différents *Acacia, Combretum gluttinosum, Guiera senegalensis*, *Sclerocarya birrea, Zizyphus mauritania*. Au sud, *Acacia albida* est dominant.

Conduite de l'élevage caprin dans les zones de collecte de données

Au centre caprin

Le système d'élevage est de type moderne (existence de chèvreries régulièrement nettoyées, animaux identifiés par des boucles auriculaires et suivis sur le plan sanitaire, rotation de pâturage à l'intérieur du centre). La nuit, les animaux sont gardés dans les chèvreries sans catégorisation. Les géniteurs restent constamment dans le troupeau, le mode d'accouplement est libre.

L'alimentation est assurée en majeure partie par le pâturage naturel composé essentiellement de graminées notamment *Eragrostis tremula, Loudeta hordeiformis, Diheteropogon hagerupei, Andropogon gayanus, Ctenium elegans* et du pâturage aérien provenant des ligneux comme *Guiera senegalensis*, *Prosopis africana, Cochlospermum planchoni, Combretum, Sclerocarya birrea, Acacia*. Le temps de pâture est de 7 heures par jour en saison sèche et 8 heures en saison de pluie La complémentation est à base de graines de coton, fanes de niébé, feuilles d'arachide, son de blé et graines de sorgho, pendant 227 jours. L'accès à l'eau est libre.

Les vaccinations contre la peste des petits ruminants et la pasteurellose sont pratiquées chaque année. Le déparasitage contre les vers gastro-intestinaux se fait trois fois par an (en début, milieu et fin de saison pluvieuse). Quant au parasitisme externe (tiques, puces, poux,. . .), l'intervention se fait selon le cas signalé.

Dans les autres sites de collecte

Le système est semi-moderne. Les chèvres sont élevées par des groupements féminins organisés et encadrés par des agents d'élevage qui assurent le contrôle sanitaire des animaux. Pendant la saison des cultures, les animaux sont gardés au piquet (pendant 3 à 5 mois) dans les chèvreries traditionnelles. L'alimentation est assurée en grande partie par le pâturage aérien (*Guiera senegalensis*, *Prosopis africana),* des fanes de niébé, des tiges de mil, du sorgho. La complémentation se fait avec du son de mil sous forme de barbotage. Après les récoltes, les animaux sont libérés toute la journée sur les pâturages naturels et ramenés au piquet le soir.

Détermination de la taille de l'échantillon représentatif d'animaux

Ne disposant ni de l'effectif total des caprins roux au Niger, ni de la proportion que représenterait le cheptel roux de race pure de la région de Maradi, nous avons estimé que dans 90% des ménages de Maradi on trouve au moins une chèvre rousse de race pure. Ainsi en appliquant la formule ci-dessous (Durand, 2002), nous avons déterminé le nombre minimum d'individus (caprins roux) représentatifs pour constituer l'échantillon sur lequel porteront les différentes mesures à effectuer:

$$n = \frac{Z^2.p(1-p)}{\varepsilon^2}$$

Avec

n = taille minimale de l'échantillon

Z = valeur standardisée correspondant au niveau de confiance = 1,963 soit environ 2.

P = Proportion de ménage = 0, 9

$1 - P = 1–0, 9 = 0, 1$

ε = marge d'erreur qu'on est prêt à accepter en décimales = 0,05

Avec ces données, *n*calculé est égal à 144 chèvres, mais nous avons travaillé sur 339 animaux (femelles et mâles) qui est largement au dessus du nombre escompté.

Choix des animaux

L'étude a été entreprise au centre caprin de Maradi et dans 4 départements de la région de Maradi (Dakoro au Nord, Tessaoua à l'Est, Madarounfa au Sud, et Guidan Roumdji à l'Ouest). Dans ces localités, 3 à 5 femmes par groupement, possédant des chèvres et encadrées par le projet « appui à la promotion, la sélection et la diffusion de la chèvre rousse de Maradi », ont été choisies au hasard; les données ont été recueillies sur l'ensemble de leurs animaux et ceux du centre caprin. Au total 339 animaux dont 77 au Centre, 88 à l'Est, 69 au Nord, 50 au Sud et 55 à l'Ouest, ont été concernés. Le sondage a porté sur des animaux adultes ayant au moins 2 ans (au moins 2 dents adultes).

Collecte et analyse de données

Les mesures corporelles réalisées sur chaque animal, ont été la hauteur au garrot, la longueur scapulo-ischiale, le tour de poitrine, la longueur du dos, la longueur des cornes, des oreilles et de la tête, la présence de pendeloques et de barbiches, la couleur de la robe et la structure du poil (ras, long) et la structure du poil (ras, long), (figure 2).

Les indices biométriques ont été déterminés tels que décrits par N'go Tama *et al.* 1994:

– l'indice de gracilité sous sternal (IGS): c'est le rapport du vide sous sternal sur la profondeur du thorax.
– l'indice auriculaire thorax (IAT): longueur de l'oreille sur la profondeur du thorax.

Le choix de la profondeur du thorax au dénominateur des indices biométriques, est justifié par sa faible variation

Tableau 1. Caractéristiques des mensurations de la chèvre rousse de Maradi.

	Effectif	Minimum (cm)	Maximum (cm)	Moyenne (cm)	Std déviation
Hauteur au garrot	339	48	77	63.10	5.160
Longueur scapulo-ischiale	339	27	71	53.18	9.928
Tour de poitrine	339	41	84	68.48	6.413
Longueur du dos	339	28	68	43.00	5.052
Longueur tête	339	11	30	17.12	2.092
Longueur Oreille	339	7	18	12.81	1.392
Longueur corne	339	3	23	10.76	3.431
Profondeur thorax	339	22	35	28.85	2.214

d'une population à l'autre et par le fait qu'il permette de s'affranchir des variations de la longueur des jambes.

Les données biométriques ont été traitées par analyse de variance en comparant les moyennes des sites. Les fréquences des profils phénotypiques ont été également calculées selon la position géographique. Toutes les données ont été analysées à l'aide du logiciel d'analyse statistique "SPSS12" version 12 (Marija, 2004)

Resultats et discussion

Les données biométriques

Les moyennes des données biométriques de l'échantillon sont présentées sur le tableau 1.

Pour la hauteur au garrot et la longueur scapulo-ischiale qui sont les données biométriques influant directement sur la taille de l'animal, les figures 3 et 4 montrent respectivement la répartition des individus en fonction de ces paramètres.

Ces figures révèlent l'existence d'une population avec une distribution ayant plusieurs modes pour les caractères étudiés. Il y a donc une grande variabilité par rapport à ces paramètres. Elle est plus accentuée avec la longueur scapulo-ischiale. Ceci offre de grandes possibilités d'amélioration génétique.

Il a été déterminé pour tous ces paramètres biométriques, les moyennes selon la position géographique (tableau 2). Pour chacun des paramètres mesurés il apparait une différence significative selon la position géographique ($P < 0{,}05$). Les indices biométriques qui sont calculés permettent de préciser les différentes formes observées de l'animal.

Les indices biométriques

Les figures 5 et 6 représentent respectivement la distribution des animaux selon les indices biométriques IGS et IAT. La distribution de l'indice de gracilité sous sternal révèle une population avec une grande variabilité. L'IGS est en moyenne de $1{,}19 \pm 0{,}15$ avec un minimum de 0,69 et un maximum de 1,64. La variabilité au sein de la population selon l'indice IAT est moins accentuée par rapport à l'IGS, plus de 73% des individus ont un IAT compris entre 0,39 et 0,50. L'IAT moyen est de $0{,}44 \pm 0{,}05$ avec un minimum de 0,22 et un maximum de 0,58. On constate que l'IGS moyen de la chèvre rousse de Maradi est supérieure à celle de la chèvre au Nord du Cameroun

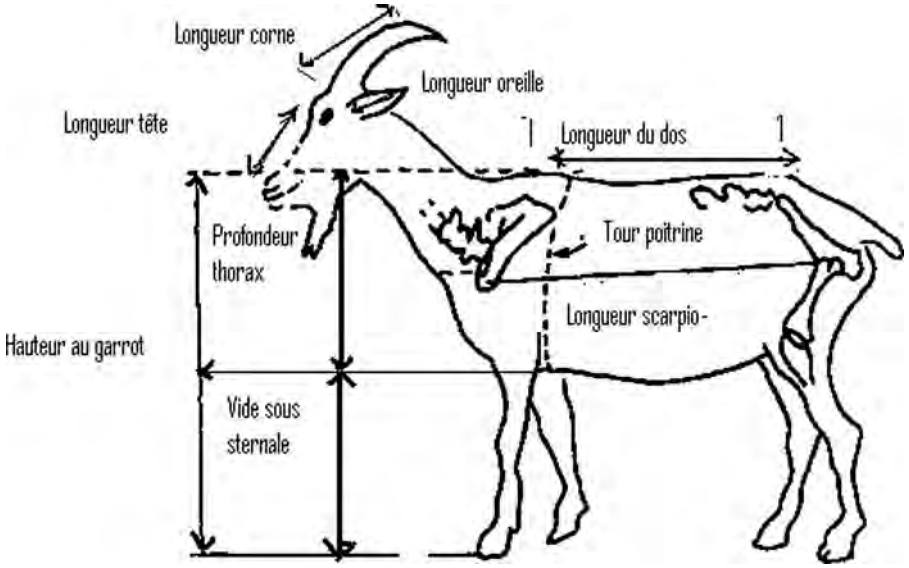

Figure 2. Positions des différentes dimensions mesurées sur le corps.

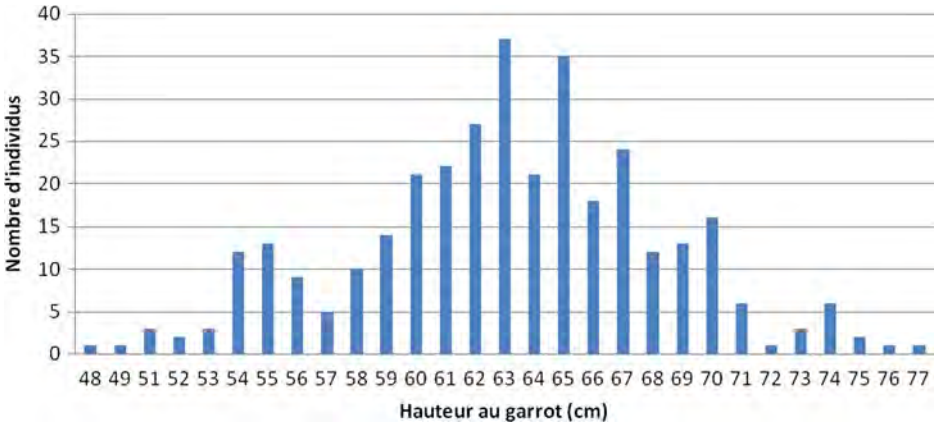

Figure 3. Répartition des individus selon la hauteur au garrot.

Tableau 2. Mensurations corporelles de la chèvre rousse de Maradi selon la position géographique.

	Hauteur au garrot	Longueur scapulo-ischiale	Tour de poitrine	Longueur du dos	Périmètre thorax	Longueur cornes	Longueur oreilles	Longueur tête
Centre	61.55[a]	55.38[b]	66.38[b]	40.14[a]	28.03[a]	9.6[c]	12.14[b]	17.74[c]
Est	64.58[b]	58.27[c]	70.61[a]	47.87[b]	29.03[b]	12[a]	13.43[a]	16.45[a]
Ouest	67.38c	60.13[c]	69.71[a]	42.13[a]	30.04[c]	11.64[a]	13.24[a]	19.47[b]
Nord	61.26[a]	36.72[a]	68.78[a]	41.09[a]	29.26[b]	11.64[a]	12.09[b]	15.95[a]
Sud	60.72a	55.86[b]	66.22[b]	42.4[a]	27.94[a]	8.2[b]	13.3[a]	16.34[a]

Le long de chaque colonne, les moyennes suivies des mêmes lettres ne présentent pas de différence significative. La différence est significative pour celles dont les lettres sont différentes ($P < 0,05$).

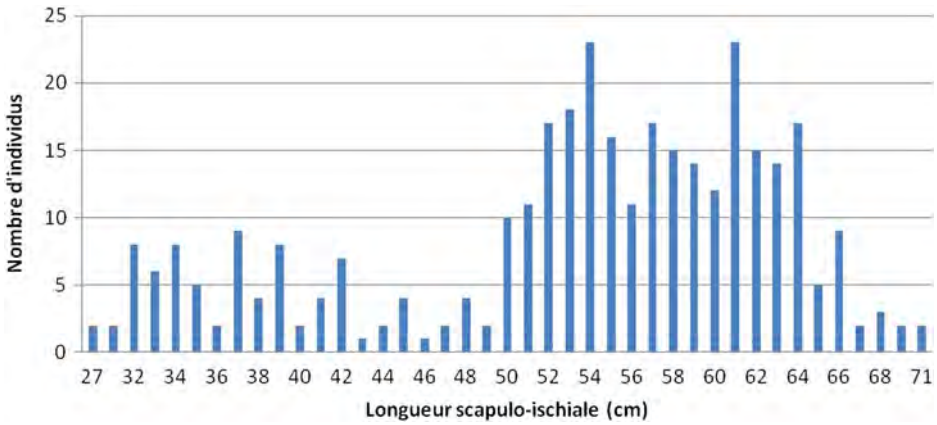

Figure 4. Répartition des individus selon la longueur scapulo-ischiale.

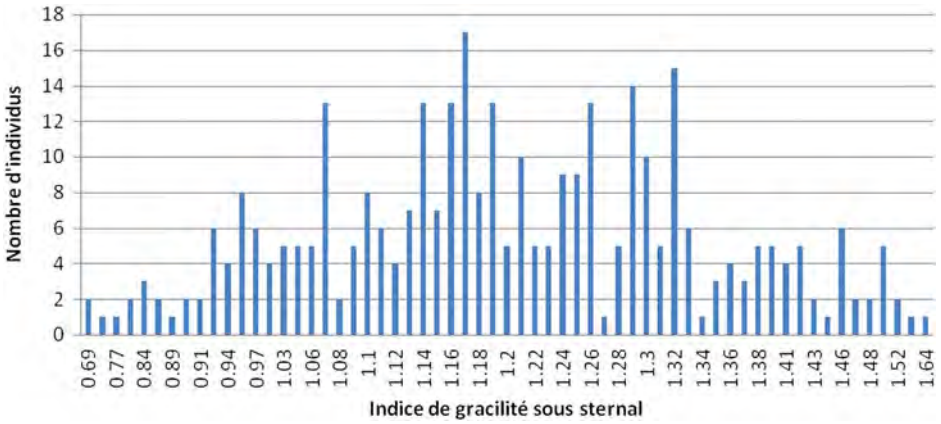

Figure 5. Répartition des individus selon l'indice de gracilité sous sternale.

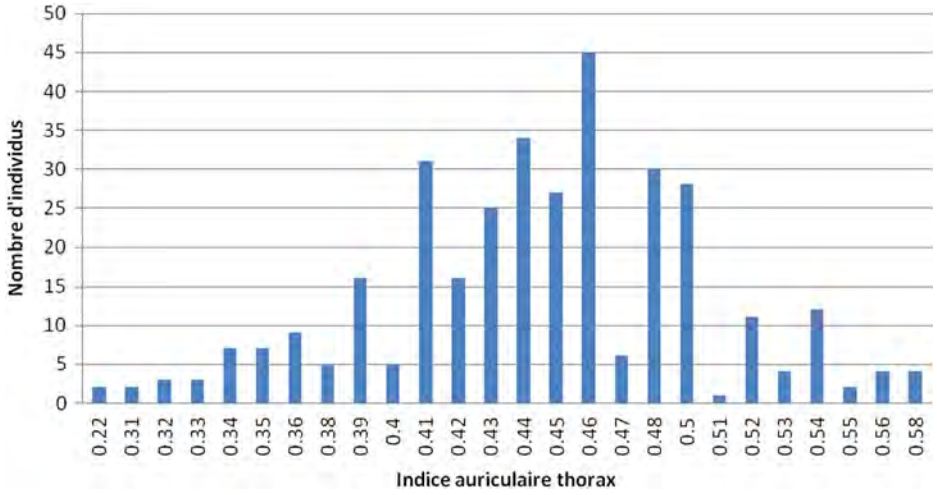

Figure 6. Répartition des individus selon l'indice auriculaire thorax.

(0, 87) (N'Go Tama *et al.*, 1994), alors que leur IAT sont comparables (respectivement 0,44 et 0,49).

Le tableau 3 rapporte l'IGS et l'IAT selon la position géographique. L'analyse de la variance en fonction de la position géographique de l'animal a montré que celle ci a une influence significative ($P < 0{,}0001$) sur les deux paramètres (IGS et IAT). Ainsi, les chèvres rousses du centre, de l'Ouest et de l'Est sont longilignes (IGS = 1,2) alors que celles du Nord et du Sud sont brévilignes (IGS = 1,1). Dans la région de Maradi la chèvre rousse se présente donc sous ces deux formats. Par rapport à l'IAT il est difficile de caractériser la chèvre rousse de Maradi puisque les indices sont homogènes à 0,4 dans toutes les zones géographiques.

Les profils phénotypiques

Les fréquences des autres phénotypes visibles (caractéristiques physiques) sont présentées dans le tableau 4.

La robe rousse domine à 74% (photos 1a et 1b) et la brune à 26% (photo 2a et 2b). Il faut noter que chez les éleveurs traditionnels dans les villages non encadrés par le projet, la variante noire (photos 3a et 3b) existe dans une grande proportion. Djariri (2005) a rapporté dans la région de Maradi : 22,7% de noirs, 38,5% de rousse, 12,9% de métisses et 25,9% de bariolées. Ainsi, la chèvre rousse de Maradi se présente sous trois robes différentes (rousse, brune, noire). Aussi, il faut noter qu'à l'âge adulte, certains sujets présentent sur la ligne dorsale des poils qui se rabattent sur les côtés.

La couleur des extrémités est généralement gris foncée (98,5%), rarement noire. Il existe une raie dorsale chez certains sujets (16,2%).

Les poils sont en général ras (96,8), mais des animaux à poils longs (photos 3b et 4) ont été rencontrés (3,2%), contrairement aux résultats de Doutressoule (1947) qui a rencontré uniquement des animaux à poils ras; cela laisse

Tableau 3. l'IGS et l'IAT en fonction de la position géographique.

Position géographique		IGS	IAT
Centre	Mean	1.2009	0.4326
	N	77	77
	Std déviation	0.12348	0.04572
Est	Mean	1.2333	.4630
	N	88	88
	Std déviation	0.13486	0.04275
Ouest	Mean	1.2469	.4415
	N	55	55
	Std déviation	0.13264	0.04275
Nord	Mean	1.0978	0.4154
	N	69	69
	Std déviation	0.18484	0.07374
Sud	Mean	1.1810	0.4786
	N	50	50
	Std déviation	0.17784	0.04664
Total	**Mean**	**1.1929**	**0.4452**
	N	**339**	**339**
	Std déviation	**0.15862**	**0.05576**

Tableau 4. Profil de la chèvre rousse de Maradi sur un effectif de 339 individus.

Caractères	Phénotype	Fréquence (%)
Oreilles port	Dressé	98.5
	Tombant	1.5
Cornes	Incliné vers l'arrière	75. 8
	Verticale	21.8
	Horizontale	2.4
pendeloque	Présence	2.4
	Absence	97.6
Poils	Long	3.2
	Ras	96.8
Raie dorsale	Présence	16.2
	Absence	83.8
Barbiche	Présence	24.2
	Absence	75.8
Couleur extrémités	Gris	98.5
	Noire	1.5
Robe	Rousse	74
	Brune	26

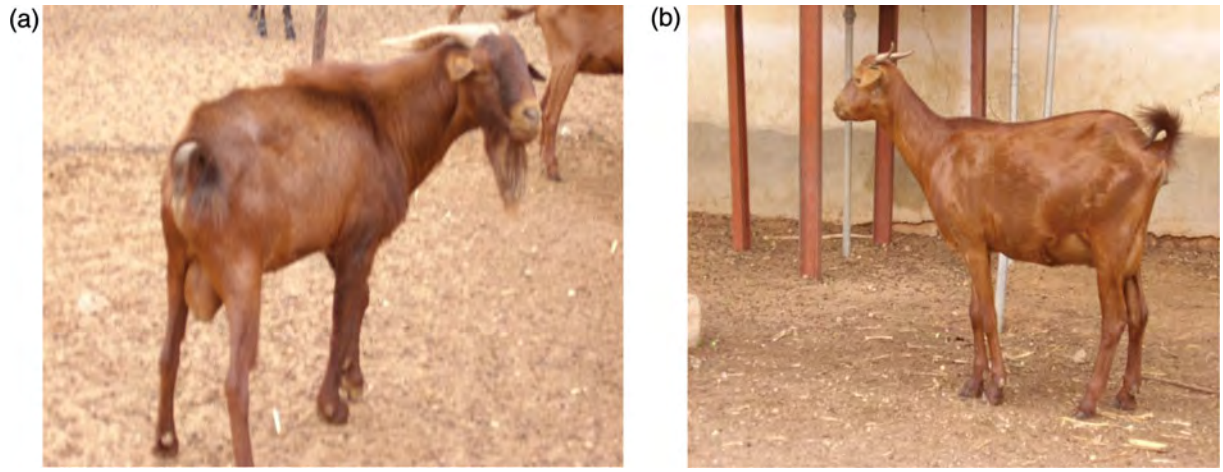

Photo 1. Caprins de Maradi à robe rousse et poils ras: bouc (a) et chèvre (b).

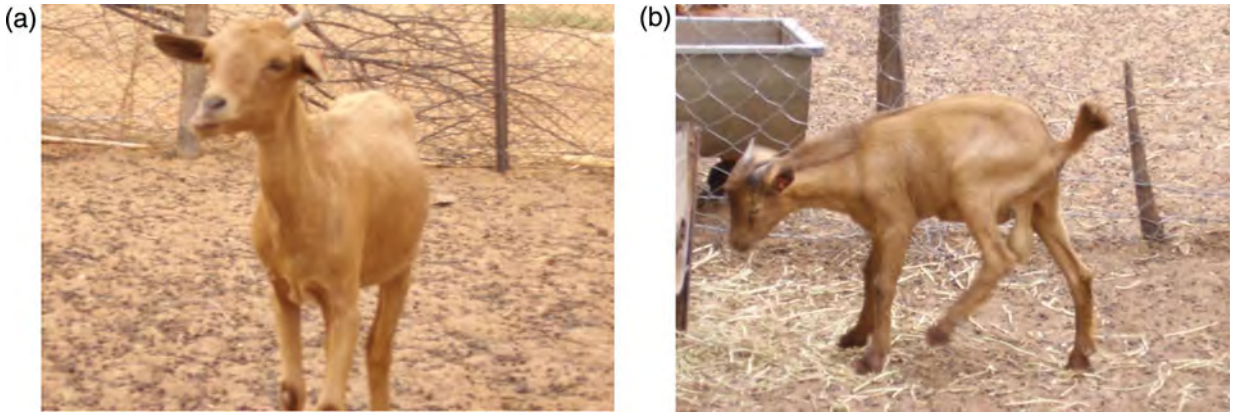

Photo 2. Chevreau de Maradi à robe brune (a et b).

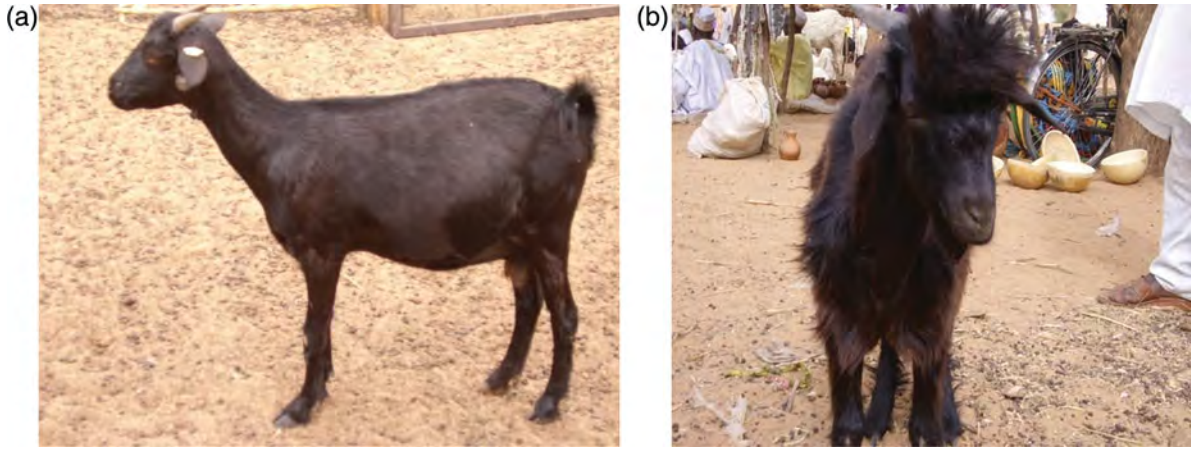

Photo 3. Caprin de Maradi à robe noire: chèvre à poils ras (a) et bouc à poils longs (b).

supposer certaines mutations chez les animaux suite aux importantes variations du milieu. Il est également possible que cela soit dû à un croisement.

Le taux de port dressé horizontal des oreilles qui est dominant à 98,5% à Maradi est comparable à celui des caprins du Nord du Cameroun (N'Go Tama *et al.*, 1994). Les oreilles sont rarement tombantes chez la chèvre rousse de Maradi (1,5%). Les cornes sont à 75,8% inclinées vers l'arrière et plus développées chez le mâle (photo 1a). Parfois on dénombre des cornes verticales présentant un

Photo 4. Chèvre de Maradi à robe rousse et poils long.

début d'inclinaison vers l'arrière. L'inclinaison des cornes est fonction de l'âge de l'animal (plus marquée chez les adultes de plus 5 ans). Aucun animal motte n'a été rencontré.

La barbiche existe dans les deux sexes (photos 1a et 5), mais elle est très développée chez le mâle; cependant, la fréquence n'est pas importante (24,2%). Ces observations sont différentes de celles rapportées par Ngo Tama *et al.*, 1994 et celles rapportées sur des animaux du bassin méditerranéen et du Brésil ayant une barbiche et une pampille. La faible fréquence obtenue dans cette étude, peut être due au fait que l'échantillon est composé de 308 femelles et 31 mâles (les mâles sont vendus très jeunes, les grands boucs sont rares). Seulement 2,4% de la population porte des pendeloques (photo 5), chez les deux sexes, surtout à l'Est de Maradi (Tessaoua).

Les mamelles sont très développées chez la femelle et certains auteurs (Doutressoule, 1947; Robinet, 1967, 1971) justifient cela par sa production laitière élevée (140 à 150 kg de lait pendant 200 à 220 jours). Les aplombs sont excellents (Robinet, 1967).

Photo 5. Chèvre rousse avec barbiche et pendeloques.

Au vu de tout ce qui précède, notre contribution sur la détermination du standard des caprins roux de Maradi peut se formuler comme une population de format moyen, avec des oreilles courtes et dressées, deux cornes (plus développées chez le mâle) inclinées vers l'arrière, le poils ras, une présence de barbiche (barbe développée chez le mâle) dans les deux sexes, la présence de pendeloques chez quelques individus des deux sexes, surtout à l'Est de Maradi (Tessaoua).

Conclusion

L'appellation « chèvre rousse de Maradi » semble limiter les acquis de la race. Il serait préférable de dire « la chèvre de Maradi » et préciser qu'elle se présente sous trois robes : la rousse, la noire, la brune. C'est un animal dont les mensurations corporelles varient en fonction du milieu.

La variabilité phénotypique de la taille au sein de la race offre dans un premier temps des possibilités de sélection en s'appuyant sur les souhaits des éleveurs. Ceci permet de dégager des populations homogènes sur lesquelles des croisements avec d'autres races peuvent être envisagés.

Remerciements

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Breed characteristics of Pattanam sheep of Tamil Nadu, India

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Summary
Pattanam is an important mutton-breed sheep of Tamil Nadu, India and is popular among the farmers for its heavy body weight. Despite its economic importance and distinct identity, this breed is not included in the list of descript sheep breeds at the national level, as it is not researched so far. Hence, a study has been made to document the habitat, distribution, physical traits, production and reproduction performances and the existing management practices of Pattanam sheep of Tamil Nadu, India. The preliminary study revealed that Pattanam sheep is a large-sized breed with compact body and uniformly creamy white in colour with black colour in the ventral region from the inner side of the jowl extending up to the inguinal region. Pure breed animals were distributed in the Paramakudi, Mudukulathur and Kamuthi taluks of Ramanathapuram district and Aruppukottai and Thiruchuli taluks of Virudunagar district of southern agroclimatic zone of Tamil Nadu, India. The means of body length, height at withers and chest girth in adult rams were 80.65 ± 0.49, 85.58 ± 0.58 and 93.65 ± 0.35 cm and in adult ewes were 70.05 ± 0.45, 72.80 ± 0.65 and 78.34 ± 0.35 cm, respectively. The body weight in adult rams and ewes were 51.50 ± 1.20 and 36.95 ± 0.51 kg, respectively. Pattanam sheep are used extensively for breeding purposes with other native breeds especially from Coimbatore, Kilakarsal and Ramnad White sheep of Tamil Nadu.

Keywords: *distribution, morphology, sheep, Pattanam*

Résumé
La race Pattanam est une importante race de moutons à viande du Tamil Nadu, en Inde, très prisée par les agriculteurs en raison de son poids corporel considérable. Malgré son importance économique et son identité particulière, cette race n'est pas incluse dans la liste nationale des races de moutons car, jusqu'à présent, elle n'avait pas encore été documentée. Par conséquent, on a réalisé une étude pour décrire l'habitat, la distribution, les caractères physiques, les performances de production et de reproduction et les pratiques existantes de gestion de cette race. L'étude préliminaire a indiqué que les moutons Pattanam présentent une taille considérable et un corps trapu. La couleur blanc crème est uniforme, avec du noir dans la partie abdominale, de la gorge jusqu'à la zone inguinale. Les animaux de race pure ont été distribués dans les taluks de Paramakudi, Mudukulathur et Kamuthi du district de Ramanathapuram et dans les taluks d'Aruppukottai et Thiruchuli du district de Vurudunagar, dans la zone agroclimatique méridionale du Tamil Nadu, en Inde. Les moyennes de la longueur du corps, de la hauteur au garrot et de la circonférence de la poitrine des béliers adultes sont respectivement de 80,65 ± 0,49, 85,58 ± 0,58 et 93,65 ± 0,35 cm et celles des brebis adultes sont de 70,05 ± 0,45, 72,80 ± 0,65 et 78,34 ± 0,35 cm. Les poids corporels des béliers et des brebis adultes sont respectivement de 51,50 ± 1,20 et de 36,95 ± 0,51 kg. Les moutons Pattanam sont une race envahissante dont les béliers sont largement utilisés pour des objectifs de sélection avec d'autres races indigènes, surtout avec les moutons Coimbatore, Kilakarsal et Ramnad White du Tamil Nadu.

Mots-clés: *distribution, morphologie, moutons, Pattanam*

Resumen
Pattanam es una raza ovina de gran importancia en Tamil Nadu (India) y muy popular entre los agricultores por su elevado peso corporal. Pese a su importancia económica y su marcada identidad, esta raza no se encuentra incluida en la lista de razas ovinas descritas a nivel nacional ya que hasta el momento no había sido estudiada. Por esta razón se realizó un estudio con el fin de documentar el hábitat, la distribución, los caracteres físicos, los resultados de producción y reproducción y las prácticas existentes de manejo de la oveja Pattanam de Tamil Nadu. El estudio preliminar reveló que la raza Pattanam se caracteriza por su gran tamaño, un cuerpo compacto y un color blanco cremoso uniforme con color negro en la región ventral desde la parte interior de la mandíbula hasta la región inguinal. Los animales de pura raza se encontraron distribuidos en las provincias de Paramakudi, Mudukulathur y Kamuthi del distrito de Ramanathapuram y las provincias Aruppukottai y Thiruchuli del distrito Virudunagar, en la zona agroclimática más meridional de Tamil Nadu. Las medias de longitud corporal, altura de la cruz y circunferencia del pecho observadas fueron 80,65 ± 0,49, 85,58 ± 0,58, 93,65 ± 0,35 cm en carneros adultos, y 70,05 ± 0,45, 72,80 ± 0,65 y 78,34 ± 0,35 cm en hembras adultas, respectivamente, y el peso corporal fue de 51,50 ± 1,20 y 36,95 ± 0,51 kg en machos y hembras respectivamente. La oveja Pattanam es una raza invasora

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cuyos machos son ampliamente utilizados para la cría con otras razas autóctonas, especialmente con Coimbatore, Kilakarsal y Ramnad White de Tamil Nadu.

Palabras clave: *distribución, morfología, ovejas, Pattanam*

Submitted 13 February 2012; accepted 22 May 2012

Introduction

Ovine genetic resources in India are a major source of livelihood for pastoralists and marginal farmers. Sheep contribute income to their keepers in terms of meat, hide and manure, in spite of being reared on minimum or no input especially under harsh agro climatic conditions (Arora *et al.*, 2011). Different types of sheep are distributed all over the southern agroclimatic zone of Tamil Nadu, adapting themselves to local soil condition, climate, rainfall, humidity and grazing facilities (Ganesakale and Rathnasabapathy, 1973). Pattanam is an important mutton-breed sheep and is popular among the farmers for its heavy body weight (Ravimurugan, Devendran and Joshi, 2010a; Ravimurugan *et al.*, 2010b). Despite its economic importance and distinct identity, this breed is not included in the list of descript sheep breeds at the national level (Ministry of Agriculture, India, 2004, 2010), as it is not researched so far. Hence, this study has been made to document the habitat and distribution, physical traits and the existing management practices of Pattanam sheep of Tamil Nadu, India.

Materials and methods

A survey was conducted between June 2009 and May 2010, to document the habitat, distribution, physical traits, production and reproduction performances and the existing husbandry practices of Pattanam sheep of Tamil Nadu, India. The habitat and distribution of Pattanam sheep was ascertained by visiting a total of 15 blocks comprising 101 villages of Ramanathapuram, Sivagangai and Virudunagar district of southern Tamil Nadu, India. Morphological characters of Pattanam sheep such as colour of coat, muzzle, eye lashes, shape of ears, head, tail, hooves, udder and teats and the presence of wattles were noted as per the descriptors prepared based on the guidelines of Food and Agricultural Organization (FAO, 1986). Body measurements *viz.* body length (BL), height at withers (HAW), chest girth (CG), paunch girth (PG), face length (FL), ear length (EL) and tail length (TL) of 362 adult sheep were recorded with a standard measuring tape of 0.5 cm accuracy after the animals were allowed to stand squarely on an even ground. Body weight was taken with the help of 50 kg (200 g accuracy) circular spring balances. This was performed in the morning before the animals were let out for grazing. In the case of adult ewes, body weight was taken only in non-pregnant animals. Information on housing pattern, feeding and breeding practices, lamb care, marketing of animals and other husbandry practices adopted by the farmers were studied by observation and through a questionnaire provided by the National Bureau of Animal Genetic Resources (NBAGR), Karnal, Haryana, India. The data collected were subjected to standard statistical analysis and test of significance as per Snedecor and Cochran (1989).

Results and discussion

Geographic distribution

The survey revealed that Pattanam sheep were distributed in Paramakudi, Mudukulathur and Kamuthi taluks of Ramanathapuram district, and part of Karaikudi, Sivangangai, Manamadurai and Ilaiyankudi taluks of Sivagangai district and Aruppukottai and Thiruchuli taluks of Virudhunagar district (Figure 1). Pattanam sheep with true to type breed characters were present in Paramakudi and Mudukulathur taluks in Ramanathapuram district and Aruppukottai taluk in Virudhunagar district.

Climate and soil

The climate of breeding tract of Pattanam sheep was tropical in nature and the temperature ranging from 22.3 to 37.8 °C. The minimum and maximum relative humidity was 68 (range 62–83) and 75 (range 62–88) percent, respectively. The average annual rainfall was 827 mm and maximum rainfall was received from northeast monsoon (501.6 mm) season. The major soil types present in the breeding tract were black soil, red loam, lateritic, coastal alluvium, sandy loam and red soil clay. However, the major part of the breeding tract was covered with black cotton soil. The habitat of this breed lies in the southern agroclimatic zone of Tamil Nadu and located at 9°10′ and10°47′N latitude and 78°10′–79°15′E longitudes.

Origin

The origin of the Pattanam breed of sheep has no documentary evidence; however, the shepherds of the home tract of the sheep express conflict of opinion with regard to its origin. One school of thought is that this breed is a result of cross between Ramnad White and Nellore sheep and subsequent selection based on local preferences. By virtue of their name Pattanam was believed to be developed from

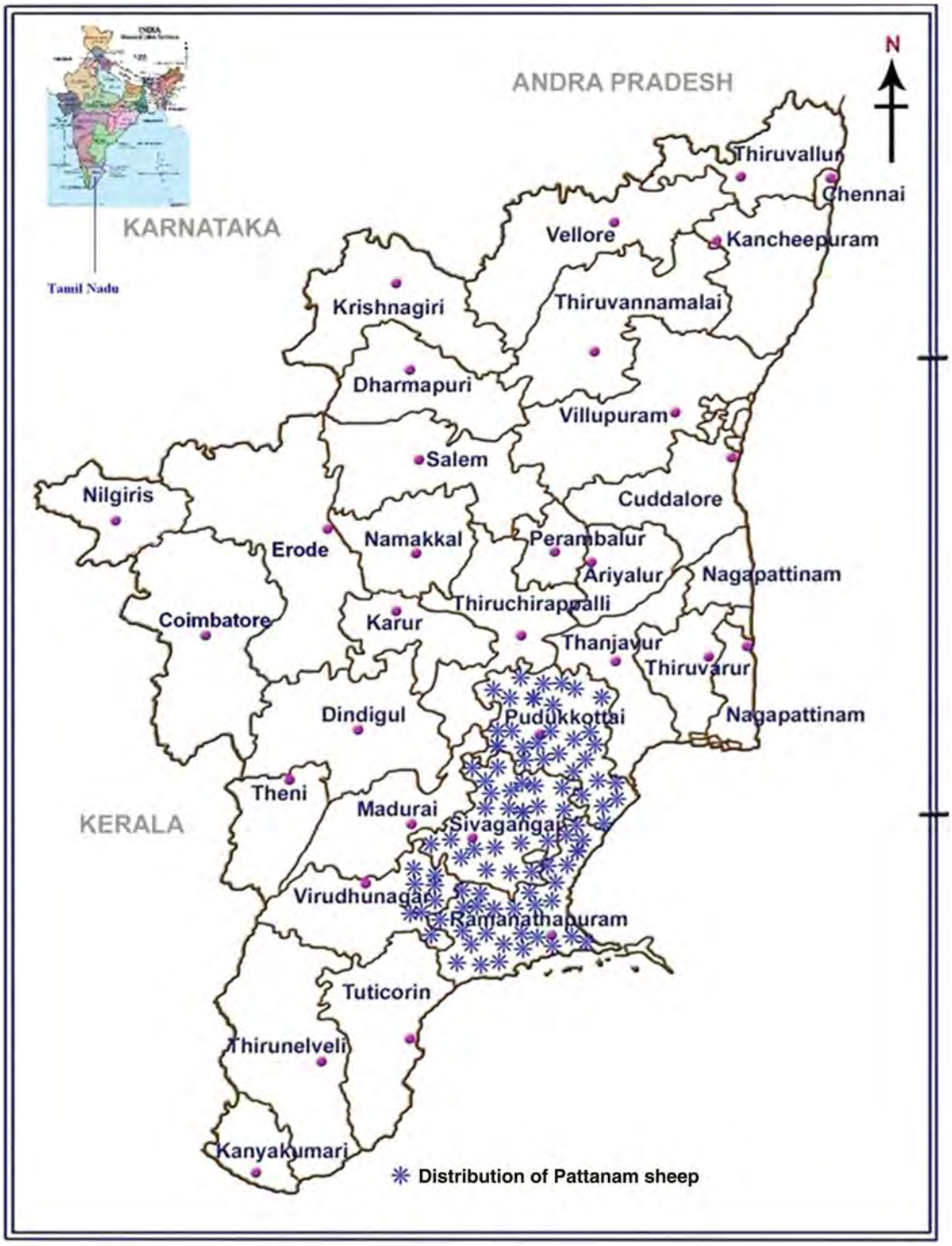

Figure 1. Distribution of Pattanam sheep of Tamil Nadu.

a small hamlet Pattanam en route to Rameswaram. Another opinion which prevails in the area is that the breed is an offshoot of Nellore sheep which was brought to this area decades ago and was developed by selection as per the preferences of the local people.

Maridas (2004) reported that the farmers developed a new breed, i.e. Pattanam by crossing Kilakarsal sheep of Tamil Nadu with Jodipi strain of Nellore sheep of Andhra Pradesh. Whereas Kumaravelu and Ravimurugan (2010) reported that migration was the predominant system of sheep production in Ramnathapuram district. The flocks migrate up to Ranipet (Vellore district), which is very near to Andhra Pradesh. The flock owners are always attracted by the larger size of Nellore rams and usually opt for crossing with ewes of Ramnad White, resulting

in the production of cross-breds which are sturdier, have long legs and are best for migration. Thus, the breed requires to be characterized at molecular level. Molecular characterization is a powerful tool to consider the genetic variation existing within and among breeds and could be used to attempt reconstruction of the history of origin of Pattanam breed of sheep.

Breed characteristics

Pattanam sheep is a large-sized animal with a compact body. They are uniformly creamy white in colour with black colour in the ventral region from the inner side of the jowl extending up to the inguinal region resembling Jodipi strain of Nellore sheep, which is native of Andhra Pradesh state. Head is medium in length and its profile is straight in both sexes. Medium to broad forehead with slight Roman nose is not uncommon. Eye lashes and muzzle are black in colour and ears are medium in length and horizontal. The mean ear length in adult rams and ewes was 12.55 ± 0.70 and 14.47 ± 0.19 cm, respectively. Rams possessed large, thick, twisted and highly corrugated horns (Figure 2), while a majority of the ewes were polled (Figure 3). Horns of the rams were grey coloured and directed backwards, inwards and upwards. The mean horn length in adult rams was 42.65 ± 0.15 cm. Legs are long and straight. Tail is medium in length. Wattles were absent in males and present in 5.2 percent of females.

Coat was short, coarse and hairy and dull in appearance. Males had slightly longer hair at withers and very long hair in the neck and brisket region. Udder was small sized and its presence could clearly be noticed, without handling the ewes. Teats were small and directed slightly outward.

Body measurements

The means (±SE) of BL, HAW, CG, PG, FL and BW of Pattanam breed of sheep are presented in Table 1. All the biometric traits in adult rams were observed to be more compared with the ewes. The average BW in adult rams and ewes was 51.50 ± 1.20 and 36.95 ± 0.51 kg, respectively. The three principal body measurements of Pattanam sheep obtained in this study were higher than those reported for Kilakarsal (Ravimurugan, Devendran and Joshi, 2010a; Ravimurugan *et al.*, 2010b), Ramnad White (Ravimurugan and Devendran, 2009) and Vembur (Chandran, Kandasamy and Panneerselvam, 2009) the other sheep breeds seen in the same agroclimatic zone of Tamil Nadu. In adult Pattanam sheep, CG had the highest value (93.65 cm in rams and 78.34 cm in ewes) among body measurements followed by HAW and BL. This relationship was in agreement with those reported for Madras Red (Balasubramanyam and Kumarasamy, 2011) and Mecheri (Karunanithi *et al.*, 2005) sheep of Tamil Nadu. The HAW found in this study was higher than any other south Indian breeds *viz.* Nellore sheep studied by (Acharya, 1982). Hence, Pattanam sheep may be considered as the tallest among South Indian breeds. The BW and body measurement of Pattanam breed of sheep in the present study was higher than that of Jodipi strain of Nellore sheep. Acharya (1982) reported that the BW of adult rams and ewes of Nellore sheep were 36.69 ± 2.56 and 30.00 ± 0.27 kg, respectively. The pooled means for BL, HAW and CG of Nellore rams were 68.31 ± 0.63, 76.46 ± 1.36 and 75.39 ± 1.74 cm and in ewes the values were 67.05 ± 0.22, 72.75 ± 0.24 and 72.78 ± 0.23 cm, respectively.

Figure 2. Pattanam ram.

Figure 3. Pattanam ewe.

Population status

Pattanam sheep rams are extensively used for breeding purposes with other native breeds especially with Kilakarsal and Ramnad White. The total sheep population in the surveyed taluks was 2 85 000 (Ministry of Agriculture, India, 2004, 2010). Out of these about 78.2 percent were Pattanam sheep. Based on the sample survey

Table 1. Means (±S.E.) for body measurements (cm) and BW (kg) of Pattanam sheep.

Sex	*N*	BL	HAW	CG	PG	FL	BW
Ram	32	80.65 ± 0.49	85.58 ± 0.58	93.65 ± 0.35	96.35 ± 0.68	28.15 ± 0.70	51.50 ± 1.20
Ewe	330	70.05 ± 0.45	72.80 ± 0.65	78.34 ± 0.35	83.87 ± 0.36	20.05 ± 0.15	36.95 ± 0.51

BL, body length; HAW, height at withers; CG, chest girth; PG, paunch girth; FL, face length; BW, body weight.

the estimated population of Pattanam sheep in its breeding tract was 222 870. The present status of Pattanam sheep breed is secured.

Management practices

Pattanam breed of sheep were reared in both stationary and migratory/nomadic types of management. Stationary flocks were maintained on an extensive production system kept in open places enclosed with wire net. Some resourceful farmers adopt semi-intensive system of management by providing temporary shelter. In both systems of management, sheep were taken for grazing at 10.00 hours and back after sunsets for a distance of 8–10 km radius. They are allowed to graze extensively in common grazing land, fallow land and shrubs area for a period of 8–10 h. The major fodder trees and shrubs found in the areas were Karuvel (*Acacia nilotica*), Kudaivel (*Acacia planifrons*), Tamarind (*Tamarindus indica*), Neem (*Azadirachta indica*), Vagai (*Albizia lebbeck*), Banyan (*Ficus bengalensis*), Arasu (*Ficus religiosa*), Manjanathi (*Morinda tomentosa*), Velikaruvai (*Prosopis juliflora*) and Elanthai (*Zizyphus mauritiana*). The major native fodder grasses and weeds were Hariali (*Cynodon dactylon*), Nut grass (*Cyperus rotundus*), Emarginata (*Merremia gangetica*), Arisipullu (*Digitaria cilliaris*) and Saranai (*Trianthema portulacastrum*). The main cultivated cereals were Paddy (*Oryza sativa*), Cholam (*Sorghum vulgare*), Millet (*Eleusine coracana*) and Maize (*Zee mays*). Horse gram (*Dolichos biflorus*), green gram (*Phaseolus trilobus*), black gram (*Phaseolus mungo*), red gram (*Cajanus cajan*) and cowpea (*Vigna unguiculata*) were the main cultivated pulses.

The average flock (stationary) size was 52 sheep heads (Figure 4). Of these 68 percent were adult ewes. The average age at first mating in rams and ewes ranged from 9 to 12 and 10 to 12 months, respectively. The age at first lambing ranged between 15 and 17 months. The breeding and lambing takes place throughout the year since rams always stay along with the ewes. Majority of ewes were bred in the month of September to November owing to availability of good quality fodder. Generally, two to three breeding rams were maintained for 100 ewes for natural mating. The breeding rams were used for two to three years in a flock and then either exchanged with other farmers or culled. The best males were selected based on breed characteristics, vigour and general appearance. Generally, castration of rams was not practiced.

In general, the lambing was observed to be single. Lambing rate was 85 percent with an average lambing

Figure 4. Pattanam flock.

interval of about eight months. It was reported by the farmers during survey that on an average, the females produced seven lambs in their life span. Ram lambs were sold from the flock after weaning, i.e. around 2–3 months of age. Few male lambs were kept in the flock for breeding purpose. However, female culling was practiced only on the ground of health and production. Hair clipping was done once in a year in order to remove lice and other external parasites in the hair of sheep.

The sales of the ram lambs were made in the villages at the cost of INR 2000–2500 depending on the weight and appearance. The sheep were drenched with anti-helmintics in the months of January and July (i.e. twice a year) and vaccinated against Anthrax and Foot and Mouth diseases. In the years, where there is adequate rainfall, vaccination against enterotoxaemia is followed. It was learnt that anthrax is the commonest contagious disease prevailing in Ramanathapuram district.

Migration

During hot and dry periods three to five flocks are made into a single flock comprising 500 to up to 1000 sheep which are taken more than 180 km away from native villages in search of grazing for a period of 4 months. The flocks were rested during night hours in the event of penning. Some farmers follow nomadic type of grazing by taking the animals from one place to another. Mostly they are concentrated fallow lands and cultivable land for offering kidai (penning).

Conclusion

Pattanam sheep are extensively used for breeding purposes with other native breeds especially with Coimbatore, Kilakarsal and Ramnad White. Diversified population of sheep breeds of Tamil Nadu is being exploited because of market demand. Pattanam as crosses with comparatively more efficient offspring gives more productivity to the sheep farmer. Pattanam are widely distributed in many districts of Tamil Nadu and warrants additional detailed survey, evaluation and characterization.

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Statement of interest

The corresponding author is involved in exploiting the unexplored small ruminant breeds distributed in Tamil Nadu and their conservation.

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The domestic livestock resources of Turkey: goat breeds and types and their conservation status

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Summary
Goats were first domesticated in Turkey some 10 000–11 000 years ago. The country's population of 5.1 million goats in 2009 (down from 24.6 million in 1960) are still an important livelihood asset for smallholder farmers and nationally are a rich array of farm animal genetic resources of current enormous and future inestimable value. The structure of agriculture is such that most farms are predominantly subsistence oriented, of small size, keep few animals and provide only minimal inputs. Native breeds have evolved to meet these conditions and are generally well adapted to the natural environment, inadequate and unbalanced nutrition and disease stress. In general, there are two classes of goat, the one being the iconic Angora that produces mohair and the other the "common" or "hair" goat. The reduction in numbers is owing to a variety of reasons both internal and external to the country, but the Angora, which now amounts to only 2.5 percent of national goat numbers, has suffered relatively more than the hair types. This paper, based on detailed reviews of the literature and on the authors' own experiences, provides information on 17 breeds or recognized populations of Turkey's goat genetic resources and their conservation status. The government is now aware of the danger of the impoverishment or loss of this important aspect of biodiversity and has established programmes for conservation and preservation of several native breeds. The government, research institutions and producers should work together to ensure that the local gene pool is preserved and can thus continue to contribute to biodiversity and sustainable livestock production.

Keywords: *biodiversity, conservation, cross-breeding, native breeds, production systems, risk status*

Résumé
En Turquie, les chèvres ont été domestiquées pour la première fois il y a 11 000 à 10 000 ans. La population de chèvres du pays, qui était en 2009 de 5,1 millions d'animaux (en baisse par rapport à 24,6 millions en 1960), représente encore un avoir important relatif aux moyens d'existence des petits exploitants et, au niveau national, une riche gamme de ressources génétiques d'animaux d'élevage ayant une valeur énorme à présent et inestimable pour l'avenir. La structure de l'agriculture est telle que la plupart des fermes sont essentiellement de petite taille et orientées vers la subsistance, élèvent peu d'animaux et ne fournissent que le minimum d'intrants. Les races indigènes ont évolué pour remplir ces conditions et sont généralement bien adaptées au milieu naturel, à une alimentation inadéquate et déséquilibrée et aux stress des maladies. En règle générale, il existe deux catégories de chèvres: l'emblématique chèvre angora qui produit le mohair; et la chèvre «commune» ou «à poils». Les populations de chèvres ont diminué pour des raisons différentes, aussi bien internes qu'externes au pays, mais la chèvre angora, qui ne représente aujourd'hui que 2,5 pour cent des chèvres au niveau national, a souffert relativement plus que les types communs. Cet article, basé sur les analyses détaillées de plusieurs publications et sur les expériences des auteurs, donne des informations sur 17 races ou populations reconnues de ressources génétiques de chèvres de la Turquie et sur leur état de conservation. Le gouvernement est à présent conscient du danger de l'appauvrissement ou de la perte de cet aspect important de la biodiversité et a mis en place des programmes de conservation et de préservation pour plusieurs races indigènes. Le gouvernement, les instituts de recherche et les producteurs devraient collaborer pour garantir la conservation du pool de gènes local et sa contribution continue à la biodiversité et à la production animale durable.

Mots-clés: *biodiversité, conservation, croisement, races indigènes, systèmes de production, état de danger*

Resumen
Los animales de la especie caprina fueron domesticados por primera vez en Turquía hace entre 11.000 y 10.000 años. El censo nacional, 5,1 millones de cabras en 2009 (frente a 24,6 millones en 1960), sigue siendo un importante medio de subsistencia para los pequeños agricultores, representado a nivel nacional una destacable variedad de recursos genéticos animales de enorme valor en la actualidad e incalculable de cara al futuro. La estructura de la agricultura está orientada en su mayoría hacia explotaciones de subsistencia, de pequeño tamaño, pocos animales y llevando a cabo las mínimas inversiones. Las razas autóctonas han evolucionado para satisfacer estas condiciones y, generalmente, están bien adaptadas al medio ambiente natural, a una alimentación insuficiente y desequilibrada y al estrés provocado por determinadas enfermedades. En general existen dos tipos de cabras, una que es la de Angora, que produce la fibra mohair, y la otra denominada cabra "común" o "de pelo". La reducción del censo se debe a motivos muy diversos, tanto internos como externos al país, pero la de Angora, que asciende a sólo el 2,5 por ciento de la población caprina nacional, se ha

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visto más afectada que la de pelo. Este trabajo, basado en revisiones bibliográficas y en las propias experiencias de los autores, ofrece información acerca de 17 razas o poblaciones reconocidas de recursos genéticos de la especie caprina de Turquía y de su estado de conservación. El gobierno es consciente actualmente del peligro de empobrecimiento o de pérdida de este importante aspecto de la diversidad biológica y ha establecido programas para la conservación y preservación de varias razas autóctonas. El gobierno, las instituciones de investigación y los productores deben trabajar conjuntamente para garantizar que el acervo genético local sea conservado y, por lo tanto, se siga contribuyendo a la conservación de la biodiversidad y a la producción ganadera sostenible.

Palabras clave: *biodiversidad, conservación, cruzamiento, razas nativas, sistemas de producción, situación de riesgo*

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Introduction

The wild goat or bezoar (*Capra aegagrus*; Figure 1) ranges widely in Turkey, from east of the Datca peninsula, through the Taurus and Anti-Taurus mountains in the mountainous regions of southeastern, eastern and northeastern Anatolia (Kence, 1987). It is, however, declining principally because of over-hunting throughout its range and the total population is believed to be less than 10 000 mature individuals, with no subpopulation larger than 1000 mature individuals (Weinberg *et al.*, 2008).

Goats were among the first animals to be domesticated beginning about 10 000–11 000 years ago. Neolithic farmers in the Near East began keeping small herds of goats for their milk and meat, for fertilizer and fuel and for materials such as clothing and building including hair, skin, bone and sinew. In view of the presence of bezoar, it is not surprising that archaeological data suggest that the Euphrates river valley at Nevali Çori in southeast Turkey was one of the two distinct places of goat domestication some 11 000 years ago, the other being the Zagros Mountains of Iran at Ganj Dareh somewhat later about 10 000 years ago. Other possible sites of domestication include Cayönü at the foot of the Taurus Mountains in southern Turkey also about 10 000 years ago (Machugh and Bradley, 2001). This local origin for domestic goats makes their study in Turkey particularly rewarding.

Recent publications on Turkish goats in international literature have generally been somewhat limited in outlook.

Figure 1. Family group of Bezoar goats in the Taurus Mountains (Photo: courtesy of wowturkey.com).

They include papers on short-term fattening experiments (Ugur *et al.*, 2004; Ocak *et al.*, 2006), reproduction (Ince, 2010; Konyali *et al.*, 2011), reproductive diseases (Ataseven *et al.*, 2006) and the performance of cross-bred animals (Gunes *et al.*, 2002; Kosum *et al.*, 2003). The current paper is based on the knowledge and experience of the authors and also aims at collating, complementing and bringing up-to-date earlier publications on Turkish goats and to provide information on the goat genetic resources of the country. It introduces some perceptions of numbers and output, provides descriptions of 17 breeds and types present or known to have been present in Turkey and describes current conservation activities. The paper is one of a series (Wilson, Yilmaz & Ertugrul 2011; Yilmaz, Ertugrul & Wilson 2011, 2012; Yilmaz *et al.*, 2012a) that will eventually cover all the nation's domestic animal species.

Production systems

Products – meat, milk, eggs, fibre and hides – from the livestock subsector in Turkey contribute 30 percent of total agricultural gross domestic product (GDP). Some 96 percent of the country's 4 million agricultural enterprises are mixed crop–livestock farms. The average number of animals per farm is low. Farm sizes are less than 5 ha for 65 percent of holdings, which accounts for only 22 percent of the agricultural land, whereas the remaining 35 percent of holdings with an individual area of greater than 5 ha occupy 78 percent of the land. An overwhelming proportion of output is for subsistence use with any surplus usually being disposed of through middlemen because of the distance to markets. In spite of its small and fragmented nature, agriculture directly contributes more than 45 percent to household income and agriculture is the key component of rural household livelihoods (Gursoy, 2006).

Poverty levels in Turkey are high. More than one-third of the population relies on the agricultural sector for employment and income generation. The family owned and managed farm is the basic unit of agricultural production and family members provide most of the farm labour. Household food security is very important to the impoverished populations of the rural and peri-urban areas and

small-scale farms contribute significantly to the nation's food supply and to local economies. Almost all goats are still managed traditionally, rely mainly on extensive and low-quality grazing for their nutriments and receive very little in the way of veterinary care. The situation is exacerbated in winter as housing standards are low, feed is often of even poorer quality and cold and crowding produce stress that reduces tolerance to disease. The fragmented nature of traditional agriculture is often accepted as the norm and its sustainability as well as its contribution to national welfare is neglected. Small-scale farms nonetheless contribute to human welfare (especially that of old and infirm people and children), are guardians of the common wealth and work, within their limits, to protect the soil, water and air and to maintain and enhance biodiversity in addition to producing essential and often high-quality animal protein for the betterment of everyone. The income derived from small farms is not only used to buy additional items of food but also helps to pay for various items including health services, school fees, water, electricity and new assets.

Goat production is economically and socially important in Turkey. An estimated 500 000 farm households keep goats and goat production contributes directly to the income of nearly 3 million people (Dellal and Dellal, 2005). Turkish goats are produced under four distinct husbandry systems and in two of them production is generally secondary to crop production. It needs to be remembered, however, that in Turkey as elsewhere because of the feeding habit of goats and their predilection for feeding on browse trees and shrubs, they are complementary to sheep and, in addition, both small ruminant species combined contribute, with cattle and other domestic herbivores, to maintaining and enhancing vegetative biodiversity.

The first production system is the "small household" common in western and northwestern Turkey. Each family has a small number of animals with a maximum holding of 10–15 head. Milk is the primary output with meat production fulfilling a secondary role. The second type is a "settled village flock" system found all over Turkey, but this system applies less to goats than it does to sheep (Yilmaz *et al.*, 2012b). Family flock sizes range from 8–10 to as many as 30 goats. In this system, goats are released by their owners early in the morning and a village flock is constituted. This flock is managed by a goatherd who is assisted in protecting them by several dogs. In both the first two systems, goats are grazed on common land in the spring and recover much of the body condition they have lost during the winter when they have been fed on cereal straws and bran. By the end of June grass has matured but the cereal harvest takes place in July and stubbles become available. Animals now reach peak condition. The third system is denominated as "highland" and is common in northeastern, eastern and southern Turkey. Goats are kept in the villages during the winter season and in early spring. As grass matures and dries in late spring and early summer, the flocks are taken to highlands from where they return, after 3–5 months when feed is exhausted and the cold sets in, to their villages for the winter. The "nomadic" system is found in eastern and southeastern Turkey. Goats stay and graze during the cold season in the lower lands of the southeastern plains of Turkey. During the hot season, the tribes migrate to the higher lands of eastern Turkey. Members of nomadic tribes always live in goat hair tents when they are with their flocks (Sonmez, 1978; Ertugrul *et al.*, 1993; Soysal, 2009).

Increased demand for goat milk and cheese has led to some intensification of production in modern facilities. Milk dairies in Turkey are located mainly in the Aegean, Marmara and Thrace regions (Ince, 2010) and make much use of exotic breeds and their crosses with local stock.

Numbers and output

Goat numbers seem to have been at an all-time high in Turkey in about 1960 when there were estimated to be some 24.6 million goats in the country (Table 1). Over the succeeding 50 years, numbers have declined drastically, one might say precipitously, to little over one-fifth of that number in 2009. The goat population diminished by about 44 percent between 1980 and 1990 and another

Table 1. Trends in goat numbers and products in Turkey, 1951–2009.

Trait	Year							Change (percent) 1990–2009
	1951	1960	1970	1980	1990	2000	2009	
Numbers (million)	20.9	24.6	20.9	19	10.7	7.2	5.1	−53
Meat production ('000 tonnes)			101	63	37	42	20	−46
Milk production ('000 tonnes)			603	612	335	220	192	−43
Mohair (tonnes)			6873	6085	1379	421	174	−86
Hair (tonnes)			8820	8960	3955	2697	2607	−34
Fresh skins (million)					2.6	1.4	1.2	−54
Carcass weight (kg)					13.8		15.5	12.3
Milk yield (kg)					54		108	100

Source: Arik (2011) and Turkstat (2011).

50 percent was lost in the 20-year period (1990–2009), although goats are still an ever present component of livestock production systems all over the country (Figure 2). There has been an even greater proportionate loss in the iconic Angora goat than in the general goat population from Angoras representing 20.9 percent of all goats in 1951 to 2.5 percent in 2009 (Arik, 2011; Turkstat, 2011). There have been concomitant reductions in output of the main products of goats which are milk, meat, fibres (hair and mohair) and skins (Table 1).

Among the manifold reasons for the reduction in numbers are changes in the structure of agriculture, smallholder farmers turning to other products or other employment, low returns to producers from goats, changing internal and external market conditions, a move away from red meat by consumers and lack of government support. Unlike the cattle subsector where reduced numbers have been compensated for by higher individual performance (Yilmaz *et al.*, 2012a), there has been no or very little increase in output per head of goats. Much of the market for meat has been taken over by the enormous increase in the numbers of poultry and structural changes in poultry production from low input extensive to high input very intensive systems. In the case of mohair (and thus Angora goats), competition especially from southern Africa (in both quantity and quality) and changes in world demand for natural fibres and their substitution by synthetics have had a drastic effect on numbers. Turkish government policy with respect to forest protection (all forestry areas are owned by the state) and dissuasion or the banning of goats from using these areas has also had a negative effect on numbers.

Genetic resources

Over the years, the goat has differentiated from its wild progenitor into more than 300 breeds that are adapted to a very broad range of climates and ecological zones. During the period of domestication body weight has increased, growth rate has accelerated, in some breeds hair has become longer and finer and other morphological changes such as changes in the shape and size of horns have occurred (Ertugrul *et al.*, 1993). Turkey has contributed to these changes and to biodiversity in the development of local breeds although sources differ with respect to the number and nomenclature of breeds in the country. It should also be noted that some "native" breeds are transboundary groupings.

The first listing of goat types in Turkey mentions only three breeds (Yarkin, 1965). A comprehensive account of sheep and goats that covers, among other subjects, management practices, population, production and research provides data on four native breeds and one cross-breed and briefly mentions four exotic breeds (Yalcin, 1986). A publication on biodiversity in Turkey published in the mid 1980s lists four breeds. The definitive dictionary on the world's types of livestock provides succinct information on nine breeds of which one is exotic (Mason, 1996). A treatise on the agriculture of Turkey states simply

Figure 2. Map of Turkey showing places referred to in the text (provinces generally take their names from the principal town).

that there are four breeds of goats in the country, but fails to name any of them (MARA/FAO, 2001). Finally, the United Nations repository of breed information has 11 breeds – the information on which is mostly minimal and often restricted to just a name – in its catalogue of which one is the wild progenitor of *Capra hircus*, two are exotic and two are cross-breeds (DAD-IS, 2010).

The remainder of this section provides detailed descriptions of the breeds and types, and provides both English and Turkish names where these are distinct.

Angora (Ankara Kecisi, Tiftik Kecisi)

In its natural environment and in traditional systems of production, the Angora is a hardy animal needing, and getting, little care, shelter or feed. Animals are at home in rocky and rugged areas and are tolerant to sudden changes in feeding and climatic conditions (Anon., 2009). The name Angora is the ancient name for present day Ankara where the breed originated. The Angora (Figure 3) is thus a breed of Central Anatolia. It is small in size (Table 2) with a narrow but graceful body. White is the preferred coat colour, but other colours do occur. In Konya Province and its vicinity in southcentral Anatolia yellow and creamy yellow colours are also found. In extreme southeastern Anatolia, there are goats with silver grey, brown and black coats. Both sexes are horned, those of the male being lightly ribbed and growing backwards in a graceful curve. Some polled goats have been bred (MRC, 2011). Twin births are very rare and the overall litter size is 1.02 (DAD-IS, 2010). Some milk and meat is produced, but this is a specialist fibre goat and the only true producer of mohair in the world. Fibre diameter in yearlings has been determined as 23.9 μm and staple length as 15.4 cm (Gerstmayra *et al.*, 1995) with other results giving fibre diameter in kids as 25.8 μm and in adults as 35.3 μm (DAD-IS, 2010).

The Angora goat was "discovered" by a Dutchman in 1550 and in 1554 a pair was presented to the Pope in Rome (BAGS, 2011). Further exports were forbidden until the middle of the nineteenth century when small numbers of males and females were exported to southern Africa in 1838 following a treaty between the Ottoman Empire and the United Kingdom (Yigit, 2011). Further goats were exported to the USA in the 1840s and then to Australia in the early part of the twentieth century from where they were re-exported to many other countries including Argentina, Canada, France, Russia and then the United Kingdom in 1981. In the UK (which has a Breed society and Herdbook as do most other nations where the Angora goat is found), it was imported from Australia and Canada, the Angora goat is very fashionable with a certain type of farmer and is a prime candidate for diversification schemes. The Turkish Angora is the origin of all Angora/mohair goats throughout the world, but exports were the harbingers of doom of the breed in its own land. Productivity and the quality of mohair in Turkey and the quality of mohair are lower than abroad and ironically most recent attempts at improvement have involved the import and use of "foreign" animals (Gerstmayra *et al.*, 1995; Gunes *et al.*, 2002). The decline in numbers of the Angora goat from more than 6 million in 1960 to 147 000 in 2009 has been greater proportionately than that of all goats from about 20 percent to 2.5 percent of the total number of goats. There has been a commensurate loss of mohair production from 6800 tonnes in 1970 to 179 tonnes in 2009 (Turkstat, 2011). A principal reason for the decline in goat numbers and output is that outside Turkey mohair has been replaced in the world textile industry by synthetic fibres and the remaining market is for a quality product that Turkey can no longer supply (it even imports mohair from abroad!). Internally, the decrease is related to socio-economic and political factors including rural–urban migration, reduced income from mohair compared with milk and meat, restrictions on goats close to woodland areas and inadequate government support in general. The producers' own organization – Tiftikbirlik (Union of Mohair Producers) with 12 registered cooperative establishments comprising 19 000 producers – is inadequate in its support and as a monopoly purchasing and onward selling business often seems to act against its members' best interests (Yigit, 2011). The Angora goat is at risk in its area of origin and the situation could become very much worse (Sonmez, 1975; Ertugrul *et al.*, 1993; Soysal, 2009).

Figure 3. Angora buck and does at Lalahan Livestock Central Research Institute (Photo: R. Trevor Wilson).

Hair goat (Kil Keci, Adi Keci, Kara Keci) or Turkish Native Black Hair (Türkiye yerli kil)

The Hair goat, Turkish Native Black Hair or Anatolian Black (Mason, 1996) is by far the most common type in Turkey and is akin to the Syrian Mountain type. Three subtypes are sometimes recognized: a small one is known as Pavga, a medium one as Candir and a large one as Davar or Kabakulak. The Hair goat is the most numerous breed and probably accounts numerically for more than 90

Table 2. Conservation status, areas of distribution, morphological characteristics and some production traits of Turkish goats.

Trait	Breed/type (Turkish name in brackets)						
	Angora (Ankara Kecisi, Tiftik Kecisi)	**Hair (Kil Keci, Adi Keci, Kara Keci)**	**Kilis**	**Honamli**	**Norduz**	**Gurcu (Kafkas, Tiflis)**	**Abaza**
Conservation status	At risk	Not at risk	Not at risk	At severe risk	At severe risk	At risk	At risk
Main area of distribution	Central Anatolia	Nationwide (especially mountain areas)	Kilis Town/ Province, Gaziantep Province, Southeast Anatolia	Southern Provinces, slopes of Taurus Mountains	Norduz area of Gurpinar County in Van Province	Northeastern Anatolia (Cildir area of Kars Province)	Northeastern Anatolia
Colour	White (occasional brown, grey or black)	Usually black (also brown, white and spotted)	Usually black (also brown and spotted)	Black (white head and feet in some localities)	Usually black (but other whole and broken colours occur	Black, grey, white (often with head and upper neck black) and spotted)	
Horns	Both sexes horned	Both sexes horned	Both sexes usually horned	Males horned, females sometimes polled	Both sexes usually horned, females occasionally polled	Males strong erect horns, females horned or polled	Male long flat scimitar horns, females usually polled
Withers height (cm)	51–55	72	66 males and 65 females	86–97 males and 80–89 females	65–67	70–75 females	–
Body length (cm)	53–56	72	62 males and 59 females	82–100 males and 76–95 females	66–70	–	–
Birth weight (kg)	2.6 males and 2.3 females	2.6 males and 2.5 females	4.6 males and 4.4 females	3.0–4.0	3.0 males and 2.7 females	–	–
Adult weight (kg)	29 females	55 males and 40–45 females	75 males and 30–35 females	70–90 males 50–60 females	48 females	–	–
Products	Mohair, meat	Milk, hair	Milk, meat	Milk, meat, hair	Meat, milk, hair	Milk	Meat, milk
Average feedlot daily gain (g)	–	101 males and 81 females	–		133	–	–
Milk lactation yield (kg)	–	60–70	200–300	135–216	347	220–250	200
Lactation length (days)	–	150–160	190–230		226	150–180	–
Greasy fleece weight (kg)	0.6	0.5–0.6	0.5–0.6	0.5	–	–	–
Litter size (kids per birth)	1.0–1.2	1.01–1.05	1.01–1.05	1.5	1.3	–	–

Source: Sonmez (1975, 1978), Ertugrul *et al.* (1993, 2010), Daskiran and Cedden (2004), Anon (2009), Bingol *et al.* (2012).

Figure 4. Hair goats showing variation in coat colour (Photo: Orhan Yilmaz).

Figure 5. A heavy milking Kilis doe showing pendulous ears (Photo: Orhan Yilmaz).

percent of the national goat flock. It is widespread and found nationwide, but especially in the south and south-west in hilly and mountainous environments. It is probably the hardiest of all Turkish goat resources, well adapted to climatic extremes, to rough and rocky terrain, to poor feed and resistant to local diseases and to managerial indifference. The predominant coat colour is black but other colours, especially brown (Figure 4), occur as do goats of broken colours: many individuals have brown or white dots on their face from eyes to muzzle. Both males and females usually have rather light horns which curve backwards and outwards (Table 2). This is mainly a meat goat with a low milk yield. Both growth rate and milk production are, however, low (Olfaz, Tozlu & Onder, 2011). Hair is an important by-product with the main outer coat used by the nomadic Yoruk people for the making of tents, rugs, saddlebags, sacks and items of clothing: in one study hair production (fleece weight per year) was 381 g, fibre diameter 76.7 µm and fibre length 13.6 cm (Toplu and Altinel, 2008). The inner down makes a useful cashmere, but the down weight is only about 46 g per goat with fineness of 16.6 µm and a length of 2.5 cm (Gokmen and Boztepe, 2004). Reproductive performance is poor with only about 2 percent of goats producing twins to give an overall litter size of 1.02 (Olfaz, Tozlu & Onder, 2011).

Kilis

Widely accepted as a native breed, the Kilis is in fact a result of "natural" crossing between Damascus (Aleppo/Halep) and Hair goats (Mason, 1996; Gursoy, 2005). Named after the town of Kilis in Kilis Province, its natural distribution is there and in the surrounding provinces of Gaziantep, Hatay, Kahramanmaras and Sanliurfa in south-central Turkey bordering Syria and the Mediterranean Sea. The breed is mostly kept by small holders (2–10 goats), but there are some larger specialist breeders (20–200 goats) (Anon. 2009). The breed is adapted to rugged terrain and extreme climatic conditions, and is resistant to most local diseases. There is considerable sexual dimorphism in this medium-sized breed (Table 2). When horns are present, those of the males are thick and strong with females having shorter and finer horns. Around Kilis the facial profile tends to be convex, but elsewhere it is flatter. The pendulous ears are up to 28 cm in length (Figure 5). Whole colours, brown or black, are the norm but there are also pied and multicoloured animals. The Kilis is a specialist milk breed with a fairly good lactation yield. Much of the milk is used to make the famous ice cream Kahramanmaras beaten ice cream (Kahramanmaras dovme dondurma) and cheeses such as tulum, orme, keci peyniri, kelle, sepet and tel (Gursoy, 2005).

Honamli

The largest of all Turkish goats the Honamli is native to Antalya, Isparta and Konya Provinces in the foothills of the Taurus Mountains. This genotype which is noted for its docility and hardiness, and its thriftiness on poor quality feed (Anon., 2009) is mainly kept by Yoruk nomads who spend the summer on the highland plateaux and the winter on lower ground. It is massive in body size (Table 2), has a convex ("Roman nose") facial profile with a prognathous lower jaw, prominent eyes and short and thick ears. The tail is longer than in other native Turkish goats and has a prominent tassel on the end. A supposed indication of breed purity is the space between the horn bases which should be 2 cm. The skin is black and the predominant coat colour is also black (Figure 6), but goats from Antalya often have a white or brown forehead and feet. Milk, which is high in fat, is the main output. The coarse hair is shorter than that of the Native Black Hair goat. This prolific goat is also renowned for its mothering ability. A small population size coupled with a restricted geographical distribution puts this breed at some risk.

Norduz

A recently described "breed", the Norduz is mainly raised in Gurpinar County of Van Province and is well known by producers in the Norduz area (Daskiran and Cedden, 2004). Recent mitochondrial DNA studies have shown this type to be distinct from Angora, Hair, Kilis and Honamli types (Kul and Ertugrul, 2011). The goat's home tract is hilly, but has good pasture and water

Figure 6. Honamli goat with whitehead and feet typical of Antalya Province (Photo: Orhan Yilmaz).

resources. It is mainly housed in winter and fed on dry feed. The animal is of medium size and usually black in colour but white, cream, grey, brown and broken colour patterns also occur. The ears are lopped and the male has long thin backward- and outward-curving horns (Figure 7): females have smaller horns or are polled. The products are meat, a moderate amount of milk (which is usually processed to butter and cheese) and hair. The rather coarse hair (74.4: diameter in 3-year-olds, 53.7: in 1-year-olds; Daskiran *et al.*, 2008), in addition to being used for tents, is much used in cottage industries that produce blankets, gloves and caps. The breed is quite prolific and shows favourable pre-weaning viability and growth (Daskiran *et al.*, 2006; 2010). The progressive decrease in the population of this goat is attributed to the high rate of rural–urban migration and the breed can be described as at critical risk (Daskiran and Cedden, 2004; Bingol *et al.*, 2012).

Figure 7. Norduz from Van in eastern Turkey with classic long thin horns and lop ears (Photo: Orhan Yilmaz).

Figure 8. Upright heavy male and finer curved female horns of Gurcu goats in their home tract in Cildir county (Photo: Orhan Yilmaz).

Gurcu

Known as Gurcu, Tiflis or Kafkas in Turkey this transboundary breed is the same as the Mingrelian of western Georgia (Mason, 1996). It is mainly raised in Cildir County of Kars Province at Turkey's boundary with the Republic of Georgia (Table 2). It is a medium to large goat of various colours, but the lighter coloured ones usually have a black or dark head and neck. In males, the twisted horns are up to 50 cm long and grow erect (Figure 8), whereas if carried in females they are shorter and finer: the lop ears are turned up at the ends. This is primarily a milk breed with a moderately good yield produced in a lactation of up to 6 months. Meat and hair are secondary products (Ureyen, 1995; Kor *et al.*, 2006). Low numbers and a restricted geographical range put this breed at risk (DAD-IS, 2010).

Abaza

Located in northeast Turkey the Abaza is pinkish white with coloured marks around the mouth and eyes and on legs. Males carry horns, whereas females are usually polled (Mason, 1996). Recent studies have shown a high degree of in-breeding in this type (Cañón *et al.*, 2006) and it can be considered at risk. The semi-hard lightly salted cheese made from the milk of this goat (Figure 9) is renowned in Turkey and internationally (Kambera, 2007).

Kurdi

The Kurdi or Maraz is listed by FAO as a Turkish breed (DAD-IS, 2010). This is a transboundary type (Mason, 1996) kept by Kurdish people in areas where they reside in Turkey, Iraq, Iran, Syria and Armenia. A small goat weighing 25–30 kg at maturity, it has a fleece weight of about 700 g. Overall some 27 percent of the fleece is down (cashmere) with a fibre diameter of 22.5: and a length of 58 mm, but this is hardly used by owners who use the longer guard hairs in traditional crafts (Aziz, 2009).

Figure 9. Commercially produced Abaza cheese (Image: courtesy of Yorsan Gida Mamulleri San. Ve Tic. A.S.).

Damascus, Maltese, Saanen and other European breeds

Goats not native to Turkey have been imported on numerous occasions and it is certain that many imports have gone unrecorded. There have been two principal reasons for imports, the first often by private individuals for localized and specialized milk production, the second through official sources for structured cross-breeding with native types. There has not, however, been as much interest in cross-breeding goats as in sheep where a veritable industry produced a plethora of at least 18 named types of varied utility (Yilmaz *et al.*, 2012b).

The Damascus goat, known as the Aleppo (Halep) in Turkey, is uncommon in the country and found mainly in small numbers in urban and peri-urban areas of southern Turkey where its milk supplies a specialized market. A lowland goat by breeding it does not thrive well in the colder parts of Turkey (Yalcin, 1986). It has been used in formal crossing to produce the Kilis and in multi-breed crosses in southeastern Turkey (Darcan and Guney, 1997). There has undoubtedly also been informal crossing with local goats by private owners.

The Maltese goat is rare in Malta and more common in southern Italy (Mason, 1996). There are few Maltese goats in Turkey and these are mainly in Izmir Province and neighbouring areas of the Mediterranean coast (Yalcin, 1986). Used as a pure animal or for cross-breeding with local goats, it is a specialist dairy animal that is mainly supplied to a niche market. It may also have been used to a limited extent in the development of the Kilis (Yalcin, 1986).

Saanen goats were brought to Turkey in 1959 and continue to be raised as pure animals (Ince, 2010). Under station conditions twinning rates of 2-year-old ones are 22.7 percent (overall litter size = 1.13) and of older females are 42.3 percent with triplet births amounting to 11.5 percent (overall litter size = 1.47). Birth weights are 3.1 kg and 90-day weight 12/9 kg. The Saanen's main role, however, has been the basis for cross-breds (Kosum *et al.*, 2004).

At least three other foreign breeds, the Anglo-Nubian, German-Improved White (GIW) and German-Improved Fawn have also been used to a limited extent for experimental purposes. It is likely that other outside breeds have also been brought into the country, but have passed largely unnoticed.

Cukurova, Taurus and Bornova

These three synthetic breeds are of minor importance. The first two are based on Saanen crosses with local goats, whereas the third is derived only from exotic blood.

The Cukurova, also known as the Akkeci or White goat, of the lowlands of southeast Turkey originated in 1973 from Saanen × (Saanen × Kilis) and is considered as a dairy and meat animal (Mason, 1996). The Taurus of the southeast highlands is also a dairy and meat type whose breeding is Saanen × (Saanen × Hair) also originating in 1973. One study has shown litter size to be 1.63 for Cukurova and 1.61 for Taurus with the Cukurova giving a lactation yield of 352 kg of milk, whereas the Taurus produced 376 kg in a slightly longer lactation (Guney Bicer & Torun 1992; Guney *et al.*, 1997).

The most bizarre of all attempts at cross-breeding in Turkey must be the Bornova. A complicated composite of Anglo-Nubian × (GIW × Maltese) and Anglo-Nubian × (GIW × [GIW × Maltese]) with no Turkish blood whatsoever, it has its origins in 1985 at Ege University in Izmir Province (Mason, 1996). Bred as a dual purpose milk–meat type in one experiment the Bornova produced 246 kg of milk in 193 days and outyielded the Saanen which produced 180–200 kg in 150–180 days (Takma, Akbas & Taskin 2009). On the other hand, Saanen goats fattened for 56 days had a higher rate of daily gain at 161.5 g than Bornova at 132.0 g (Kosum *et al.*, 2003). In a third study, birth weight was 3.4 kg and litter size 1.6 making this breed one of the most prolific in Turkey (Sengonca *et al.*, 2002).

Conservation measures

The number of goats in Turkey has fallen steadily since the middle of the twentieth century. Concomitant to the loss in numbers has been a reduction in the genetic resource with the result that several recognized types are of such low numbers or of such limited geographic distribution that they are considered to be endangered and at possible risk of extinction in the future. Alarmed, perhaps belatedly, by this situation, the Turkish government began to apply conservation policies in an attempt to prevent further decline and to conserve Turkish indigenous goat breeds.

Table 3. Locations and breeds of goat under conservation activities at Government centres.

Location	Breed/line
Lalahan Central Livestock Research Institute (LCLRI), Ankara	Angora, Turkish Native Black Hair
Cukurova Livestock Research Institute (CLRI), Adana	Kilis
Bahri Dagbas Institute for International Agricultural Research (BDIIAR), Konya	Honamli
East Anatolia Livestock Research Institute (EALRI), Erzurum	Norduz

Source: Anon (2009).

Three breeding programmes were initially pursued by universities and government institutions. First, Angora goats were bred at Yerkoy Livestock Research Institute by the University of Ankara, Faculty of Agriculture for triple purpose production of mohair, meat and milk. Second, Kilis and Saanen goats were bred at both the University of Ankara, Faculty of Agriculture and the Department of Animal Science and the F1 progeny backcrossed again to Saanen to produce the Akkeci (White goat), which has a milk yield of 500 kg per lactation, which is a huge amount for a smallholder. Third, native Hair goats were selected for within breed performance to increase meat and milk yields, with encouraging results (Ertugrul *et al.*, 1993).

More recently, the Genetic Engineering and Biotechnical Institute (GEBI), Marmara Research Centre (MRC), The Scientific and Technological Research Council of Turkey (STRCT) Gebze, Kocaeli, prepared a project entitled the "In Vitro Conservation and Preliminary Molecular identification of some Turkish Domestic Animal Genetic Resources (TURKHAYGEN-I)" in 2005 (Arat, 2011). Consequently on several iterations the project was approved by STRCT in March 2007 with a budget of 9.1 million Turkish Lira (about US$ 5.0 million). The implementation period was 4.5 years with the project expected to be completed by the end of 2011 (Arat, 2011). As indicated in the project document, its expected outcomes were:

- establishment of DNA and viable cell banks (gametes, embryos, somatic cells and tissue samples) of animal genetic resources through cryopreservation at GEBI and at Lalahan Central Livestock Research Institute (LCLRI);
- genetic characterization and registration of valuable species and breeds; and
- enhancement of the competitiveness of national human resources in the area of animal husbandry and the building of a critical mass of researcher capacity.

Collection of genetic material for cattle had begun in 2006 and goats were included in the programme in 2007. Some five conservation flocks of goats have been established at various research stations (Table 3) and an extensive bank of genetic material has been established for these same breeds as a result of the project (Table 4). It is expected that this resource will be expanded for preservation, conservation and use of Turkey's native genetic resources in the future. A flock of 70 Norduz goats is being maintained independently at the Research Farm of Agricultural Faculty of Van University in the far east of Turkey (Koyun, 2011).

In addition to direct government and university activities, subsidies are paid to encourage local farmers in community-based conservation and improvement programmes. The subsidies are of two types, the one for *in situ* conservation, the other for improvement of stock under farmer management conditions. The breeds for which subsidies are paid are Angora, Kilis, Honamli and Norduz for 1000 head of each breed. The *in situ* subsidy is equivalent to Euro 30 per head and the improvement subsidy is Euro 17.

Discussion

Locally developed breeds are a pool of irreplaceable genetic material of unacknowledged merit and value that must

Table 4. Genetic material conservation status of Turkish goat breeds in May 2011.

Breed	Genetic Engineering and Biotechnical Institute (GEBI)			Lalahan Central Livestock Research Institute (LCLRI)		
	DNA	Cell	Embryo	Sperm	DNA	Cell
Angora (Ankara Tiftik Kecisi)	59 animals	52 animals, 520 vials	231	25 animals, 679 straws	59 animals	47 animals, 470 vials
Turkish Native Black Hair (Türkiye Yerli Kil)	51 animals	45 animals, 450 vials	74	6 animals, 193 straws	51 animals	51 animals, 510 vials
Kilis	51 animals	51 animals, 510 vials	127	24 animals, 692 straws	51 animals	49 animals, 490 vials
Honamli	49 animals	49 animals, 294 vials	171	20 animals, 642 straws	49 animals	41 animals, 410 vials
Norduz	49 animals	47 animals, 470 vials	63	13 animals, 444 straws	49 animals	–

Source: MRC (2011).

not be lost but must be conserved for possible unknown and unseen future use (Wilson, 2009). Impoverishment of the nation's natural capital is not acceptable under any circumstances but the modest start of conservation measures by the government augurs well for the future and for safeguarding the country's heritage. Livestock production will not remain sustainable if the nation's gene pool is not fully characterized and preserved for use by future generations who will face as yet unforeseen circumstances.

Turkey is a country that is still on the road to development. Livestock production remains an important economic activity, but its produce is inadequate to supply the nutritional requirements of its people. Native goats are generally of low output, but still constitute almost the entirety of the national flock. Efforts should continue to characterize and improve their productive traits alongside the use of exotic breeds with possibly and potentially superior productivity but lower adaptability. The government, universities and the mass of livestock producers and ancillary industries should work together to conserve and improve the native goat breeds of Turkey.

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Typical features, characterization and breeding objectives of Begait sheep in Ethiopia

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Summary
Typical features, breeding objectives and morphological as well as biometrical characters of Begait sheep breed were studied in two districts (Setit Humera and Kafta Humera) of Ethiopia. Semi-structured questionnaires, recording body weight, linear body measurements and field observations were employed. Begait sheep breed is described as long and thin tailed (up to 50-cm long), with muscular body, short and smooth hair and polled for both male and female sexes. As reported by the respondents' growth rate (0.21), tail length (0.20), appearance/conformation (0.19) and coat colour (0.18) were the most important traits in selecting breeding rams. For breeding ewes' body size (0.27), age at first service (0.15), growth rate (0.14) and coat colour and tail (0.13) were their first, second, third and fourth traits, respectively. Sites and age had significant ($P < 0.01$) effect on body weight and most linear body measurements. Relatively, Kafta Humera had lower values in body weight and most of the linear body measurements than Setit Humera. The overall mean body weight and body length of female Begait sheep were 31.4 ± 0.4 kg and 62.5 ± 0.5 cm, respectively. The corresponding values for male Begait sheep were 34.5 ± 0.5 kg and 66.1 ± 0.5 cm, respectively. The existing traditional herding, breeding practices and trait preferences are the key breeding components that need improvement at smallholder farmers' in Ethiopia.

Keywords: *Begait sheep, breeding practices, trait preferences, typical features*

Résumé
Les caractéristiques, les objectifs de sélection et les caractères morphologiques et biométriques des moutons Begayit ont été étudiés dans deux districts (Setit Humera et Kafta Humera) de l'Éthiopie en utilisant des questionnaires semi-structurés, l'enregistrement du poids corporel et des mensurations du corps et des observations sur le terrain. Les moutons Begayit possèdent une queue longue et mince (jusqu'à 50 cm de longueur), un corps musclé, des poils courts et lisses et, les mâles autant que les femelles, n'ont pas de cornes. Les interviewés ont signalé que le taux de croissance (0.21), la longueur de la queue (0.20), l'aspect/conformation (0.19) et la couleur de la robe (0.18) représentaient les caractères les plus importants dans la sélection des béliers reproducteurs. Pour ce qui concerne les brebis reproductrices, la taille du corps (0.27), l'âge à la première mise bas (0.15), le taux de croissance (0.14) et la robe et la queue (0.13) étaient respectivement le premier, le deuxième, le troisième et le quatrième caractère d'importance. L'emplacement et l'âge influencent ($P < 0.01$) le poids et la plupart des mensurations du corps. Les moutons du district Kafta Humera présentaient des valeurs concernant le poids et les mensurations du corps relativement plus faibles que les moutons du district de Setit Humera. Les moyennes générales du poids et de la longueur du corps des femelles Begayit étaient respectivement de 31.4 ± 0.4 kg et de 62.5 ± 0.5 cm. Les valeurs correspondantes pour les mâles des moutons Begayit étaient respectivement de 34.5 ± 0.5 kg et de 66.1 ± 0.5 cm. Les pratiques traditionnelles existantes d'élevage et de sélection et les préférences de caractères sont les composantes principales de sélection qu'il faut améliorer chez les petits exploitants de l'Éthiopie.

Mots-clés: *moutons Begayit, pratiques de sélection, préférences de caractères, caractéristiques*

Resumen
Se estudiaron las características típicas, los objetivos de cría y los caracteres tanto morfológicos como biométricos de la raza ovina Begait en dos distritos de Etiopía (Setit Humera y Kafta Humera). Se utilizaron cuestionarios semi-estructurados con registro del peso y medidas lineales del cuerpo y de observaciones de campo. La descripción de la raza Begait es: cola larga y delgada (hasta 50 cm de largo), cuerpo musculoso, pelo corto y liso, y desprovistos de cuernos en ambos sexos masculino y femenino. Según las respuestas de los encuestados, la tasa de crecimiento (0.21), la longitud de la cola (0.20), la apariencia/conformación (0.19) y el color del pelaje (0.18) fueron las características más importantes en la selección de los carneros de reproducción. Para la cría de hembras el tamaño corporal (0.27), la edad de la primera cubrición (0.15), la tasa de crecimiento (0.14) y el color del pelaje y de la cola (0.13) fueron las primeras cuatro características, en ese orden. El emplazamiento y la edad tuvieron un efecto significativo ($P < 0.01$) en el peso corporal y en la mayoría de las medidas corporales lineales. Los ejemplares de Kafta Humera mostraron en términos relativos valores más bajos de peso corporal y de la mayoría de las medidas corporales lineales que los de Setit Humera. En conjunto, el peso corporal medio y la longitud corporal media de las hembras Begait fueron respectivamente 31.4 ± 0.4 kg y 62.5 ± 0.5 cm. Los valores correspondientes para los machos Begait fueron 34.5 ± 0.5 kg y 66.1 ± 0.5 cm, respectivamente. Las prácticas tradicionales existentes

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de manejo del rebaño y cría y las preferencias por determinados caracteres son los componentes de la cría más importantes que requieren mejoras en la ganadería a pequeña escala de Etiopía.

Palabras clave: *oveja Begait, prácticas de cría, preferencias de características, caracteres típicos*

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Introduction

Ethiopia is a route of sheep migration from Asia to Africa and has diverse traditional sheep breeds spread across diverse ecology, communities and production systems (Solomon, 2008). It is the home for at least nine breeds and 14 traditional sheep populations (Solomon *et al.*, 2007a) with estimated 25.5 million heads (CSA, 2010/11). Locally available sheep breeds in Ethiopia are the result of many generations of human and natural selection. The sheep can survive under harsh environments such as feed scarcity, disease challenges and are highly adapted to low-input systems (Tibbo *et al.*, 2006). Besides being safe investment for the family and rendering social prestige within the community, they are sold to meet compelled family financial obligations or slaughtered for consumption at home or festivals (Abebe, 1999). The low performance as compared with temperate breeds (Kassahun, 2000) and the poor understanding of production system, poor nutrition, prevalence of disease, lack of appropriate breed and breeding strategies make them low in production and productivity. However, detailed and up-to-date information on indigenous knowledge of managing the breed, identification of important traits and typical features with full participation of farmers are important for effective and sustainable utilization of typical sheep breeds (Kosgey *et al.*, 2006). Unfortunately, such information is not readily available for Ethiopian sheep breeds (Ayalew *et al.*, 2004) in general and for Begait sheep breed in particular at smallholder farmer's level.

Therefore, the objective of this study was to assess the typical features, breeding practices, breeding objectives and morphological as well as biometrical characteristics of Begait sheep breed at smallholder farmers' level in two districts of western Tigray, Ethiopia

Material and methods

Study sites

The study was conducted in two districts (Setit Humera and Kafta Humera) of the western zone Tigray, Ethiopia

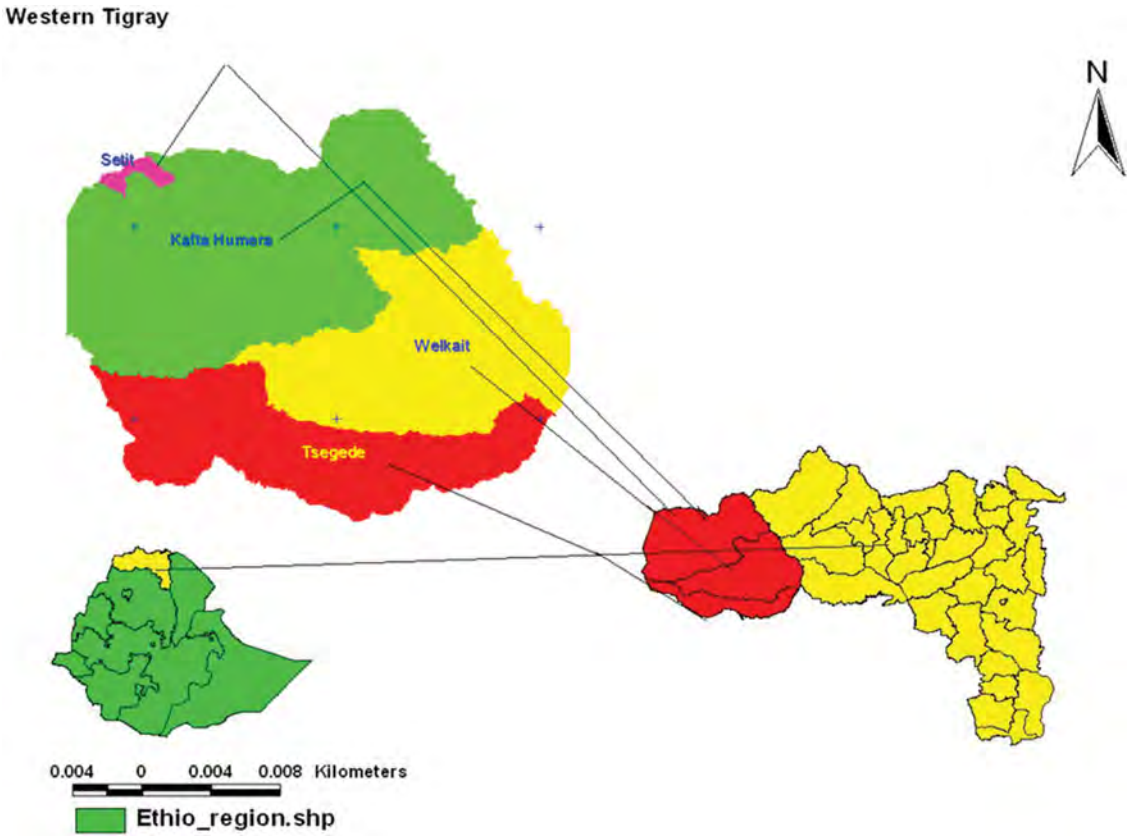

Figure 1. Map of the study area, Setit and Kafta Humera.

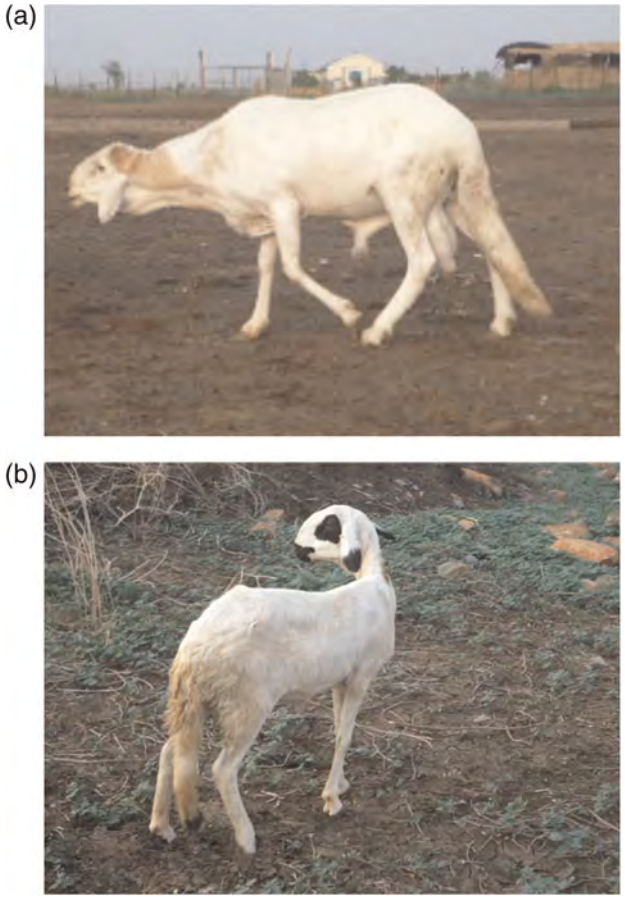

Figure 2. (a) Typical male Begait sheep. (b) Typical female Begait sheep (ewe).

(Figure 1), which are located 1 500 km from Addis Ababa to the north and 252 North West of Gondar and altitude range of 560–1849 m above sea level. The mean maximum temperature varied from 33 to 41.7°C, while the mean minimum temperature varied from 17.5 to 22.2°C. Annual rainfall in the area ranges from 448.8 to 1 102.5 mm in which 80–85 percent is received during the summer/rainy season. Generally, climate is characterized by distinct dry (October–May) and wet seasons (June–September).

Data collection methods and procedures

The survey and field observation were conducted from March 2011 up to January 2012. Two sites in Setit Humera and three sites in Kafta Humera were selected based on sheep population, traditional of sheep production system, practices of communal grazing land, market and access of infrastructure of the study sites. A total of 126 households (52 in Setit Humera and 74 in Kafta Humera) were randomly selected for the interview within the selected sites. For typical trait characterization and body linear measurements, a total of 219 female (90 in Setit areas and 129 in Kafta areas) 120 male (30 in Setit areas and 90 in Kafta areas) sheep were considered.

Besides semi-structured questionnaires, participatory rural appraisal together with a focused group discussion and field observation, typical trait characterization and body measurements were employed. For the morphological and biometrical measurements, all sheep ($n = 339$) above 4 months of age were measured. The live weights of the sheep were measured using the Salter scale (50 kg capacity with 200 g precision). Other body measurements (heart girth, height at wither, body length, pelvic width and chest depth) were taken using flexible metal tape (3 m length) to the nearest 0.5 cm after restraining and holding the animals in an unforced position.

Data analyses

The Statistical Package for Social Sciences (SPSS) computer software (SPSS for window, release 16.0, 2007) was used to analyse the qualitative data. Chi-square test was used to assess statistical significances. Indices were calculated to provide ranking of selection criteria and breeding objectives.

The General Linear Model (GLM) procedures of SAS (2008) were employed to study the body weight and linear body measurements as well as effects of study sites and dentition (PPI) classes.

Model to analyse adult body weight and other linear body measurements were:

$$Y_{ijk} = \mu + A_i + S_j + T_k + (AT)_{ik} + e_{ijkl},$$

where Y_{ijk} is the observed body weight or linear body measurements in the ith age group, jth sex, kth district (study sites) at the lth household; μ is theoverall mean; A_i is the effect of ith age group ($i = 0$, 1, 2, 3 and 4); S_j is the effect of jth sex (j = male and female); T_k is the effect of district/site; AT_{ik} is the effect of ith age group and the effect of district/site interaction; e_{ijkl} is the random residual error.

Results

Typical morphological features

The breed is described as muscular body size, coat color is dominated by white, white and black mouse, grey, slightly red and creamy white (Figure 2a, b). The sheep have typical long and thin tail with straight pointed end (Figure 2a, b). Both males and females are polled; the ear is long, the hair is short and smooth. They are also known for travelling long distance and their ability to disease and heat resistances.

Breeding objectives

The index value (0.5) revealed that the primary objective of the farmers for breeding and keeping sheep in both districts was for income generation. Meat consumption (0.26), wealth status expression (0.16), celebration of ceremonies (0.06) and

Table 1. Ranked and percentage (%) of breeding objectives of smallholder farmers in two districts (Setit Humera and Kafta Humera) of the study area.

Ranked breeding objectives	Percentage of breeding objectives				
	Meat	Income	Savings	Ceremonies	Wealth status
Setit Humera					
Rank 1	3.8	96.2	–	–	–
Rank 2	53.8	3.8	1.9	3.8	19.2
Rank 3	42.3	–	7.7	28.8	51.9
Index	0.27	0.50	0.02	0.06	0.15
Kafta Humera					
Rank 1	4.1	95.9	–	–	–
Rank 2	45.9	4.1	2.7	5.4	24.3
Rank 3	45.9	–	8.1	24.3	50.0
Index	0.26	0.50	0.02	0.06	0.16
Overall index	0.26	0.50	0.02	0.06	0.15

Index, sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular purpose divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all purpose.

source of savings (0.02) had significant index value showing farmers breeding objectives (Table 1).

Breeding practices

In the study districts, mating was predominantly uncontrolled except in Setit Humera where rams were isolated during the day time. This was related to protect rams from theft and not to mate the ram with other flocks. Out of the total farmers interviewed, about 93.2 and 90.4 percent kept their own breeding rams in Kafta and Setit Humera, respectively. The majority (86.5 percent) of breeding rams for Setit Humera and 89.2 percent for Kafta Humera originated from own flock. On average, breeding rams were kept for 2.94 ± 0.83 years with the range of 2–5 years for Setit Humera and 2.97 ± 1.03 years with a range of 1–5 years for Kafta Humera.

Selection criteria

Of the total respondents, 82.7 and 85.1 percent of the farmers in Setit Humera and Kafta Humera, respectively, practice selection for breeding rams. Similarly, 69.2 and 95.9 percent of the respondents in Setit Humera and Kafta Humera practice selection of breeding females, respectively. Ranking of selection criteria for breeding rams and females is presented in Table 2. In Setit Humera, majority of the respondents select breeding rams based on their growth (0.21), tail length (0.20) appearance/conformation and colour with the same value of 0.19 was ranked as their first, second, third and fourth, respectively. Similarly, in Kafta Humera breeding ram was ranked first for fast growth (0.22), second for tail length (0.20), third for appearance (0.19) and fourth for colour (0.17), respectively. In Setit, selection of breeding ewes, traits of body size (0.28), age at first maturity (0.16), lamb growth (0.13), tail length (0.13) and coat color (0.12) were their first, second, third and fourth traits, respectively. On the other hand, in Kafta humera body size (0.27), lamb growth (0.16), age at first service (0.14), coat color type and tail length (0.13) were the first four important traits in their order, respectively.

Body weight and linear body measurements

The least squares means of body weight and linear measurements of Begait sheep are presented in Table 3. The overall least squares means of body weight and body length obtained for Begait sheep were 32.8 ± 0.4 kg and 62.9 ± 0.4 cm, respectively.

Table 2. Ranked index and percentage (%) of selection criteria of trait preference for breeding rams and ewes.

Traits	Setit Humera		Kafta Humera		Overall index	
	Male	Female	Male	Female	Male	Female
Body size/appearance	0.19 (19%)	0.28 (28%)	0.19 (19%)	0.27 (27%)	0.19 (19%)	0.27 (27%)
Colour	0.19 (19%)	0.12 (12%)	0.17 (17%)	0.13 (13%)	0.18 (18%)	0.12 (12%)
Lamb survival	–	0.06 (6%)	–	0.07 (7%)	–	0.07 (7%)
Growth	0.21 (21%)	0.13 (13%)	0.22 (22%)	0.16 (16%)	0.21 (21%)	0.14 (14%)
Age at first sexual maturity	0.09 (9%)	0.16 (16%)	0.08 (8%)	0.14 (14%)	0.08 (8%)	0.15 (15%)
Lambing interval	–	–	–	–	–	–
Twining ability	–	0.08 (8%)	–	0.07 (7%)	–	0.07 (7%)
Ability to walk long distance	0.01 (1%)	0.02 (2%)	0.01 (1%)	0.01 (1%)	0.01 (1%)	0.02 (2%)
Tail length	0.20 (20%)	0.13 (13%)	0.20 (20%)	0.13 (13%)	0.20 (20%)	0.13 (13%)
Ear length	0.02 (2%)	0.02 (2%)	0.02 (2%)	0.02 (2%)	0.02 (2%)	0.02 (2%)
Pedigree	–	–	–	–	–	–
Character	0.01 (1%)	–	0.02 (2%)	–	0.02 (2%)	–
Adaptability	0.06 (6%)	–	0.05 (5%)	–	0.05 (5%)	–
Libido	0.02 (2%)	–	0.04 (4%)	–	0.04 (4%)	–
Over all index	1	1	1	1	1	1

Index, sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for particular purpose divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all purpose.

Table 3. Least squares means and standard error (LSM ± SE) for main effects of districts, sex and dentition (PPI) on the body weight and linear measurements of Begait sheep.

Variable	*N*	BW (kg) LSM ± SE	BL (cm) LSM ± SE	HG (cm) LSM ± SE	HW(cm) LSM ± SE	PW (cm) LSM ± SE	CD (cm) LSM ± SE
Overall	339	32.8 ± 0.4	62.9 ± 0.4	68.6 ± 0.8	64.4 ± 0.5	18.4 ± 0.3	25.8 ± 0.3
District		**	**	**	**	**	**
Setit	120	34.1 ± 0.5	63.7 ± 0.5	70.3 ± 0.8	65.2 ± 0.6	19.3 ± 0.3	26.6 ± 0.3
Kafta	219	31.6 ± 0.4	62.1 ± 0.4	66.9 ± 0.5	63.6 ± 0.4	17.5 ± 0.3	24.9 ± 0.3
Sex		**	**	**	NS	NS	**
Male	120	34.5 ± 0.5	63.1 ± 0.5	70.9 ± 0.8	63.6 ± 0.6	18.2 ± 0.3	26.4 ± 0.4
Female	219	31.4 ± 0.4	62.5 ± 0.5	66.6 ± 0.6	64.5 ± 0.5	18.1 ± 0.3	25.0 ± 0.2
Dentition		**	**	**	**	**	**
0PPI	50	25.9 ± 0.5^{a}	54.9 ± 0.5^{a}	57.5 ± 0.6^{a}	54.8 ± 0.5^{a}	13.7 ± 0.3^{a}	21.3 ± 0.5^{a}
1PPI	50	27.4 ± 0.6^{ba}	57.3 ± 0.5^{b}	63.9 ± 0.7^{b}	57.3 ± 0.6^{b}	13.8 ± 0.4^{ba}	22.5 ± 0.5^{b}
2PPI	75	33.0 ± 0.5^{c}	63.7 ± 0.4^{c}	65.4 ± 0.6^{cb}	67.2 ± 0.4^{c}	19.6 ± 0.4^{c}	25.1 ± 0.3^{c}
3PPI	86	36.3 ± 0.4^{d}	66.5 ± 0.4^{de}	71.2 ± 0.7^{d}	67.3 ± 0.4^{de}	20.2 ± 0.4^{dc}	27.3 ± 0.3^{ed}
4PPI	78	35.3 ± 0.5^{ed}	65.9 ± 0.4^{ec}	76.9 ± 0.6^{e}	68.1 ± 0.5^{ec}	20.0 ± 0.3^{ecd}	27.8 ± 0.3^{ed}

^{a,b,c,d,e}Means on the same column with different superscripts within the specified dentition group are significantly different ($P < 0.01$).
**$P < 0.01$.
BW, body weight; BL, body length; HG, heart girth; WH, wither height; PW, pelvic width; CD, chest depth; 1PPI, 1 pair of permanent incisors; 2 PPI, 2 pairs of permanent incisors; 3PPI, 3 pairs of permanent incisors; 4PPI, 4 pairs of permanent incisors.

Table 4. Phenotypic correlations between body weight and liner body measurements of Begait sheep.

Dentition	BW	BL	HG	HW	PW
0PPI					
BL	0.72**				
HG	0.79**	0.53**			
HW	0.72**	0.84**	0.57**		
PW	0.81**	0.62**	0.63**	0.67**	
CD	0.47*	0.39*	0.23^{NS}	0.40*	0.57**
1PPI					
BL	0.78**				
HG	0.79**	0.54**			
HW	0.77**	0.84**	0.49*		
PW	0.74**	0.73**	0.58**	0.68*8	
CD	0.71**	0.56**	0.60**	0.51*	0.69*8
2PPI					
BL	0.76**				
HG	0.89**	0.71**			
HW	0.42*	0.39*	0.33*		
PW	0.53*	0.39*	0.56**	0.18^{NS}	
CD	0.55**	0.36*	0.55*	0.22*	0.27*
3PPI					
BL	0.74**				
HG	0.82**	0.54**			
HW	0.65**	0.55**	0.48**		
PW	0.32*	0.27*	0.03^{NS}	0.22*	
CD	0.75*	0.56**	0.64**	0.57**	0.19^{NS}
4PPI					
BL	0.67**				
HG	0.81**	0.61**			
HW	0.44**	0.65**	0.44**		
PW	0.55**	0.29*	0.52**	0.15^{NS}	
CD	0.59**	0.51**	0.49**	0.30*	0.32*

0PPI, 0 pair of permanent incisors, 1PPI, 1 pair of permanent incisor; 2PPI, 2 pairs of permanent incisors; 3PPI, 3 pair of permanent incisors; 4PPI, 4 pair of permanent incisors; NS, non-significant ($P > 0.05$); BW, body weight, HG, heart girth, BL, body length, HW, height at withers, PW, pelvic width, CD, chest depth.
**Correlation is significant at $P < 0.01$.
*Correlation is significant at $P < 0.05$.

Correlation and prediction of weight using body measurements

The Pearson's correlation coefficient for body weight and linear body measurements are presented in Table 4. Among the body measurements heart girth had the highest correlation coefficient ($r = 0.89$, $P < 0.01$) with body weight in all dentition groups, except, in dentition group of 0PPI; in that case pelvic width had the highest correlation coefficient ($r = 0.81$, $P < 0.01$).

The high correlation coefficients observed between body weight and heart girth for all dentition groups suggest that heart girth alone or in combination with other body measurements could provide a good estimate for live weight of Begait sheep at different dentition groups. Parameter estimates of linear and multiple linear regression equations predicting live weight from body measurements of Begait sheep are presented in Table 5. In this study, heart girth alone had the highest accuracy for estimating body weight (R^2 up to 84 percent) for female's, except, in dentition group 1PPI (R^2 of 46 percent). On the other hand, in male's heart girth alone explains body weight with up to 96 percent accuracy. Comparing dentition groups, the highest coefficient of determination was depicted by age group 2PPI (84 percent of the variation in weight was explained by the equation) for female and at 4PPI age group (96 percent of the variation in weight was explained by the equation) for males, respectively. The differences in the coefficient of determination of equations between different dentition groups indicated that weight can be estimated using different equations for different age groups with different accuracies. Within dentition groups, the coefficient of determination revealed that weight was better predicted when two or more measurements were included in the equation.

Table 5. Prediction equations at different sex and age groups.

Age group	Equation	Intercept	β1	β2	R^2
Female age group					
0PPI	HG	−10.97	0.64		0.52
	HG + BL	−22.20	0.43	0.41	0.66
1PPI	HG	−6.31	0.51		0.46
	HG + BL	−22.80	0.40	0.41	0.68
2PPI	HG	−19.45	0.80		0.84
	HG + BL	−23.62	0.70	0.16	0.85
3PPI	HG	−13.14	0.71		0.79
	HG + BL	−20.36	0.57	0.25	0.82
4PPI	HG	−13.29	0.61		0.65
	HG + BL	−31.21	0.42	0.50	0.79
Male age group					
0PPI	HG	−11.17	0.64		0.55
	HG + BL	−13.96	0.31	0.40	0.74
1PPI	HG	−5.08	0.53		0.76
	HG + BL	−23.91	0.30	0.57	0.87
2PPI	HG	3.73	0.45		0.84
	HG + BL	−19.36	0.17	0.65	0.94
3PPI	HG	−29.37	0.88		0.64
	HG + BL	−44.34	0.67	0.45	0.79
4PPI	HG	−18.54	0.03		0.96
	HG + BL	−18.90	0.72	0.01	0.96
Female age group					
0–4PPI	HG	−1.00	0.48		0.57
	HG + BL	−20.20	0.17	0.64	0.81
Male age group					
0–4PPI	HG	−11.90	0.65		0.87
	HG + BL	−20.87	0.41	0.41	0.91

BL, body length; HG, heart girth; 0PPI, 0 pair of permanent incisors, 1PPI, 1 pair of permanent incisors; 2 PPI, 2 pairs of permanent incisors; 3PPI, 3 pairs of permanent incisors; 4 PPI, 4 pairs of permanent incisors.

Discussions

For sustainable genetic improvement programmes understanding of the production system and breeding objectives are important factors (Kosgey *et al.*, 2006). This study revealed that the primary breeding objectives of the farmers were to generate income with an index value of 0.50. This value was higher than the value of Afar sheep (0.23; Getachew *et al.*, 2010). In this study, it was found that mating was predominantly uncontrolled and was similar to Bonga and Horro indigenous sheep breeds of Ethiopia (Zewdu, 2008). Our study also confirmed that farmers' breeding rams and ewes selection was mainly based on growth and tail length, which was different from Afar and Menz, (physical appearance; Getachew *et al.*, 2010). The least squares mean body weight (34.5 ± 0.53 kg) obtained for male Begait sheep was higher than that of Washera ram (28.3 kg) and Bonga ram (27.7 ± 0.17 kg) as reported by Mengistie (2008) and Tesfaye (2008), respectively. The mean value of body weight in female Begait sheep was higher than that of female Washera (25.0 kg) and Horro ewe (27.7 ± 0.21 kg) as reported by Mengistie (2008) and Tesfaye (2008), respectively, but closer to female Bonga sheep (31.9 ± 0.19; Tesfaye, 2008). This shows that the Begait sheep breed has higher body weight gain compared with the known Ethiopian sheep breeds. The correlation between body weight and linear body measurements in Begait sheep were in line with Kassahun (2000), Thiruvenkadan (2005), Afolayan, Adeyinka and Lakpini (2006) and Khan *et al.* (2006). The highest coefficient of determination was depicted at age group 2PPI (84 percent) for females and at 4PPI age group (96 percent) for male Begait sheep, respectively. Kassahun (2000) found out that heart girth alone explains 83 and 81 percent of weight of Menz and Horro ram lambs, respectively.

Conclusions

Typically the breed is described as long and thin tail with straight pointed end and known for their disease and heat resistance ability and travelling long distance. As a whole, for sustainable and improved sheep breeding programmes, it is important to measure, observe the production environments and involve farmers for exploiting the existing

breeding practices, management systems and trait preferences accustomed to the community.

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Characterization of indigenous pigs in Southwestern Nigeria using blood protein polymorphisms

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Summary
The Nigerian indigenous pigs (NIP) are threatened to lose their genetic diversity through unsustainable farming practices in Nigeria. Therefore, the genetic relationships of NIP and commercially developed cross-bred pigs were evaluated to pinpoint a possible source of pure uncontaminated genetic stocks of NIP for conservation. Blood protein polymorphisms were used as a preliminary genetic analysis of blood samples from a total of 120 pigs (79 NIP from three separate locations and 41 cross-bred pigs). Nineteen polymorphic bands of the blood proteins globulin, transferrin and albumin were observed by sodium dodecyl sulphate-polyacrylamide gel electrophoresis (SDS-PAGE) and a phylogenetic dendrogram was developed to analyse the genetic relationship between the NIPs. The three NIPs were found to have a high genetic similarity (84 percent similarity coefficient), and were found to be distinctly different from the commercially cross-bred strains. One line from a farm in Ogbooro, Saki Oyo, Nigeria was identified as a relatively stable genetic resource that may be a suitable NIP for future conservation efforts.

Keywords: *animal genetic resources, conservation, electrophoresis, Nigerian indigenous pig*

Résumé
Les diversités génétiques et les relations avec les porcs indigènes du Nigéria (NIP) et des ceux Croisés ont été évalués pour pourvoir ciblé une source possible des stocks génétiques purs non-contaminés dans le but de la conservation finale des NIP. Un total de 120 échantillons des couchons ont été recueilli, dont 79 étaient NIP et 41 Croissées. Subsequenment, 12% SDS-PAGE (éléctrophorèse d'acrylamide avec sulfate de sodium dodécyl) a été fait et les profils éléctrophorètiques des animaux sont evalués et comparés. En suite l'analyse UPGMA a été construie pour les groupements génétiques. Tous les NIPs en provenance de trois localités ont revelé une haute similarités génétiques (84%) montrant leur relations génétiques très proches.

Mots-clés: *ressources zoogénétiques, conservation, électrophorèse, porc indigène du Nigeria*

Resumen
La insostenibilidad de las prácticas ganaderas en Nigeria amenaza la diversidad genética de los cerdos autóctonos nigerianos (NIP por sus siglas en inglés). Por tanto, se evaluó la relación genética entre NIP y los cerdos cruzados usados a nivel comercial con el fin de detectar una posible fuente genética de NIP puros no contaminados para su conservación. El polimorfismo en las proteínas sanguíneas se usó como análisis genético preliminar en las muestras de sangre de un total de 120 cerdos (79 NIP procedentes de tres ubicaciones distintas y 41 cerdos cruzados). Mediante electroforesis en gel de poliacrilamida con dodecilsulfato sódico, se observaron 19 bandas polimórficas para las proteínas sanguíneas globulina, transferrina y albúmina. Se desarrolló un dendograma poligenético para analizar la relación genética entre los NIP. Así, se encontró que los tres grupos de NIP tenían una elevada similitud genética (84 percent de coeficiente de similitud) y que diferían claramente de las líneas cruzadas comerciales. En una granja de Ogbooro, Saki Oyo (Nigeria) se identificó una fuente genética relativamente estable de NIP que podría usarse para futuros esfuerzos de conservación.

Palabras clave: *recursos zoogenéticos, conservación, electroforesis, cerdo autóctono nigeriano*

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Introduction

All domesticated animal breeds, strains and species that are of economic, scientific and cultural interest to current and future human needs in terms of food and agricultural production are referred to as animal genetic resources (AnGR) (Rege and Gibson, 2003). However, the development of new technologies that alter the traditional production environment, the need to meet the world's increasing demand for animal products and the unpredictable effects of climate change put AnGRs under pressure. This includes farming practices to alter AnGR diversity through the creation of new breeds, breed improvements and breed

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adaptations to address changing global circumstances (FAO, 2007). Unfortunately, not all of these changes are beneficial (Woolliams, Matika and Pattison, 2008) and many animal species are now in danger of extinction, while others are threatened by inefficient use or loss due to cross-breeding (FAO, 2007). Therefore, to meet future challenges in the agricultural and food industries, special efforts are imminently needed to conserve AnGR.

Although, it may not be possible to conserve all breeds, the adequate maintenance of the biodiversity of AnGRs can allow farmers to adapt to environmental challenges, veterinary health issues as well as the changing demands of human socio-economic activities by either conserving existing stocks or by developing new breeds (FAO, 2000). The appropriate use and sustainable farming of AnGRs will help to assure both national and global food security, especially since the majority of the world's food products (75 percent) come from a small number of plant and animal species (FAO, 2007). Therefore, it becomes important not only to protect the biodiversity (the evolutionary and genetic foundations that describe both phenotypic and molecular aspects of numerous populations and species distributed globally in small ecosystems and larger biomes but also to proceed diligently.

One AnGR that calls for great concern and requires further study and cataloguing is the domestic pig as they are one of the most prolific and fastest growing livestock. Currently, there are more than 730 breeds or lines of pigs all over the world, two-thirds of which are raised in China and Europe, but approximately 270 of these breeds are threatened by extinction (FAO, 2007). The loss of this diversity will have considerable impact, not only on the global pork industry, but more dramatically on small, local farmers in developing countries such as Nigeria. The indigenous pigs are monogastric animals raised by rural families to supplement protein intake or family income because of the less intensive management and feed requirements (Omitogun, 2004). Local pigs are easily adapted to variable environmental conditions and can also convert food waste into valuable products that supplement the local economy. Additionally, the pig has several advantages over other farmed animal species because of their large litters and/or two or more litters per year. This allows the pig to transit from a local economic AnGR to a more valuable economic resource because pedigrees can be produced faster (Archibald and Haley, 1992). Further advantages of pigs are the relatively low cost of pig production and fast growing rate (Osaro, 1995), short generation interval and high production potential, prolific fecundity (Holness, 1991; Osaro, 1995) and highly efficient carcass yield or high meat to bone ratio (Pathiraja and Oyedipe, 1990; Ikani and Dafwang, 1995; Olomu and Oboh, 1995). The Nigerian indigenous pigs (NIP) (Figure 1) is a valuable genetic resource that is gradually disappearing because of the cross-breeding practices of local farmers with exotic breeds and little is known about the NIP genetic make-up. They may possess ancient

Figure 1. NIP from Igbara Odo, Nigeria.

characteristics or genetic variants that were present in their ancestors that are absent in improved modern livestock. Such traits may be of commercial, scientific, aesthetic or historical value (CTA, 1994). Although there have been few genetic studies on the NIP, there has been relatively more research on the growth and reproductive performance (Oseni, 2005), feed conversion rate and carcass quality (Pathiraja and Oyedipe, 1990) of the NIP as well as these performances in hybrids crossed between NIP and exotic pigs (Fetuga, Babatunde and Oyenuga, 1976; Adebambo, 1982; Adebambo and Onekade, 1983; Sonaiya, 1987). More recently, the karyotypes of the NIP were characterized with eight chromosome pairs by submetacentric sex chromosomes XX for females and XY for males (Oluwole and Omitogun, 2009), which were not found to be different from the domestic pig, *Sus scrofa domestica* (CSKSS, 1988). However, no comprehensive molecular analysis of the genetic make-up of the NIP has been conducted.

Furthermore, the extensive and random distribution of exotic pig breeds in the Nigerian pig population is believed to dilute the indigenous genetic stock and if this trend continues, the gene pool of the indigenous pigs could be lost in the near future, before they are described and studied. This general threat is in line with the views of Cardellino (2006) that AnGRs in developing countries are being eroded through the rapid intensification of tropical agricultural systems favouring exotic commercial breeds. This then calls for a sustained research on NIP genetics because of their general hardiness and importance to the local and sustainable economy. Additionally, the NIP may be a potential source of important genetic information that controls specific and economically favourable traits. However, there is a lack of up-to-date information on this subject, making the formulation of future and sustainable NIP breeding programmes difficult (Omitogun, 2004). In order to develop breed conservation programmes, an evaluation of the genetic uniqueness and breed diversity of NIP is needed. Although microsatellite loci and other DNA markers remain popular and efficient polymorphic

markers used to measure genetic diversity in various farm animal species (Kemp *et al.,* 1995; MacHugh *et al.,* 1998; Handley *et al.,* 2007; Granevitze *et al.,* 2007), endangered animals (Akst, Boersma and Fleischer, 2002; Vidya *et al.,* 2005; Bhagavatula & Singh 2006; Gaur *et al.,* 2006), plants (Yu *et al.,* 2009) and human studies (Ghosh, Das and Seshadri, 2003), the use of protein polymorphism markers in diversity studies provides an economically feasible approach to perform preliminary studies on the genetic diversity of many species, including the NIP. Therefore, the aim of this paper was to investigate the genetic diversity, as a preliminary assessment of NIP, using pig stocks known to be uncontaminated and unlikely to have been altered by cross-breeding with exotic strains. Blood protein polymorphisms were analysed as an estimate of the genetic similarity between three NIP stocks and a collection of pigs selectively cross-bred with commercial exotic founder stocks at Obafemi Awolowo University, Osun, Nigeria.

Materials and Methods

Animals and study sites

One hundred and twenty pig blood samples were collected from four different locations more than 100 km apart in southwestern Nigeria (Figure 2). The geographic of the region are as follows: latitude: 7–9° south; longitude: 3–6° west; altitude range: 200–500 m above sea level; climate: abundant and reliable rainfall from April through October. NIP samples were collected from three separate locations: (i) Ogbooro, Saki Oyo State (30 NIP samples from pigs that were locally kept in a mud house and were occasionally released to roam about the village. These animals may have undergone limited, but restricted genetic infiltration by other breeds of pigs from neighbouring states, although the animals were inherited and maintained by a few Christian families in a predominantly Muslim region); (ii) Institute of Agricultural Research and Training (IAR&T), Ibadan, Oyo State (16 NIP samples from animals kept on a research farm, where animals received regular feeding and proper records were kept on each animal); and (iii) Igbara Odo, Ekiti State (33 NIP samples from local pigs that were allowed to roam about scavenging for survival. These animals had a history of being reared for many years (Figure 1)). Cross-bred pig samples were collected from Obafemi Awolowo University (OAU), Teaching and Research Farm (T&R Farm), Ife, Osun State (41 cross-bred samples were obtained from animals crossed with selected or introduced commercial exotic founder stocks (Landrace/Large White and Duroc). These animals had a known history of cross-breeding for at least 5 years followed by inbreeding within a closed herd and served as an out group with considerable contamination of their genetic line (i.e. the commercial exotic breeds have been developed through extensive crossing with other breeds of pigs). The sampling areas were identified and selected after a field reconnaissance

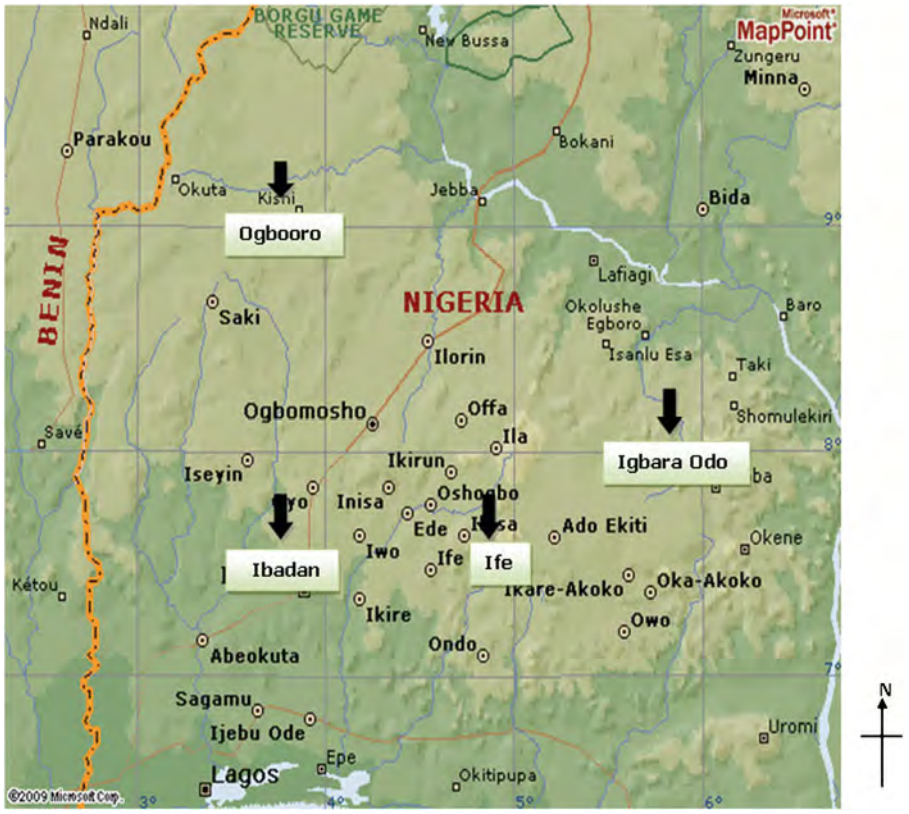

Figure 2. Map of southwestern Nigeria. The four sampling locations are highlighted by arrows. Nigerian indigenous pigs were from Ibadan, Igbara Odo and Ogbooro, respectively, and the crossbreed strains were from the Teaching and Research Farm, Obafemi Awolowo University, in Ife, Osun State.

of the geography and after personal interviews of the pig farmers were conducted to confirm the uncontaminated genetic lines of the NIP.

Sample preparation and electrophoresis

Blood samples (5 ml) were collected from the jugular vein of each pig with 5 ml hypodermal syringes. All whole blood samples were transferred to the laboratory at OAU and were analysed as previously described by Adeleke *et al.* (2011). Briefly, blood serum was collected by centrifugation and stored at −35°C. Protein polymorphisms of three blood proteins (globulin, transferrin and albumin) were then analysed by sodium dodecyl sulphate-polyacrylamide gel electrophoresis (SDS-PAGE). All sample preparation steps and the electrophoresis protocol were maintained throughout the analysis. Serum samples were denatured in 7.5 percent β-mercaptoethanol by heating at 95°C for 5 min. Then 15 µl samples were loaded on SDS–polyacrylamide gels (4 percent stacking gel (pH 6.8) and 10 percent resolving gel (pH 8.8)) and separated at 150 V for 2 h with the Bio-Rad Mini Protean II Electrophoresis system. Each gel contained a molecular weight standard and three lanes each loaded with the individual marker proteins.

Following SDS-PAGE, gels were rinsed and then stained in 0.1 percent Coomassie Blue in 1:4 glacial ethanoic acid:methanol. Following staining, gels were de-stained with 60 percent 1:4 glacial ethanoic acid:methanol. Gels were then scanned and protein bands were visually scored (positive bands were scored as (1) and negative or absent bands were scored as (0).

Statistical analysis

Each sample was awarded a total score based on the cumulative presence of the three marker proteins. The total score was then analysed and a dendrogram was produced with the mean score of each breed using the unweighted pair group method (UPGMA; Sneath and Sokal, 1973) with the statistical software package PAST (Hammer, Harper and Ryan, 2001). The similarity index within each of the four groups, within the whole NIP (i.e Ogbooro, IAR&T & Igbara Odo) and within the four groups was calculated using the model $S_{jk} = M/(M + N)$, where S represents the genetic similarity; M the number of matches and N the total number of columns with a presence in just one band. Genetic distance (D) was scored from a similarity matrix between breeding groups where $D = 1–S$.

Results

The genetic makeup of Nigerian indigenous and cross-bred pigs was estimated and compared using polymorphism in the size and expression of three blood proteins: globulin, transferrin and albumin. The three proteins examined were found to display a maximum of 19 bands in the SDS-PAGE analysis. However, not all of the pigs displayed these 19 bands and the frequency of the protein loci (globulins, transferrins and albumins) for each pig were represented in the descending order of the relative anodal migrations of each marker on the gel. The range of frequencies for each of the 19 protein loci were found to be between 0.41 and 1.0; where a frequency of 1.0 represented a polymorphism found in all samples. Globulin 1 and 2 were found to be monomorphic for all pigs sampled. However, some of the transferrin and albumin markers were found to be polymorphic in the gel migration.

The protein polymorphisms were used to cluster the NIP and crossbred pigs into similar strains and a phylogenetic relationship was developed (Figure 3). The UPGMA dendrogram established that the NIP samples from the three different locations clustered together, while the cross-bred samples formed a separate phylogenetic branch. Comparison of the four populations found the mean genetic similarity to be 55 percent; with the cross-bred pigs being the least related among the four populations. Overall, the four populations were divided into two branches with the three NIP groups forming one branch and the cross-bred pigs clustered into the other branch. Among the local pig populations, samples from Igbara Odo and Ogbooro clustered first, followed by the NIP from the IAR&T. The values of the genetic similarities between each cluster used for the construction of the dendrogram are presented in Table 1.

Among the individual pig populations, the pigs from Ogbooro were found to have a very high level of genetic similarity (91 percent similarity coefficient), the IAR&T pigs had 87 percent similarity coefficient and samples

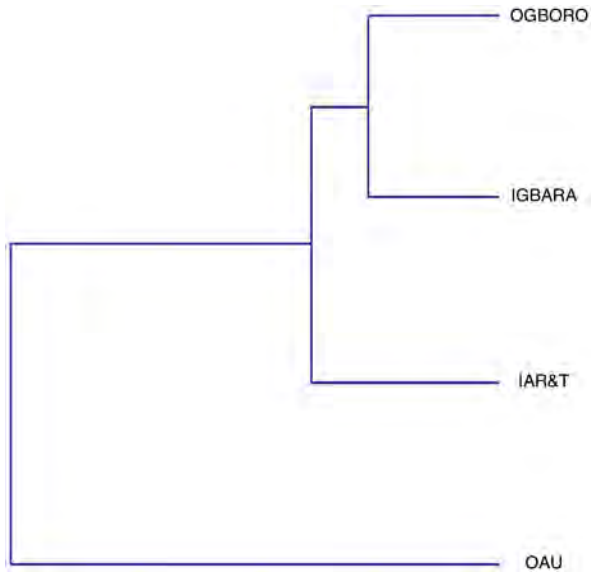

Figure 3. UPGMA-dendrogram of Nigerian indigenous pig populations (Ogboro, Igbara and IAR&T) and crossbred population (OAU) protein polymorphisms in southwestern Nigeria. The dendogram was created with a UPGMA cluster analysis to identify genetic similarities in the pig populations sampled from each of the four locations where the animals were studied.

Table 1. Genetic similarities within and among the four populations of Nigeria indigenous and crossbred pigs studied.

	OAU	Igbara	IAR&T	Ogbooro
OAU	0.81			
Igbara	0.79	0.56		
IAR&T	0.78	0.92	0.87	
Ogbooro	0.79	0.94	0.91	0.91

Values on the diagonals are the similarity coefficients of the four different populations.

collected from Igbara Odo showed a 56 percent similarity coefficient. The cross-breeds from the T & R Farm, OAU, had a high level of genetic similarity, with 81 percent similarity coefficient.

Discussion

The similarity measure produced here indicated very low levels of genetic variability, which tend towards homozygosity, among the individual populations of NIP in Ogbooro and at the IAR&T in Ibadan. Their SDS-PAGE results showed relatively high similarity (91 and 87 percent, respectively), and this is in agreement with results obtained in Korean and Chinese native pigs using microsatellite DNA markers that local indigeneous pigs have relatively stable genetic lines (Kim and Choi, 2002). It is likely that these animals tended to be homozygous due to genetic drift and/or reproductive isolation of the Korean native pigs (Kim, Yeo and Kim, 2002). This reproductive isolation has also been seen in a Chato Murciano pig breed (Peinado *et al.*, 2006). This suggests that the high genetic similarities observed in the Ogbooro NIP samples might be in concordance with the farming history of the animals. These NIPs reared in Ogbooro originate from a small genetic pool of founder individuals that had been used to establish the investigated populations, raised by a few Christian families, leaving the NIPs more or less genetically isolated. Similarly, samples from the IAR&T tended towards homozygosity, which also may have been a result of inbreeding among the few numbers of individuals kept at the institute.

However, the NIP from Igbara Odo were found to have a relatively lower genetic similarity (56 percent), which may be attributed to the fact that the animals were reared in a way that allowed them not only to scavenge for food but probably also to mix with distant strains.

However, the dendrogram supported the separation of all NIPs from the cross-bred pigs at T&R farm at OAU. The three NIP samples clustered together with a similarity coefficient of 95 percent confirming their genetic distinctness from the commercially developed breeds. In addition to being from a distinct line of animals, the cross-bred animals were found to have a low genetic diversity. This observation in the T&R Farm samples is likely due to known history of cross-breeding followed by inbreeding within a closed herd of two commercial strains (Landrace/Large White and Duroc) as a founder stock over the past few years.

The results of this first baseline information on the genetic structure of the NIP may be useful in further designing a breeding as well as conservation programme to protect the remaining NIP pure population. The Ogbooro stock was found to be genetically distinct, as well as considerably uniform in its genetic make-up. Therefore, it is recommended that samples from this population be utilized for an NIP breeding and conservation programme.

Conclusions

This preliminary genetic analysis suggests that further studies with more specific polymorphic DNA markers on the pig stocks from Ogooro, Nigeria may be used to conserve the NIP as a genetic resource in a planned NIP breeding program at the IAR&T (Oluwole, personal communication). This paper is now an urgent call for the development of an NIP conservation programme as number of indigenous pigs in the country are dwindling, which may eventually lead to a total of loss of the animals' adaptive characteristics and its important genetic resource.

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Comparación de la frecuencia alélica de las proteínas lácteas en cinco poblaciones bovinas cubanas

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Resumen
Fue evaluado el polimorfismo de los loci de seis proteínas lácteas en cinco razas bovinas cubanas mediante el análisis de ADN por las técnicas combinadas de PCR y de creación de sitio de restricción (ACRS), metodología de oligonucleótidos alelo-específicos (ASO) y polimorfismo de longitud de los fragmentos de restricción (RFLP). Se estimaron las frecuencias alélicas para CASA1, CASAB, CASA2, CASK, LAA y LGB en las cinco razas (N = 324), siendo la cantidad de individuos por población: Siboney de Cuba (SC = 85), Criollo Cubano (CC = 60), Cebú Cubano (ZC = 61), Mambí de Cuba (MC = 60) y Taíno de Cuba (TC = 58). Se evaluó el estado de equilibrio Hardy–Weinberg para cada locus en cada población, observándose que todas las poblaciones tienen al menos un locus desviado de esta condición de equilibrio y siempre por exceso de heterocigotos. Se identificaron los alelos $CASA1^C$ y LAA^Aen el CC y TC, lo que evidencia la presencia de genes Bos indicus en estas poblaciones. Se aprecia un incremento de la heterocigosidad en estas poblaciones y las frecuencias genotípicas en cada población permiten diferenciar éstas de aquellas que las originaron.

Palabras clave: *proteínas lácteas, frecuencias alélicas, bovino*

Summary
The polymorphism of six milk protein loci in five Cuban breeds was investigated by means of DNA analysis by combined techniques of PCR and amplification created restriction sites (ACRS), the method of allele-specific oligonucleotides (ASO), and restriction fragment length polymorphism (RFLP). Allele frequencies of loci CASA1, CASAB, CASA2, CASK, LAA and LGB were estimated in the five breeds ($N = 324$), the number of individuals per population being: Siboney de Cuba (SC = 85), Cuban Creole (CC = 60) Cuban Zebu (ZC = 61), Cuba Mambí (MC = 60) and Taíno of Cuba (TC = 58). Hardy–Weinberg equilibrium was estimated for each locus in each population, showing that all the populations have at least one locus deviated from this condition of equilibrium and always through heterozygote excess. Alleles $CASA1^C$ and LAA^A were identified in the CC and CT breeds, showing the presence of *Bos indicus* genes in these populations. An increase of heterozygosis is observed in these populations, and genotype frequencies in each population allow differentiation of these from those which originated them.

Keywords: *milk proteins, allele frequencies, bovine*

Résumé
Le polymorphisme de loci dans six protéines de lait de cinq races cubaines a été évalué à travers de l'analyse de l'ADN par les techniques combinées de la PCR et la création d'un site de restriction (ACRS), l'hybridation allèle-spécifique (ASO) et le polymorphisme de longueur des fragments de restriction (RFLP). Les fréquences des allèles ont été estimées pour CASA1, CASAB, CASA2, CASK, LAA et LGB au cours des cinq races (N = 324), le montant d'individus par population: Siboney de Cuba (SC = 85), Cubaine Créole (CC = 60) Cubaine Zébu (ZC = 61), Mambí de Cuba (MC = 60) et Taíno de Cuba (TC = 58). Le statut d'équilibre Hardy–Weinberg a été évalué pour chaque locus, dans chaque population, montrant que toutes les populations ont au moins un locus dévié de cette condition d'équilibre et toujours à la suite d'un excès d'hétérozygotes. Les allèles $CASA1^C$ et LAA^A ont été identifiés dans le CC et CT, ce qui montre la présence de gènes *Bos indicus* dans ces populations. Une augmentation de l'hétérozygotie dans ces populations a été observée, et les fréquences génotypiques dans chaque population permettent de différencier ces dernières de celles qui leur ont donné lieu.

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Mots-clés: *protéines de lait, fréquences alléliques, bovine*

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Introducción

La población bovina cubana en la década del 60 estaba formada en un 96% por animales cebuinos. Bajo estas condiciones, Cuba se trazó como estrategia incrementar las potencialidades en la producción de leche, e indirectamente en la producción de carne, mediante el aumento del número de individuos. Para ello, en 1964 se creó el Programa Nacional de Genética, donde la inseminación artificial jugó un papel primordial en el cruzamiento de las poblaciones acebuadas con animales Holstein importados fundamentalmente de Canadá (Buxadera y Dempfle, 1997). Esto posibilitó la creación de nuevas razas como es el caso Siboney de Cuba (⅝ Holstein – ⅜ Cebú Cubano), Mambí de Cuba (¾ Holstein – ¼ Cebú Cubano) y Taíno de Cuba (⅝ Holstein – ⅜ Criollo de Cuba).

Con el desarrollo de metodologías para la identificación de polimorfismos se ha demostrado que las cuatro caseínas (α_{S1}-caseína, CASA1; β-caseína, BCAS; α_{S2}-caseína, CASA2; κ-caseína, KCAS) y las dos principales proteínas séricas (β-lactoglobulina, LGB; α-lactoalbúmina, LAA) presentan diferentes formas alélicas, controladas por genes codominantes autosómicos (Ng-Kwai-Hang y Grosclaude, 1992; Formaggioni *et al.*, 1999). Los métodos basados en la identificación de polimorfismos de ADN para el estudio de los genes que codifican para las proteínas lácteas se usan en un gran número de investigaciones, pues no dependen del sexo ni del estado de desarrollo fisiológico del individuo a caracterizar (Prinzenberg, Krause and Erhardt, 1999).

El creciente interés en el estudio del polimorfismo existente en los genes que codifican para las proteínas lácteas se evidencia en el número creciente de investigaciones en este campo. Esto puede ser explicado por los diferentes niveles de relación encontrados entre estos polimorfismos y los niveles de producción o composición de la leche (Ripoli *et al.*, 2003; Tsiaras *et al.*, 2005; Kučerova *et al.*, 2006; Heck *et al.*, 2009; Bonfatti *et al.*, 2010), efectos en la salud humana (Elliott *et al.*, 1999; McLachlan, 2001) y la caracterización de razas (Silva and Del Lama, 1997; Lien *et al.*, 1999; Beja-Pereira *et al.*, 2002; Uffo *et al.*, 2006; Alipanah, Kalashnikova and Rodionov, 2008).

Las razas autóctonas o adaptadas a un ambiente cuentan con una combinación de genes que no se encuentran en otras razas, permitiéndoles resistir a enfermedades, condiciones ambientales adversas y baja calidad nutricional de los alimentos (Maudet, Luikart and Taberlet, 2002). La caracterización de estas poblaciones puede contribuir al desarrollo de estrategias racionales para su conservación (European Cattle Genetic Diversity Consortium, 2006).

El objetivo del presente trabajo fue estudiar las frecuencias alélicas de las principales proteínas lácteas en cinco genofondos bovinos cubanos (Siboney de Cuba, Criollo de Cuba, Cebú Cubano, Mambí de Cuba y Taíno de Cuba) para estimar la estructura genética en estas poblaciones.

Materiales y métodos

Animales y obtención del material genético

Se tomaron muestras de sangre en pleno cumplimiento de las normas establecidas por el comité de ética y bienestar animal, de 324 vacas representativas de cinco razas bovinas cubanas (Siboney de Cuba SC = 85, Criollo de Cuba CC = 60, Cebú Cubano ZC = 61, Mambí de Cuba MC = 60 y Taíno de Cuba TC = 58), cuyos rebaños son considerados de alto valor genético, con tres de ellos (SC, MC y TC) ubicados en la región occidental de la isla y los dos restantes (CC y ZC) en la región oriental. Los individuos en cada población no están relacionados genéticamente entre si. Se emplearon 0,5mL de 0,5M EDTA como anticoagulante y se procedió a la extracción y purificación del ADN mediante el método de precipitación salina descrito por Miller,Dykes and Polesky (1988).

Genotipado de las seis proteínas lácteas

Las condiciones de reacción fueron descritas previamente (Osta, 1994; Uffo, 2003; Acosta *et al.*, 2011). La mezcla de reacción estaba compuesta de buffer de reacción 10X libre de magnesio, 50 mM |MgCl2, 1,25 mM dNTPs, 20 nmol/μL oligonucleótidos correspondientes para cada uno de los fragmentos a amplificar y 2U de ADN polimerasa comercial (Promega). Se emplearon 40 ng de ADN por cada muestra y se completó el volumen de reacción a 30 μL con agua.

Las metodologías empleadas para establecer el genotipo de las muestras fueron tres: la creación de los sitios de restricción (ACRS, Amplification Created Restriction Sites) para CASA1 (Lien *et al.*, 1993) y CASB (Medrano y Sharrow, 1991), tipificación del polimorfismo de longitud de los fragmentos de restricción (RFLP, Restriction Fragment Length Polymorphism) para la CASA2 (Osta, 1994), la LAA (Osta, 1994) y LGB (Medrano y Aguilar-Córdova, 1990), y la metodología oligonucleotidos alelo-específicos (ASO, Allele-Specific

Oligonucleotides) empleada para el genotipado de la KCAS (Osta, 1994).

A partir de 10 µL del producto amplificado se procedió a la digestión con las enzimas específicas para cada uno de los fragmentos, siendo la temperatura de incubación de 37 °C durante 3 horas (Osta, 1994; Uffo, 2003; Acosta *et al.*, 2011). La visualización del producto digerido se realizó por medio de una electroforesis en gel de agarosa al 2%, TBE 0.5X, con tinción de Blue Green Loading Dye I (LGC Biotecnologia), empleando 0.3 µL por cada 5 µL de producto digerido.

Procesamiento estadístico

Fue empleado el programa GENEPOP versión 3.4 (Raymond y Rousset, 1995; Rousset, 2008) para el cálculo de las frecuencias alélicas, genotípicas y la prueba exacta de la desviación de los locus del estado de equilibrio Hardy–Weinberg. El programa Arlequin (Excoffier, Laval and Schneider, 2005) fue empleado en el cálculo del número de alelos por locus y la heterocigosidad observada (H_o) y esperada (H_e). Para estimar la relación genética existente entre las cinco poblaciones, se aplicó un análisis de componentes principales con empleo del programa SPSS versión 8.0.0 (SPSS Inc., Chicago) partiendo de la frecuencia genotípica de cuatro locus, exceptuando la BCAS y CASA2.

Resultados y discusión

Variabilidad por loci

Tras el genotipado de 324 muestras de los seis genes de las proteínas lácteas se estimaron las frecuencias alélicas y se calculó la heterocigosidad observada y esperada en cada grupo (Tabla 1). Las variantes alélicas observadas se muestran en la Figura 1. De manera general se apreció un comportamiento polimórfico en todos los loci, con excepción del locus CASA2, que se comportó monomórfico en todas las poblaciones evaluadas y el locus BCAS en las poblaciones SC y MC.

En el locus CASA1 (Figura 1a) se observaron altas frecuencias para el alelo C. Este resultado era de esperar para la población de ZC, así como para aquellas donde participó en su formación (SC y MC). Similares resultados se describen en estudios donde incluyen razas pertenecientes al género *Bos indicus* (Silva y Del Lama, 1997; Ceriotti *et al.*, 2004). Nuestros resultados reafirman los ya publicados en estudios previos de poblaciones incluidas en esta investigación (Uffo *et al.*, 2006), pues el comportamiento frecuencial de alelos C es similar al expuesto en el presente trabajo. Las altas frecuencias del alelo C en poblaciones *Bos taurus* (CC) y el cruzamiento en que participan (TC) indican un alto grado de introgresión de genes *Bos indicus* en estas poblaciones. Estos resultados se sustentan por los obtenidos por Lirón *et al.* (2011) donde tras estudiar cinco microsatélites del cromosoma y del ganado CC observaron haplogrupos cebuinos Y3. La heterocigosidad observada fue superior a la esperada, apreciándose un desvío del estado de equilibrio Hardy–Weinberg en las poblaciones CC, MC y TC. El desequilibrio observado en el ZC fue debido a una disminución de la H_o; en los estudios realizados por Silva y Del Lama (1997) se aprecian valores de H_o inferiores a la H_e.

El alelo A del locus BCAS (Figura 1b) se comportó fijado para las poblaciones SC y MC, mientras que para las restantes poblaciones su frecuencia fue superior o igual a 0,95, siendo muy próximo a la fijación en el caso del TC. Estos resultados, comparados con estudios previos en los genofondos SC, CC y ZC realizado por Uffo *et al.* (2006), indican una reducción de la diversidad genética en estas poblaciones. Las altas frecuencias de alelo A se han puesto de manifiesto en otras investigaciones donde se estudian razas taurinas y cebuinas (Mahé *et al.*, 1999), pues al sumar las diferentes variantes del alelo A en los dos grupos de razas se obtienen valores similares a los encontrados en nuestra investigación. Este locus se manifiesta en equilibrio Hardy–Weinberg para las razas CC y ZC; en la población TC no se analizaron las condiciones de equilibrio por encontrarse el alelo A prácticamente fijado.

El locus CASA2 (Figura 1c) se comportó monomórfico para el alelo A en las cinco poblaciones estudiadas. Similares resultados se describen en los estudios realizados por Uffo *et al.* (2006), también en poblaciones de la raza española Rubia Gallega (Osta *et al.*, 1995). Otros estudios en razas portuguesas refieren que el alelo A está fijado en las poblaciones evaluadas (Beja-Pereira *et al.*, 2002). Por otra parte, en la investigación de Jann *et al.* (2004) donde se estudiaron 30 razas, se observó que en 20 de ellas el alelo A está fijado y en otras cinco razas su frecuencia es superior a 0,95.

Para el locus KCAS (Figura 1d) las mayores frecuencias se observaron en el alelo A, el cual también se comportó con las mayores frecuencias en cuatro razas del ganado cebú brasileño (Silva y Del Lama, 1997). En el caso del ganado taurino la frecuencia reportada para el alelo A fueron superiores al 0,5, con excepción de la raza Marinhoa donde se observó una frecuencia de 0,25 (Beja-Pereira *et al.*, 2002). De forma similar se comportan las razas nórdicas, pues de 22 poblaciones estudiadas 17 mostraron una frecuencia del alelo A superior a 0,5 (Lien *et al.*, 1999). En el caso de dos razas rusas (Black Pied y Red Pied) las frecuencias del alelo A son mayoritarias con valores de 0,83 y 0,69, respectivamente (Alipanah Kalashnikova and Rodionov, 2008). Se aprecia una desviación del estado de equilibrio Hardy–Weinberg en el SC con un exceso de la heterocigosidad.

El locus LAA muestra con mayor frecuencia el alelo B en las cinco poblaciones (Figura 1e). Comparativamente, son menores las frecuencias encontradas del alelo A con respecto a estudios previos en poblaciones cubanas (Uffo *et al.*, 2006), pero son superiores a las descritas en razas *Bos taurus* (Mahé *et al.*, 1999). El interés en el

Tabla 1. Frecuencia alélica, heterocigosidad observada (H_o) y esperada (H_e) y estado de equilibrio Hardy–Weinberg de los loci en estudio en cinco genofondos cubanos.

Locus	**Genofondos cubanos**				
Alelos	*SC*	*CC*	*ZC*	*MC*	*TC*
CASA1					
B	0,422	0,339	0,076	0,557	0,538
C	0,578	0,661	0,924	0,443	0,462
$H_o(H_e)$	0,458 (0,491)^{NS}	0,576 (0,452)*	0,085 (0,142)*	0,887 (0,498)***	0,698 (0,502)***
BCAS					
A	1,000	0,950	0,959	1,000	0,991
B		0,050	0,041		0,009
$H_o(H_e)$		0,100 (0,096)^{NS}	0,049 (0,079)^{NS}		0,017 (0,017)
CASA2					
A	1,000	1,000	1,000	1,000	1,000
KCAS					
A	0,694	0,717	0,847	0,632	0,732
B	0,306	0,283	0,153	0,368	0,268
$H_o(H_e)$	0,612 (0,427)***	0,500 (0,410)^{NS}	0,305 (0,261)^{NS}	0,561 (0,469)^{NS}	0,393 (0,396)^{NS}
LAA					
A	0,100	0,212	0,434	0,053	0,181
B	0,900	0,788	0,566	0,947	0,819
$H_o(H_e)$	0,176 (0,181)^{NS}	0,322 (0,337)^{NS}	0,415 (0,496)^{NS}	0,106 (0,102)^{NS}	0,234 (0,299)^{NS}
LAG					
A	0,306	0,207	0,352	0,419	0,500
B	0,694	0,793	0,648	0,581	0,500
$H_o(H_e)$	0,494 (0,427)^{NS}	0,379 (,331)^{NS}	0,593 (0,460)*	0,605 (0,492)^{NS}	0,592 (0,505)^{NS}

NS: No significativo *$P < 0,05$ ** $P < 0,01$ *** $P < 0,001$.

comportamiento de la frecuencia del alelo A se debe a que fue empleado como marcador racial en los cruces donde participó el CC (Pérez-Beato y Granado, 1982). En tal sentido se evidencian altas frecuencias del alelo A en razas cebuinas con valores que van desde 0,176 a 0,386 en Silva y Del Lama (1997) y desde 0,17 a 0,29 en el reporte de Mahé *et al.* (1999). Por otra parte, para las razas españolas se describe el alelo B fijado (Osta *et al.* 1995), por lo que la presencia de alelos A en la raza CC constituye un elemento más para demostrar la introgresión de genes *Bos indicus* en estas poblaciones. Este locus se comportó en equilibrio Hardy–Weinberg para todas las poblaciones.

El alelo B del locus LAG (Figura 1f) se observó con mayor frecuencia en las cinco poblaciones, con valores de la misma mayores que 0,5. Este alelo se encuentra ampliamente distribuido en poblaciones *Bos taurus* y *Bos indicus,* como alelo predominante. Ejemplo de ello se encuentra en poblaciones cebuinas brasileñas (Silva y Del Lama, 1997) y en razas nórdicas donde 20 de estas presentaron frecuencias superiores a 0,5, de un total de 22 razas estudiadas (Lien *et al.*, 1999). También se observa este comportamiento de altas frecuencias del alelo B en poblaciones *Bos taurus* y *Bos indicus* incluida en los estudios de Mahé *et al.* (1999) y Ceriotti *et al.* (2004). Se observó una desviación del equilibrio Hardy–Weinberg en la raza ZC con un exceso de heterocigotos. En el estudio previo realizado por Uffo *et al.* (2006) se observó una desviación del equilibrio para este locus, pero sólo en la raza SC.

Diversidad genética y diferenciación de las poblaciones

Para estimar la estructura genética de las poblaciones en el estudio se calcularon cinco indicadores genéticos que permiten inferir el grado de diversidad en las mismas (Tabla 2).

La heterocigosidad media observada en las cinco poblaciones es mayor que la esperada, con valores del coeficiente de fijación negativos y significativamente inferiores de cero, con excepción en la raza ZC. Analizando estos resultados de forma conjunta con los obtenidos del estado de equilibrio Hardy–Weinberg por locus y por población, se observa que todos los grupos genéticos tienen al menos un locus desviado de esta condición de equilibrio y siempre por exceso de heterocigotos, por lo que los valores medios de Hobs, Hesp y F_{IS} pudiesen explicarse por esta causa. Esto pudiera deberse a la disminución considerable en el número de individuos de estos rebaños por el deterioro de la economía del país, que imposibilitó la satisfacción de los requerimientos mínimos de estas poblaciones, quedando sujetas al proceso de selección natural, donde se espera que sobrevivan los animales con una mayor capacidad de adaptación, es decir los heterocigotos (Fisher, 1930; Ortiz y Montes de Oca, 2003).

El porciento de loci polimórficos en cuatro de las poblaciones en estudio fue de 66,7%, siendo superior para el ganado CC con un 83,3% de loci polimórficos. En el caso de las razas SC, CC y ZC que fueron evaluadas previamente (Uffo *et al.*, 2006), el indicador de $P_{0,95}$ se mantiene igual en las razas CC y ZC, mientras que en

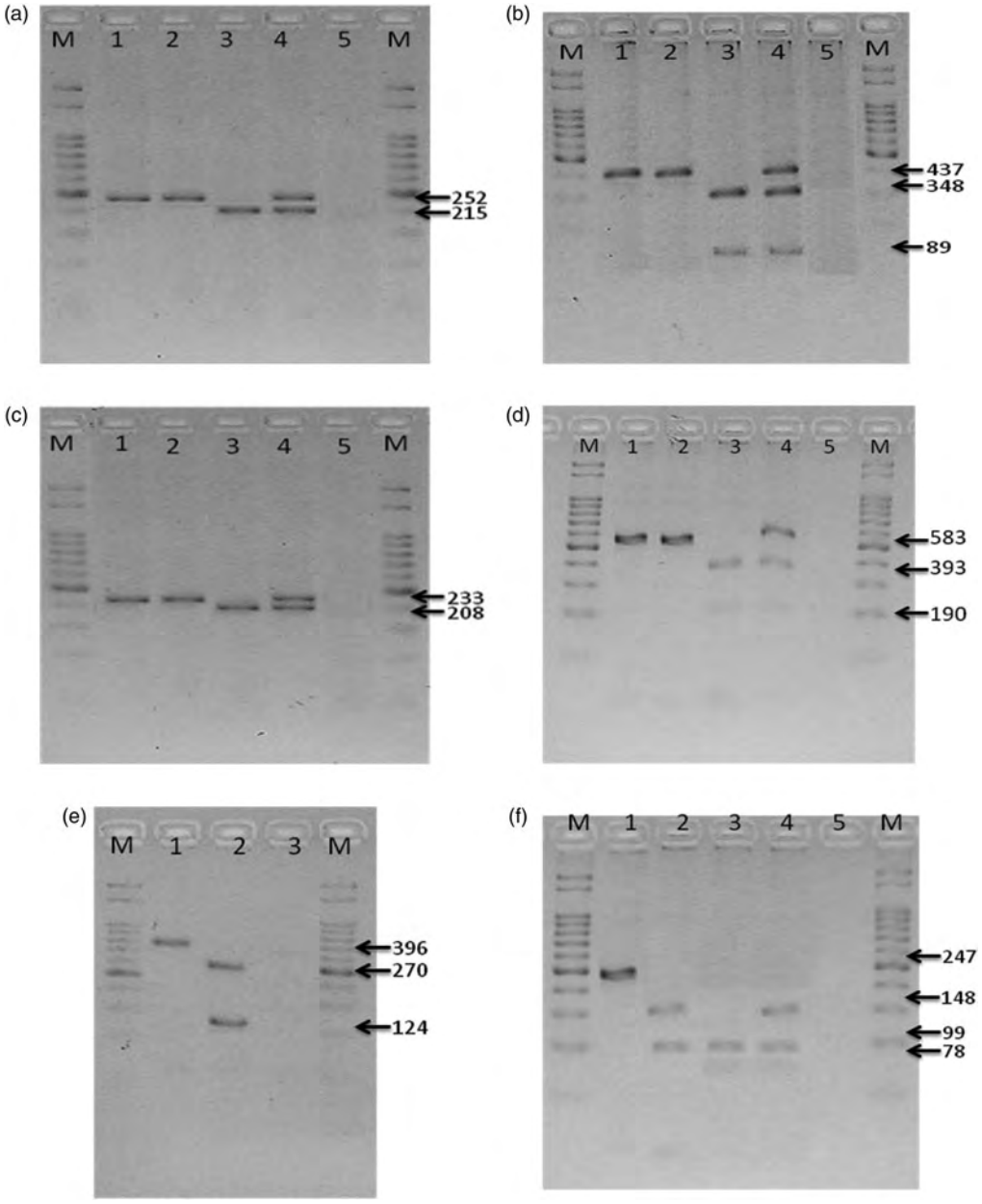

Figura 1. Visualización de genotipos encontrados en genofondos cubanos. (a) CASA1 MPM 50pb; L. 1 producto amplificado; L. 2 CC; L. 3 BB; L. 4 BC; L. 5 control negativo. (b) CASB MPM 50pb; L. 1 producto amplificado; L. 2 BB; L. 3 AA; L. 4 AB; Línea 5 control negativo. (c) CASA2 MPM 50pb; L. 1 producto amplificado; L. 2 AA; L. 3 control negativo. (d) CASK MPM 100pb; L. 1 producto amplificado; L. 2 AA; L. 3 BB, L. 4 AB; L. 5 control negativo. (e) LAA MPM 100pb; L. 1 producto amplificado, L. 2 AA; L. 3 BB; L. 4 AB; L. 5 control negativo. (f) LGB MPM 50pb; L. 1 producto amplificado; L. 2 AA; L. 3 BB; L. 4 AB; L. 5 control negativo.

el SC se observó el locus BCAS fijado para el alelo A. El número medio de alelos por población se comportó de igual forma, observándose una reducción del mismo en el SC a 1,67, al compararse con estudios previos.

Para determinar la relación entre las poblaciones se aplicó un análisis de componentes principales (Figura 2), pudiéndose agrupar el 93,57% de la variabilidad total en dos componentes (CP-1 y CP-2).

Se observa que el ZC se aleja de las restantes poblaciones, aún y cuando formó parte en la conformación de dos de ellas (SC y MC). Este resultado es esperado, si partimos de estudios previos donde se involucran las poblaciones SC, CC y ZC con empleo de otra metodología molecular para la identificación del polimorfismo (RAPD), donde el ZC se ubica formando un grupo en el dendograma que muestra las relaciones genéticas entre estas poblaciones (Acosta *et al.*, 2010). El agrupamiento del CC, SC y TC puede deberse, en el caso de los dos últimos, a la proporción de Holstein usada en su formación ($^5/_8$ para ambos casos), lo cual explica el acercamiento de estas con el CC, de origen mayoritariamente taurino. En el caso del MC las proporciones de las razas que lo originaron son diferentes, por lo que su comportamiento genotípico hace que se comporte como un grupo aislado de los otros, aunque su ubicación lo acerca a las poblaciones CC, SC y TC.

Tabla 2. Parámetros medidos para evaluar la variabilidad genética en los cinco genofondos cubanos. Heterocigosidad media observada (Hobs) y esperada (Hesp), número medio de alelos (A), porcentaje de loci polimórficos ($P_{0,95}$) e índice de fijación (F_{IS}). Errores estándar dentro de paréntesis.

Parámetros	Genofondos cubanos				
	SC	CC	ZC	MC	TC
Hobs (ES)	0,290 (0,109)	0,313 (0,092)	0,241 (0,096)	0,340 (0,153)	0,322 (0,119)
Hesp (ES)	0,254 (0,091)	0,271 (0,074)	0,240 (0,083)	0,260 (0,102)	0,287 (0,093)
A (ES)	1,67 (0,21)	1,83 (0,17)	1,83 (0,17)	1,67 (0,21)	1,83 (0,17)
$P_{0.95}$	66,7%	83,3%	66,7%	66,7%	66,7%
F_{IS}	−0,140	−0,155	−0,006	−0,382	−0,125

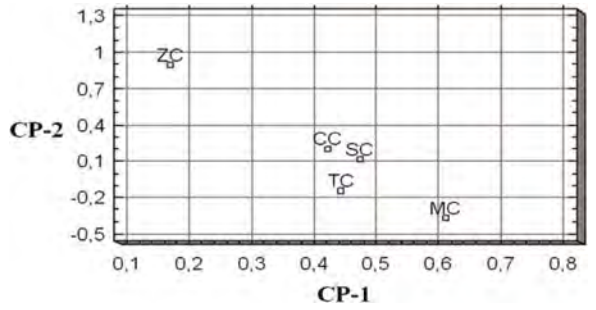

Figura 2. Ploteo de las dos principales componentes (CP-1 y CP-2) a partir de la distribución de frecuencia genotípica de cinco locus. El CP-1 acumula el 69.61% y el CP-2 el 23.96% del total de la variación.

Conclusiones

Se evidencia la presencia de genes *Bos indicus* en las poblaciones CC y TC debido a las frecuencias alélicas $CASA1^C$ y LAA^A observadas. Se aprecia un incremento de la heterocigosidad en estas poblaciones y las frecuencias genotípicas en cada población permiten diferenciar estas de aquellas que la originaron.

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Declaración de interés

No hay intereses relevantes.

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Performance of 4-way cross-bred Ethiopian and exotic chicken breeds in two management systems in Southern Ethiopia

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Summary
Two indigenous chicken breeds: naked neck (N) and local white (W) feathered chicken called *Netch* as sire lines and two exotic chicken breeds: Fayoumi (F) and Rhode Island Red (R) as dam lines were crossed with the objective of producing 4-way cross-bred chicken population, which will later be used as base population to produce synthetic chickens. They were tested under on-station conditions in a college farm and under on-farm conditions at several typical village farms. Mortality during brooding period was lower under on-farm than on-station conditions, which may be owing to housing of the chicks in hay box-brooder on-farm and the coccidiosis infection on-station. However, higher on-farm mortality was observed during the laying period than on-station; mainly because of predation. There was a significant difference between the two systems in recorded body weight from early age to maturity. Age at first egg was lower on-farm than on-station. Average number of eggs produced was not significantly different; although chickens on-station laid more eggs than those on-farm. Hen-housed egg production was lower on-farm than on-station owing to higher mortality in the on-farm system.

Keywords: *body weight, egg, mortality, reciprocal crossing, village poultry*

Résumé
Les mâles reproducteurs de deux races de poules indigènes (les Naked-Neck et les poules blanches locales appelées *Netch*) et les mères de deux races de poules exotiques (les Fayoumi et les Rhode Island Red) ont été croisés pour obtenir une population de poules croisées à quatre voies utilisable par la suite en tant que population de base pour la production de poules synthétiques. On a testé ces poules dans des conditions d'élevage en station, dans une ferme universitaire, et au niveau des exploitations, dans plusieurs fermes villageoises typiques. La mortalité pendant la couvaison était plus faible à la ferme que dans la station en raison probablement de la collocation des poussins dans une couveuse de foin à la ferme et de l'infection de coccidiose dans la station. Cependant, durant la période de la ponte, la mortalité était plus élevée à la ferme que dans la station en raison principalement des prédateurs. La différence entre les deux systèmes était significative pour ce qui concerne le poids corporel enregistré de la naissance à la maturité. Le premier œuf était pondu plus tôt à la ferme que dans la station. Le nombre moyen d'œufs produits n'était pas très différent même si les poules dans la station pondaient plus d'œufs que les poules à la ferme. La production d'œufs des poules logées était plus faible à la ferme que dans la station en raison de la mortalité plus élevée du système à la ferme.

Mots-clés: *poids corporel, oeuf, mortalité, croisement réciproque, aviculture familial*

Resumen
Se cruzaron dos razas autóctonas de gallinas: la de cuello desnudo (N) y la de plumaje blanco local (W), llamada Netch, como líneas paternas, y dos razas exóticas, la Fayoumi (F) y la Rhode Island Red (R), como líneas maternas, con el objetivo de producir una población mestiza de gallina de cuádruple origen que sirviera después como población base para producir pollos sintéticos. La investigación se realizó en las condiciones de estudio de una estación experimental de la universidad y en las condiciones típicas de las fincas agrícolas en varias granjas rurales. La mortalidad durante el período de incubación fue menor en las granjas que en la estación experimental, lo cual pudo ser debido al alojamiento de los polluelos en cajas incubadoras de heno en las granjas y a la infección por coccidiosis en la estación experimental. Sin embargo, en las granjas se observó una mayor mortalidad durante el período de puesta que en la estación experimental, principalmente por causa de los depredadores. Hubo una importante diferencia entre los dos sistemas en cuanto al peso corporal registrado desde la edad temprana hasta la madurez. La edad al primer huevo fue menor en las granjas que en la estación. El número medio de huevos producidos no varió de forma significativa si bien las gallinas de la estación pusieron más huevos que las de las granjas. La producción de huevos de las gallinas en jaulas fue menor en las granjas que en la estación debido a una mayor mortalidad en el sistema de las granjas.

Palabras clave: *peso corporal, huevo, mortalidad, cruzamiento recíproco, avicultura rural*

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Introduction

More than 80 percent of the world poultry population is in village poultry production systems contributing up to 90 percent of poultry products in some developing countries. Village poultry mainly consists of indigenous or local breeds. However, commercial hybrids and crosses between indigenous and hybrids also exist (Besbes, 2009). Village chickens contribute to household food security in many ways including supplying high-quality animal protein, generate income as household savings and insurance. They also play important roles in religious and cultural life of the society in most of the developing countries (Tadelle, Alemu and Peters, 2000; Nasrollah, 2008; Besbes, 2009). Moreover, the genetic attributes of indigenous chickens in terms of tolerance to some diseases and parasite and adaptation to harsh environmental conditions make them important as gene pool source for improvement of village poultry production (Nasrollah, 2008; Saadey *et al.*, 2008; Besbes, 2009).

Rural poultry production in Ethiopia contributes to the national economy in general and the rural economy in particular, representing 98.5 and 99.2 percent, respectively, of the national egg and poultry meat outputs, as cited by Tadelle, Alemu and Peters (2000). However, the per capita egg and poultry meat consumptions in Ethiopia are among the lowest in the world. One of the reasons for low productivity from traditional poultry farming is the fact that comparatively little research and development work has been carried out on indigenous chickens (Tadelle, Alemu and Peters, 2000). Village poultry occupies a unique position in rural communities as there are few alternative animal protein sources and no cultural taboos related to the consumption of egg and poultry meat unlike those from pig meat. Moreover, village poultry can be reared by women and resource poor farmers and does not require large investments (Tadelle, Alemu and Peters, 1999).

Production superiority of improved commercial breeds and poultry hybrids under low input village production systems is very much decreased because of the prevailing environmental conditions. There are very few examples of breeding programmes for indigenous poultry breeds around the world, and those that exist are mainly in Europe and for specialized production traits only. Indigenous poultry breeds are most often dual purpose; therefore, improving their performance will be achieved through increasing growth and egg production. Moreover, survival or longevity under village conditions is also very important for the output and should be used as an important selection criterion (Besbes, 2009).

Cross-breeding of indigenous with improved exotic breeds is one of the tools for improving village poultry productivity, which requires continuous supply of pure lines. An alternative to regular crossing is to perform one or a few crosses between two or more populations to produce a single population of animals containing a mixture of genes from each population which is called synthetic or composite animal. One of the main advantages of synthetic is that only one population has to be maintained, rather than the two or more parental populations required for regular crossing programme. Moreover, heterosis can be exploited in some traits mainly owing to the wide genetic differences of parents. However, performance can be reduced from base generation to first generation produced by *inter se* mating in the synthetic population because of the reduced heterozygosity (Syrstad, 1992).

In this study, a 4-way cross-bred chicken population using two indigenous and two exotic chicken breeds was produced and evaluated under on-station in the college farm and on-farm in village farm conditions. The indigenous naked neck (N) and *Netch* (white feathered)(W) were used as sire pure lines and the exotic Rhode Island Red (R) and Fayoumi (F) were used as dam pure lines. The 4-way cross-bred chickens will be developed to a synthetic chicken after crossing within the 4-way cross-bred population. The different attributes of the four breeds are expected to be expressed in the final synthetic population. This study was therefore conducted with the objectives of producing 4-way cross-bred chicken population and to compare their performance under on-station and on-farm management systems.

Materials and methods

Experiment sites and animals

The on-station experiment was conducted at the poultry farm of Hawassa University, College of Agriculture, which is located 275 km south of the Ethiopian capital Addis Ababa. The on-farm trials were done with farmers in the Boricha village, 20 km south of Hawassa.

The experimental chickens were a result of 4-way crossing using two indigenous male chicken breeds: naked neck (N) and local white, a white feathered chicken called *Netch* (W), and two exotic female breeds: Fayoumi (F) and Rhode Island Red (R). Among the local chickens in Ethiopia, naked neck ecotype is known for its high egg production and heavy body weight, which is somewhat better than that of the other local breed *Netch* (Teketel, 1986). Specifically, chickens carrying the Na (naked neck) gene have been known to have higher growth rate and egg production under high ambient environment (Merat, 2003; El-safty, 2006; Islam and Nishibori, 2009). The *Netch* is, on the other hand, widely available in the experiment area and considered to be highly adapted to the environment. Fayoumi is an Egyptian breed developed for high egg production and is believed to withstand harsh tropical condition, whereas Rhode Island Red is a dual purpose chicken breed characterized by hardiness and high productivity (Gueye, 1998). Reciprocal crossing were done for comparison. Figure 1 shows the 4-way crossing scheme of the breeds used. There was no selection

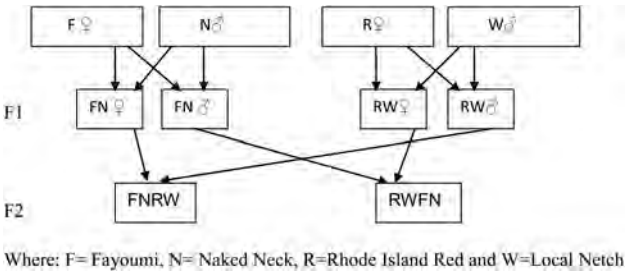

Figure 1. Schematic representation of the 4-way crossing used in the experiment.

made on F1 population and all chickens laying eggs were used to produce F2.

Crossing was conducted at the college poultry farm at the Hawassa University. Mating was done in two rounds; each cock mated with two hens in the first round and with two other hens in the second round. The hens and cocks were housed separately and mating was facilitated by bringing a hen and a cock from their pens and putting them in a separate pen. After the first hen had been successfully mated, she would be taken out and the second hen would be introduced to the pen with the cock.

Trap nests were provided in pens for both the F1 and F2 crosses so that individual egg production could be recorded. The date of lay and ID number of the hen that laid the egg were written on all eggs during collection. Eggs from the parents (F1) were collected from the pens and stored in a room with a ventilator for up to 10 days. All eggs were weighed individually at setting. At the 18th day of incubation the eggs were candled and eggs with live embryo were transferred to the hatchery. The trays in the hatchery were modified by fitting 6 cm × 6 cm cells, made of plywood, and individual eggs were placed in the cells. Each cell was again identified with the same information found on the egg to avoid confusion if the information written on the egg shell was lost during hatching. The tray was covered with a wooden frame with mesh wire to avoid mix up of chicks at hatching and during tagging. The chicks were individually tagged. They were then weighed and vaccinated against New Castle Disease (NCD) before they were transferred to the brooding house. The chicks were hatched in batches because of the small number of eggs produced during the 10 days collection period. The eggs would be spoiled if more days were added to incubate more eggs. Chicks from the same batch were placed together in separate pens within brooding house and were moved to layer pens together when they were 4 months old.

Management of experimental animals

On-station

The chicks were provided with starter ration until they were 4 months old. At the age of 8 week, the lamps used for heating were removed and the pens were widened proportionate to the number of chicks in the batch. After 4 months the chickens were transferred to the layer house where a layer ration was provided. The layer house was a deep litter house divided into several pens using mesh wire. The pullets were assigned to 10 different pens with a maximum of 10 pullets in each pen. The cocks were housed separately in two different pens. The walls of the house were partially made of thick mesh wire for natural ventilation and light. The type and composition of rations used are presented in Table 1. Feeders and waterers were placed in each pen and feeding was *ad lib*. Trap nests with four separate compartments were provided in each pen so that individual egg production could be recorded.

On-farm

One-day-old full sibs and half sibs of the on-station chicks were distributed to 10 women farmers. All chicks were vaccinated against NCD and leg banded with ID number. Hay box brooders were provided, and they consisted of two parts: a brooder box stuffed with hay and a box used for exercise. Starter ration for at least 2 weeks was also given to the farmers to help the chicks adapt to the village conditions. Farmers gave the chicks local bread softened with water, ground maize or other kitchen scraps. Water was provided with containers such as old plastic, clay or metal containers. A broad spectrum antibiotic medicine was also given to the farmers with instructions on how to administer the medicine in case of disease symptoms. The chicks were released to the field within a few weeks after their arrival at the farm, but placed in the brooder box during night and cold times. After the chicks had grown larger, i.e. at 3–4 months, farmers placed them either in separate house built for chickens or they stayed in the farmers' house during the night.

All chicks were identified with plastic leg band with ID numbers which were used till the end of the experiment. The plastic band was replaced at least twice as the chick's leg grew. Data were collected twice a week or once a month, depending on the trait recorded.

Table 1. Ingredient and analysed chemical composition of chick and layer rations used in the trial.

	Chick ration (%)	Layer ration (%)
Ingredient		
Maize	32	39
Wheat bran	29	22
Noug (*Guiziota abyssinica*) cake	19	25
Soya bean (roasted)	18	6
Salt	1	1
Bole (soil with limestone)	1	7
Chemical composition (DM basis)		
Crude protein (%)	17.4	16.8
ME (MJ/kg)	13.2	13.4

Data collection

Hatching and growth

All chicks were weighed upon hatching before they were transferred to the brooding house. They were hatched in six different batches and chicks of the same batch were housed in the same pen for ease of management. The chicks in some batches were more in number and thus they were divided into more than one pen. The chicks were weighed every week until they were 8 weeks old and then monthly thereafter. All chicks were weighed individually by using a digital weighing scale powered both by electricity and battery. Body weight gain was calculated as a difference between consecutive body weight measurements.

Mortality

Chicken mortality was recorded during weighing day, i.e. any chicken not alive for weighing on a particular weighing day was considered as dead. No post-mortem analysis was done for on-farm dead chickens but occasional post-mortem analysis was done for on-station dead chickens. Structured questionnaire was prepared to collect information about the causes of mortality under on-farm condition.

Egg production and quality

Age at first egg (AAFE) was recorded in days for both on-farm and on-station chickens. Number of eggs produced by each chicken was recorded individually daily in the on-station trial and at least twice a week in the on-farm trial. Egg production recording under the on-farm condition was done by a development agent stationed in the farmers' village. Three types of egg production analysis were made for both management systems; egg number (EN) is the average number of eggs produced by a layer in a particular period; hen housed egg production (HHEP) is calculated as the total number of eggs produced divided by the number of hens originally housed in a pen or farmer's house; and hen day egg production (HDEP) in percent is calculated as the number of eggs produced in a particular time divided by the number of layers alive at that particular time. Calculation of HHEP was started from the month at which the layers were first housed in a pen, i.e. at 4 months of age. The number of live layers was calculated as the average number of layers at the beginning and end of a particular recording period. Moreover, percent HHEP was also calculated for comparison with percent HDEP.

$$\text{HHEP} = \frac{\text{Number of eggs produced}}{\text{Number of hens originally housed in a pen or farmer's house}},$$

$$\text{HDEP}(\%) = \frac{\text{Number of eggs produced}}{\text{Number of live hens in a pen or farmer's house}} \times 100.$$

Internal and external egg quality in both management systems were recorded at the age of 8 and 12 months on-station, but only at the age of 12 months on-farm. The eggs were weighed individually using a digital weighing scale, and average egg weight was calculated for each pen/farmer. Average egg shell thickness (mm) was measured using digital calliper at broad, narrow and middle side of each egg, and the average of three measurements was used for statistical analysis. Yolk colour was measured using Roche colour fan scale (1 = very pale to 16 = deep orange). It was measured by three people and the average of the three measurements was used for further analysis. Albumen and yolk height (mm) were measured using tripod micrometer after the egg was broken out on a flat glass. Egg length and width (mm) were measured by digital calliper and egg shape index was calculated as the ratio of egg width over egg length. Haugh unit was calculated using the formula:

$$\text{HU} = 100 \log(\text{AH} + 7.57 - 1.7\,\text{EW}^{0.37}),$$

where AH is the observed albumen height in mm and EW is the egg weight in grams.

Statistical analysis

All traits were analysed using the mixed model procedure in the software package SAS (Statistical Analysis System) (SAS, 2003) using sex, age, management system and their interactions as fixed effects, depending on the trait in question. Pen number, individual farmer and ID number of chickens were all used as random effect, depending on the model. The effect of reciprocal crossing on almost all traits was insignificant and it was thus removed from the models.

Model 1 was used to analyse body weight traits, using sex and management system as fixed main effects and fixed interaction effect of sex and management systems at different ages.

$$Y_{ijn} = \mu + S_i + M_j + S_i(M_j) + e_{ijn}, \quad (1)$$

where Y_{ijn} is the individual body weight and body weight gain of chickens in both on-station and on-farm; μ, is the overall mean; S_i, is the fixed effect of sex i, $i = 1$–2 (male and female); M_j, is the fixed effect of management system j, $j = 1$–2 (on-station and on-farm); S_i (M_j), is the effect of sex unique to each management systems; and e_{ijn}, is the random error.

Egg number was analysed by model 2 using age and management systems as fixed main effects and fixed interaction effect of age and management systems. Moreover, Id number of chickens and pen or farmer was used as random effects. There are no repeated records for AAFE and thus effect of age and individual ID number were removed from the model. HHEP was calculated per pen or farmer in which they were kept, therefore the random effect of ID was not used in the model.

$$Y_{ijkln} = \mu + A_i + M_j + A_i(M_j) + \text{ID}_k + \text{PF}_l + e_{ijkln}, \quad (2)$$

where all effects and levels are the same as model 1 except Y_{ijkln} = egg production in both on-station and on-farm; A_i is

the fixed effect of age i, $i = 1–2$ (between 4– 8 months and 9–12 months); A_i (M_j) is the effect of interaction between age and management systems; ID_k is the random effect of individual chicken; PF_l is the random effect of farmer or pen m, $m = 1–10$ pens or 1–10 farmers; e_{ijkln} is the random error.

Model 2 was modified to model 3 to analyse egg quality traits because of the unequal number of measurement times in the two systems.

$$Y_{ijkln} = \mu + M_j + A_i(M_j) + ID_k + PF_l + e_{ijkln}, \quad (3)$$

where all other effects and levels are the same as model 2 except Y_{ijkln} = egg quality in both on-station and on-farm; A_i is the fixed effect of age i, $i = 1–2$ (at 8 and 12 months on-station and at 12 month on-farm).

Results

Mortality

Mortality during the brooding time was higher in on-station than in on-farm. Most of the mortality in on-station occurred during the early stage of the growth period. Mortality decreased during the laying period in on-station, but increased over the same period in on-farm (Table 2). The cause of mortality in different age groups under the on-farm management system is presented in Table 3 and chickens that were lost for unknown reasons were not included in the mortality. All mortality in on-station was because of disease.

Body weight and gain

Body weights of chicks measured at different ages are presented in Table 4. The average hatching weight of the male and female was not significantly different. Likewise the difference in body weight of chicks from week 1 to week 7 was not significant for males and females, but the gap became widened every week until it was significantly higher for males at week 8. Management system had significant effect on body weight of chicks after week 2, but no significant interaction was observed between sexes and management systems. Weekly body weight gain of chicks was not significant for either the males or the females but difference because of management systems was increasingly significant as age increases (Table 5).

Body weight of grown chicken was significantly higher for males than females, as was chickens kept under on-station compared with on-farm (Table 6). Although body weight gain of male chickens was significantly higher than females, the difference decreases and eventually disappeared after month 8. However, in general, there is a trend of higher body weight gain for males than for females, especially for chickens kept under on-farm condition compared with those kept under on-station condition (Table 7). Figure 2 shows body weight of chickens during the entire measurement period. As described above the increasing gap in body weight between the management systems started at early age but became stabilized as the chickens grew older.

Table 3. On-farm number of chicken deaths with percentage because of disease and predator.

	Between hatching and month 4	Between month 4 and 12
Chickens alive	180 (at hatching)	106 (at month 4)
Death because of diseases	27 (15%)	15 (14%)
Death because of predator	17 (9%)	22 (21%)

Egg production and quality

Although no significant difference in AAFE between the management systems was found, it is worth noting that on-farm chickens started laying at 203 days as compared with 222 days for on-station chickens. The number of eggs laid in the first period, between the age at which the chickens were housed in layer's pen (months 4) and month 8, was lower than the number of eggs produced in the last period, i.e. between month 9 and end of the recording period (i.e. month 12) in both management systems. Management system had no significant effect on the average number of eggs produced, but there was an interaction effect between

Table 2. Mortality of chickens under on-station and on-farm condition at different ages.

	On-station		On-farm	
	Alive	Mortality	Alive	Mortality
Number of hatched chicks (both sexes)	450		180	
Number of chicks alive up to 8 weeks of age (both sexes)	322		153	
Mortality in number and percentage from hatching to 8 weeks		128 (28%)		27 (15%)
Number of chickens alive up to 4 months of age (both sexes)	275		106	
Mortality in number and percentage from 8 weeks to 4 months		47 (15%)		47 (31%)
Number of layers at 4 months of age	88		64	
Number of layers alive up to 8 months of age	86		37	
Mortality of layers from 4 to 8 months in number and percentage		2 (2.3%)		27 (42%)
Number of layers alive up to 12 months of age	81		28	
Mortality of layers from 9 to 12 months in number and percentage		5 (6%)		9 (24%)

Table 4. Least square means with standard error of chick body weight (g) from hatching to 8 weeks of age.

Effects and levels	Chick body weight								
	Hatching wt	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**
Sex	NS	NS	NS	NS	NS	NS	NS	NS	**
Female	30.6 ± 0.2	41.9 ± 0.4	54.0 ± 0.9	72.3 ± 1.2	90.1 ± 1.9	112.8 ± 2.1	137.6 ± 3.8	164.6 ± 3.6	237.7 ± 5.7
Male	30.3 ± 0.3	42.5 ± 0.5	56.2 ± 0.9	74.5 ± 1.5	93.6 ± 2.1	115.6 ± 2.4	144.3 ± 4.2	172.3 ± 4	255.0 ± 5.8
Management		NS	***	***	***	***	***	***	
On-station	30.5 ± 0.2	42.7 ± 0.3	57.3 ± 0.6	78.9 ± 1.0	98.9 ± 1.3	125.3 ± 2.7	160.4 ± 2.7	201.2 ± 2.9	246.3 ± 4.1
On-farm		41.8 ± 0.5	52.9 ± 1.1	67.8 ± 1.6	84.7 ± 2.5	103.3 ± 2.4	121.5 ± 5.0	136.2 ± 4.6	NA
Sex (management)		NS	NS	NS	NS	NS	NS	NS	
Female (on-station)	30.6 ± 0.2	42.2 ± 0.5	56.1 ± 0.6	77.2 ± 1.4	96.6 ± 1.8	123.4 ± 2.4	155.3 ± 3.7	194.9 ± 4.1	237.7 ± 5.7
Male (on-station)	30.3 ± 0.3	43.2 ± 0.5	54.4 ± 0.6	80.8 ± 1.5	101.4 ± 1.9	127.4 ± 2.4	165.6 ± 3.8	207.4 ± 4.2	255.0 ± 5.8
Female (on-farm)		41.8 ± 0.6	51.9 ± 1.5	67.5 ± 2.1	83.6 ± 3.3	102.5 ± 3.5	119.9 ± 6.7	134.3 ± 5.9	
Male (on-farm)		41.7 ± 0.8	53.9 ± 1.7	68.2 ± 2.6	85.8 ± 3.7	104 ± 4.2	123.1 ± 7.5	138.1 ± 6.9	

*** = $P \leq 0.001$; NS, not significant; NA, not available.

age and management, since slightly more eggs were laid between months 4 and 8 on-farm than on-station, whereas the reverse happened between months 9 and 12. However, HHEP was significantly higher for chickens kept under on-station condition compared with those kept under on-farm condition. Egg mass was only calculated for chickens kept under on-station condition. (Table 8). Percent HDEP and HHEP are presented in Figure 3. No significant difference in egg quality traits were found caused by management system, except for yolk colour. However, higher egg weight and egg length were found on-station (Table 9).

Discussion

The higher on-station chick mortality was mainly because of coccidiosis that occurred on chicks that were hatched in the second round. Owing to shortage of brooding pens the chicks were housed in pens close to the layers, and this may have facilitated transmission of the disease. On the other hand, the relatively low mortality of chicks kept on-farm may be attributed to provision of chick brooder box for the farmers, which has proved to be effective in reducing chick mortality in village poultry-keeping condition. Solomon (2007) found that mortality of chicks reared on-farm up to 8 weeks of age using hay box chick brooder was 10 percent, compared with 14 percent mortality for chicks kept on-station using an infra red electric brooder. It has also been reported that in Ethiopia, survival rate of chicks reared to an age of 3 months under natural brooding condition reaches up to 40 percent, and the results found in the present study might thus be considered as satisfactory. In addition to the hay box brooder, some farmers had constructed day-time shades to protect the chicks from predators. As the chicks grew older, mortality on-station was reduced owing to provision of anti-coccidial treatment and also control of other diseases and parasites. On the other hand, mortality of chickens on-farm increased very much in the same period, mainly because of attack by predators. After the brooding period the chickens are left outside to search for feed in the backyard vegetable farm, and this makes them an easy prey to stalking predators such as fox and wild cats. Cause for mortality on farm is summarized in Table 3, which was obtained by questionnaires answered by the farmer at the end of the experiment.

Hatching weight and body weight up to week 7 were not significantly different for males and females, but the males had significant higher body weight after week 8. Also Mekki *et al.* (2005) reported insignificant difference

Table 5. Least square means with standard error of chick body weight gain (g) from week 1 to week 8.

Effects and levels	Chick body weight gain							
	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**
Sex	NS	NS	NS	NS	NS	NS	NS	NS
Female	10.3 ± 0.5	12.3 ± 0.6	19.0 ± 1.1	17.2 ± 1.1	22.3 ± 1.2	25.3 ± 2.2	28.4 ± 2.0	42.7 ± 2.4
Male	11.3 ± 0.5	13.9 ± 0.7	18.8 ± 1.3	18.5 ± 1.2	21.9 ± 1.2	28.6 ± 2.4	29.3 ± 2.2	47.2 ± 2.5
Management	*	**	**	**	***	***	***	
On-station	12.2 ± 0.3	14.6 ± 0.4	21.6 ± 0.8	20.0 ± 0.7	26.2 ± 0.8	34.9 ± 1.5	40.7 ± 1.4	44.9 ± 1.7
On-farm	9.5 ± 0.6	11.8 ± 0.8	16.2 ± 1.5	15.6 ± 1.4	17.9 ± 1.5	18.9 ± 2.9	16.9 ± 2.7	NA
Sex (management)	NS	NS	NS	NS	NS	NS	NS	
Female (on-station)	11.6 ± 0.4	13.9 ± 0.6	21.0 ± 1.1	19.4 ± 1.0	26.8 ± 1.1	31.9 ± 2.1	39.7 ± 1.9	
Male (on-station)	12.8 ± 0.5	15.2 ± 0.6	22.3 ± 1.1	20.6 ± 1.0	25.6 ± 1.1	37.6 ± 2.2	41.8 ± 2.0	
Female (on-farm)	9 ± 0.9	10.8 ± 1.1	17.1 ± 1.9	14.9 ± 1.8	17.8 ± 2.0	18.6 ± 3.8	17.1 ± 3.6	
Male (on-farm)	9.9 ± 0.9	12.7 ± 1.2	15.3 ± 2.3	16.3 ± 2.1	18.1 ± 2.2	19.3 ± 4.3	16.9 ± 3.9	

*** = $P \leq 0.001$; ** = $P \leq 0.01$; * = $P \leq 0.05$; NS, not significant; NA, not available.

Table 6. Least square means with standard error of chicken body weight (g) from 4 to 12 months of age.

Effects and levels	Chicken body weight								
	Month 4	Month 5	Month 6	Month 7	Month 8	Month 9	Month 10	Month 11	Month 12
Sex	***	***	***	***	***	***	***	***	***
Female	653.2 ± 13.6	860.9 ± 19.9	988.5 ± 19.5	1057.5 ± 20.4	1070.0 ± 25.0	1117.3 ± 197	1108.2 ± 32.9	1103.8 ± 23.2	1113.7 ± 25.9
Male	725.2 ± 15.6	1003.7 ± 22.3	1223.3 ± 24.4	1362.2 ± 27.55	1421.0 ± 31.9	1559.0 ± 23.5	1474.5 ± 36.0	1506.5 ± 29.9	1533.7 ± 40.9
Management	***	***	***	**	**		**	***	**
On-station	797.5 ± 11.3	1015.9 ± 20.9	1167.8 ± 13.5	1259.8 ± 14.6	1309.9 ± 14.6	1338.2 ± 15.3	1363.2 ± 14.6	1377.5 ± 15.5	1391.3 ± 17.3
On-farm	580.9 ± 17.4	848.8 ± 23.9	1043.9 ± 28.2	1159.9 ± 31.0	1181.2 ± 37.8	NA	1219.7 ± 46.6	1232.7 ± 34.6	1255.9 ± 45.2
Sex (management)	NS	NS	NS	*	*		*	NS	NS
Female (on-station)	749.9 ± 15.8	912.4 ± 23.8	1020.8 ± 18.5	1069.3 ± 19.6	1084.0 ± 18.9		1141.1 ± 25.8	1146.6 ± 19.4	1169.3 ± 21.3
Male (on-station)	845.1 ± 16.3	1119.4 ± 26.9	1314.9 ± 19.5	1450.3 ± 21.6	1535.8 ± 22.2		1594.9 ± 22.8	1608.5 ± 24.1	1613.4 ± 27.3
Female (on-farm)	556.4 ± 22.3	809.5 ± 31.9	956.2 ± 34.2	1045.8 ± 35.8	1056 ± 46.3		1085.2 ± 63.3	1060.9 ± 42.1	1058.1 ± 47.2
Male (on-farm)	605.4 ± 25.7	888.1 ± 26.7	1131.7 ± 44.7	1274.1 ± 50.7	1306.3 ± 59.7		1354.2 ± 68.3	1404.5 ± 54.9	1453.9 ± 77.2

*** = $P \leq 0.001$; ** = $P \leq 0.01$; * = $P \leq 0.05$; NS, not significant; NA, not available.

in body weight at hatching between males and females, but as the chicks grew, males were significantly higher than females in body weight owing to the presence of sexual dimorphism. Interaction of sex of chicken with management system for body weight is shown in Figure 2.

The higher body weight of on-station chickens is most likely because of the fact that the chickens reared on-station were fed on formulated ration throughout the whole experiment period. Formulated feed were provided with the chicks to the farmers to feed the chicks for at least 2 weeks, but the farmers then had to provide their own feed, which mainly consisted of crushed maize and other kitchen scraps. This feed may not supply enough nutrients for growth. Moreover, after some weeks farmers also released the chicks outside the brooding boxes for a few hours per day, and when they were fully grown they stayed out all day to look for food, which in turn increases exercise and resulted in loss of energy. In a study by Dou *et al.* (2009) chickens kept in the free range system had lower body weight compared with those kept indoors. They concluded that the performance of chickens kept in free-range system would be inferior to that of a controlled environment because of fluctuating temperature and increased exercise.

Significant body weight difference after the brooding period leads to a widening of the gap between male and female body weight, as shown in Figure 2. This figure also shows that the difference in body weight between chickens kept in the two systems is most pronounced at 4 months of age. Higher body weight gain during early stage of growth in chicks kept on-station than on-farm (Table 4) has practical significance for future management. Chambers (1990) reported that it is necessary in applied poultry breeding to evaluate growth during juvenile stages to permit choice of actions long before maturity. Actions such as provision of better management practices such as better feed and disease control in the on-farm system during early stage of growth could increase body weight and could narrow the difference in body weight of chickens in the two systems during the rest of the production period.

AAFE was lowered by about 20 days in chickens under on-farm conditions compared with those kept on-station. This is reflected in the average number of eggs laid, which is slightly higher in on-farm than in on-station (Table 8) and the relatively higher HDEP percent up to 8 months of age (Figure 3). Early laying is considered to be important for the farmers because a chicken should produce as many eggs as possible before disease or predation terminates the production under these difficult conditions. Chickens kept under relatively better feed and management conditions (on-station) is expected to have a lower AAFE than scavenging chickens reared on-farm. Islam and Nishibori (2009) reported that exotic and cross-breds of indigenous naked neck with exotic chickens kept under scavenging system showed delayed age at sexual maturity and lower egg production. AAFE depends on the type of feed the chickens had in their early growth stage, length and intensity of

Table 7. Least square means with standard errors of chicken body weight gain (g) from 5 to 12 months of age.

Effects and levels	Chicken body weight gain							
	Month 5	**Month 6**	**Month 7**	**Month 8**	**Month 9**	**Month 10**	**Month 11**	**Month 12**
Sex	***	***	*	NS	NS	NS	NS	NS
Female	183.1 ± 11.7	133.9 ± 11.7	73.3 ± 12.5	22.3 ± 12.8	25.7 ± 7.6	8.3 ± 8.2	19.7 ± 12.5	12.7 ± 12.0
Male	250.8 ± 12.8	200.7 ± 14.8	115.6 ± 16.8	49.5 ± 16.3	21.8 ± 9.2	14.4 ± 10.1	40.1 ± 15.3	13.8 ± 18.9
Management	**	NS	NS	NS			*	NS
On-station	191.1 ± 8.3	171.6 ± 8.0	88.6 ± 8.9	38.0 ± 7.5	23.7 ± 5.9	11.3 ± 6.5	8.9 ± 5.3	9.9 ± 8.0.6
On-farm	242.8 ± 15.3	162.9 ± 17.0	100.3 ± 18.9	33.8 ± 19.4	NA	NA	50.9 ± 19.0	16.6 ± 20.9
Sex (management)	*	NS	NS	NS			NS	NS
Female (on-station)	136.1 ± 11.4	126.2 ± 11.0	54.9 ± 11.9	6.6 ± 9.7			10.8 ± 6.6	22.3 ± 9.9
Male (on-station)	246.1 ± 11.9	217.1 ± 16	122.2 ± 13.3	69.5 ± 11.4			6.9 ± 8.2	−2.5 ± 12.6
Female (on-farm)	230.1 ± 20.5	141.6 ± 20.6	91.6 ± 21.9	37.9 ± 23.7			28.6 ± 24.1	3.1 ± 21.9
Male (on-farm)	255.5 ± 22.7	184.3 ± 27.2	108.9 ± 30.9	29.6 ± 30.6			73.3 ± 29.5	30.1 ± 35.8
Variance component								
Residual	13391	11831	8427.9	8427.9	5027.5	5554	3475.6	7672.8

*** = $P \leq 0.001$; ** = $P \leq 0.01$; * = $P \leq 0.05$; NS, not significant; NA, not available.

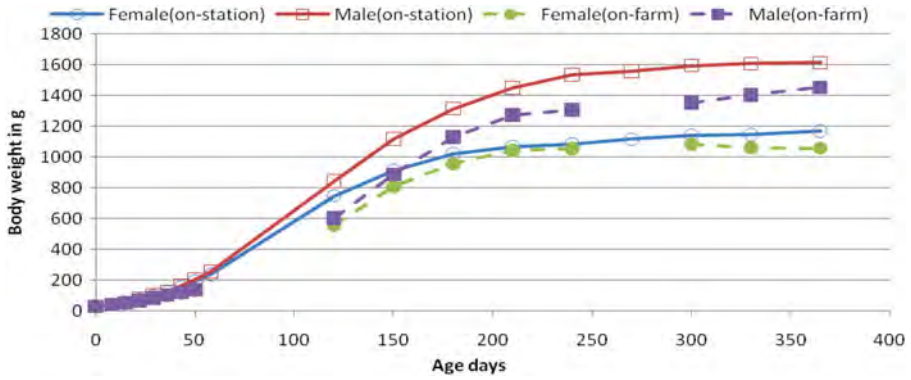

Figure 2. Body weight of chickens at different weeks of age.

light etc. Therefore, a possible reason for the result may be that there was enough forage in the backyard during the short rainy season in this important early life phase of the chickens. Moreover, the chicks on-station were infected with coccidiosis during the first few weeks, which may have had negative influence on AAFE. Although average number of egg produced per bird was not significantly different between the two systems, there was a relatively

Table 8. Least square means with standard error and variance components for AAFE in days, egg number (EN)/layer, HHEP and egg mass.

Effects and levels	AAFE	Egg Number	HHEP	Egg mass
Age		***	***	***
4–8 months		9.5 ± 1.0	7.9 ± 1.4	492.5 ± 61.2
9–12 months		23.6 ± 1.0	18.9 ± 1.4	1200.8 ± 56.9
Management	NS	NS	*	
On-station	221.5 ± 8.5	17.8 ± 1.2	16.1 ± 1.6	846.7 ± 50.7
On-farm	202.6 ± 10.3	15.2 ± 1.4	9.8 ± 1.6	NA
Age (management)		*	*	
4–8 months (on-station)		9.2 ± 1.2	8.9 ± 1.9	
9–12 months (on-station)		26.5 ± 1.2	25.0 ± 1.9	
4–8 months (on-farm)		9.7 ± 1.7	6.9 ± 1.9	
9–12 months (on-farm)		20.7 ± 1.7	12.8 ± 1.9	
Variance components				
Farmer or pen	521.8	7.8	21.5	12181
IDNo		18.3		29728
Residual	835.6	65.3	18.5	116279

*** = $P \leq 0.001$; * = $P \leq 0.05$; NS, not significant; NA, not available.

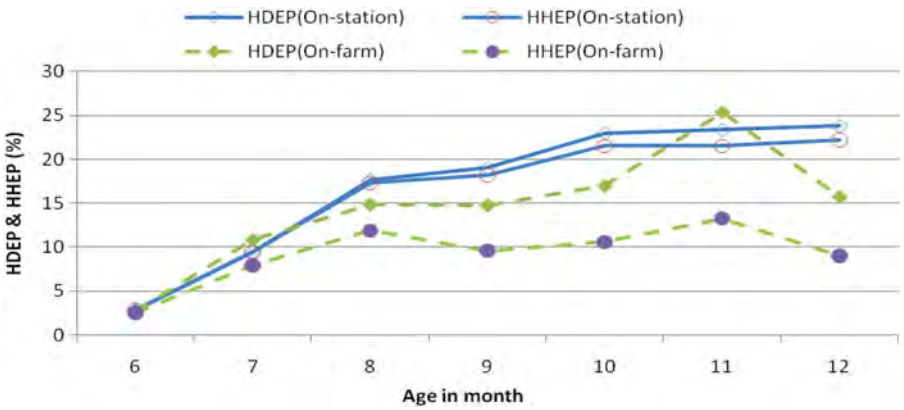

Figure 3. HDEP and HHEP for one day at different age in the two management systems.

higher egg production under the on-station management system. This was expected because scavenging chickens produce less number of eggs compared with those kept in intensive management systems (Hossain, 1992; Solomon, 1996; Dana and Ogle, 2002). As expected, HHEP was lower in on-farm than in on-station because of higher mortality in the former system during the laying period. Figure 3 consequently shows relatively smaller difference in HDEP percent between the two systems than in HHEP percent. In general, egg production in this study was lower than expected in both management systems. However, it is reasonable to believe that selection at all levels of crossing would have improved the production potential of the final synthetic breed.

Egg weight and egg length at the age of 12 months was higher in on-station than in on-farm. A higher egg length is expected to give heavier egg, as the two is highly correlated (Fassill *et al.*, 2009). Egg weight is also affected by the type and amount of feed consumed, which was superior in the on-station system. Hossain (1992) also reported a relatively higher egg weight from chickens kept under intensive than rural conditions. As expected yolk colour was more yellow and therefore superior on-farm compared with on-station, mainly because of the consumption of green forages by the chickens in the backyard vegetable farms.

Although the effect of reciprocal crossing was insignificant on almost all traits recorded, it has practical importance to this project in that it is possible to produce more number of offspring, i.e. with the use of both crossings.

Conclusions

As expected performance of the chickens under on-station management system where there is better feed and housing was higher than those kept under on-farm condition. Compared with a study by Fassill *et al.* (2009), the current study showed a substantial improvement in egg production of local chickens under farmer's management condition. AAFE laid was shortened. Body weight of chickens was also improved by the 4-way cross-bred chickens compared with local chickens. However, much has to be done to reduce mortality during laying period under on-farm condition. Overall performance of the 4-way cross-bred chicken under on-farm condition could further be improved by providing better housing in order to protect the chickens from predators, extreme temperatures, diseases and parasites. Moreover, supplementing the chickens with relatively quality feed ingredient especially during growing period could improve production performance in later ages. Further study on cross-breds of different blood levels of indigenous and exotic chickens under on-station and on-farm systems

Table 9. Least square means with standard error and variance components for egg quality traits.

Effects and levels	EW	AEST	YC	YH	AH	EL	EWd	ESI	HU
Management	*	NS	***	NS	NS	*	NS	NS	NS
On-station	45.2 ± 0.9	0.297 ± 0.004	5.2 ± 0.1	14.3 ± 0.3	5.1 ± 0.3	52.8 ± 0.3	39.4 ± 0.2	74.8 ± 0.4	75.5 ± 1.5
On-farm	41.1 ± 1.5	0.299 ± 0.008	8.3 ± 0.3	14.4 ± 0.4	4.9 ± 0.4	50.7 ± 0.7	38.4 ± 0.4	75.9 ± 1.0	75.9 ± 3.7
Age (management)	***	NS	NS	***	***	***	NS	NS	**
8 months (on-station	43.3 ± 0.9	0.302 ± 0.004	5.3 ± 0.2	13.3 ± 0.3	4.2 ± 0.3	51.9 ± 0.4	39.1 ± 0.3	75.4 ± 0.6	70.3 ± 2.0
12 months (on-station)	46.9 ± 1.0	0.292 ± 0.005	5 ± 0.2	15.3 ± 0.3	6.1 ± 0.3	53.7 ± 0.4	39.6 ± 0.3	74.1 ± 0.6	80.7 ± 2.2
12 months (on-farm)	41.1 ± 1.5	0.299 ± 0.008	8.3 ± 0.3	14.4 ± 0.4	4.9 ± 0.4	50.7 ± 0.7	38.4 ± 0.4	75.9 ± 1.0	75.9 ± 3.7
Variance component									
Pen	5.8	0.0	0.06	0.6	0.5	0.3	0.3	0	0
IdNo	9.1	0.0	0	0	0	1.8	0.4	0	0
Residual	15.9	0.001	1.4	1.9	2	7.3	1.9	21	268.5

*** = $P \leq 0.001$; ** = $P \leq 0.01$; * = $P \leq 0.05$; NS, not significant; EW, egg weight; AEST, average egg shell thickness; YC, yolk colour; YH, yolk height; AH, albumen height; EL, egg length; EWd, egg width; ESI, egg shape index; HU, Haugh unit.

should be made in order to choose the best possible combinations for each system. Selection at all levels of crossing would increase production. Economic aspect should also be included in the study.

Although it is believed that heterosis is expected in the F1 and F2 generations, it was not estimated in this experiment owing to significant loss of female indigenous breeds as they had adaptation problem in the college farm. Males from indigenous breeds were used for mating and there was very limited performance data from females which made it difficult to analyse heterosis.

Acknowledgments

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Animal Genetic Resources, 2012, 51, 149. © Food and Agriculture Organization of the United Nations, 2012
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Recent Publication

Kodi Adu goat. A monograph

A.K. Thiruvenkadan
Tamil Nadu Veterinary and Animal Sciences University and International Foundation for Science, Sweden
Published in 2012, pp. 87

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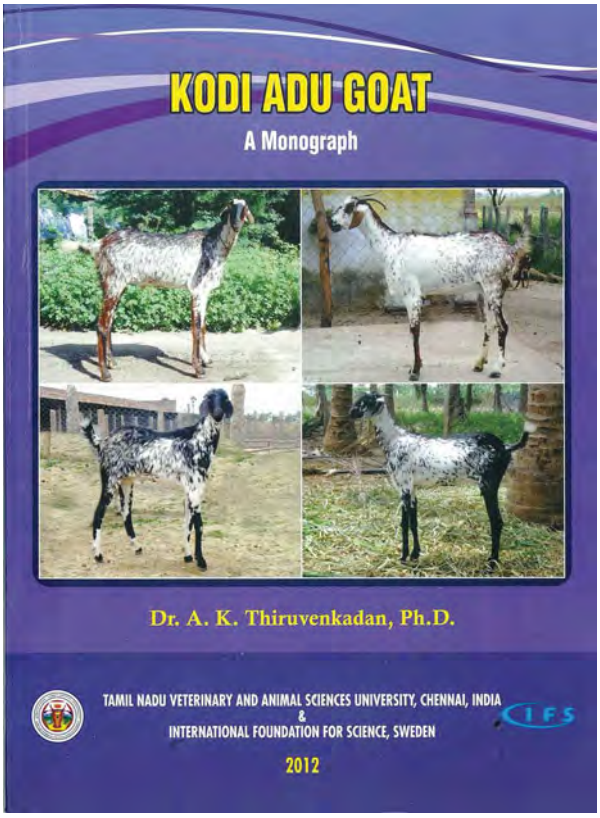

The Kodi Adu goat of southern Tamil Nadu, India, is raised mainly for meat, with skin as an important by-product. This monograph begins with a description of the breed's origin, habitat and distribution, including its population size and a description of the physical aspects of its production environment. Further sections provide descriptions of the economic status of the breed's owners; its morphology, production and reproductive performance; the management practices used in raising the breed; the economics of its production; disease prevalence and health care; molecular polymorphism; and breed improvement and conservation. The latter section concludes that the breed's population status does not warrant immediate conservation measures, but that breed improvement programmes and other improvements to management should be considered. Options discussed include initiating an open nucleus breeding scheme, establishment of a breed society, forage and range-development programmes including silvipasture systems, provision of training on goat husbandry, better breeding management to reduce the risk of inbreeding, development of marketing infrastructure, and the development of fattening schemes for male kids to increase meat production and quality. The book is illustrated with many colour photographs.

Animal Genetic Resources, 2012, 51, 150. © Food and Agriculture Organization of the United Nations, 2012
doi:10.1017/S2078633612000598

Recent Publication

Livestock Breeds in the Republic of Bulgaria
Породи селскостопански животни в Република България

Edited by V. Nikolov
Executive Agency on Selection and Reproduction in Animal Breeding
Published in 2011, pp. 215
ISSN: 1314-538X

doi:10.1017/S2078633612000598

This dual-language Bulgarian/English publication catalogues the breeds of cattle, buffaloes, sheep, goats, horses, pigs, rabbits, poultry, honey bees, dogs and fish present in Bulgaria. Each breed has its own two-page spread, illustrated with several colour photographs, and featuring information on its classification, origin, use, breeding status, gene bank conservation and physical characteristics. Tables present morphological measurements, production performance and reproduction characteristics. Each section is introduced by a short description of the history and current status of the respective species in Bulgaria. Also included is a description of the role of the country's Executive Agency on Selection and Reproduction in Animal Breeding in the organization, management and conservation of genetic resources.

Animal Genetic Resources, 2012, 51, 151. © Food and Agriculture Organization of the United Nations, 2012
doi:10.1017/S2078633612000604

Recent Publication

Animal Genetic Resources in China: Sheep and Goats
China National Commission of Animal Genetic Resources
Published in 2012, pp. 451
ISBN: 978-7-109-15881-8

Animal Genetic Resources in China: Bovines
China National Commission of Animal Genetic Resources
Published in 2012, pp. 439
ISBN: 978-7-109-15351-6

Animal Genetic Resources in China: Poultry
China National Commission of Animal Genetic Resources
Published in 2012, pp. 618
ISBN: 978-7-109-15221-2

Animal Genetic Resources in China: Pigs
China National Commission of Animal Genetic Resources
Published in 2012, pp. 486
ISBN: 978-7-109-15882-5

Animal Genetic Resources in China: Horses, Donkeys, Camels
China National Commission of Animal Genetic Resources
Published in 2012, pp. 391
ISBN: 978-7-109-15350-9

Animal Genetic Resources in China: Bees
China National Commission of Animal Genetic Resources
Published in 2012, pp. 175
ISBN: 978-7-109-15212-0

Animal Genetic Resources in China: Other Animals
China National Commission of Animal Genetic Resources
Published in 2012, pp. 310
ISBN: 978-7-109-16524-3

doi:10.1017/S2078633612000604

This set of seven Chinese-language volumes presents the outcomes of the Second National Survey on Animal Genetic Resources organized by the China National Committee for Animal Genetic Resources between 2006 and 2010. Seven-hundred and seventy-six animal breeds used for food and agriculture are described, of which 555 are local breeds. The set comprises 5.3 million Chinese characters and includes 2134 pictures. Each volume has two parts: “General introduction to the species” and "Detailed description of breeds”.

Animal Genetic Resources, 2012, 51, 152. © Food and Agriculture Organization of the United Nations, 2012
doi:10.1017/S2078633612000616

Recent Publication

Invisible guardians – women manage livestock biodiversity
Animal Production and Health Paper No. 174
FAO
Published in 2012, pp. 56
ISBN: 978-92-5-107307-0
Available at: http://www.fao.org/docrep/016/i3018e/i3018e00.htm

doi:10.1017/S2078633612000616

This publication presents an analysis of women's role in the sustainable use, development and conservation of animal genetic resources. The importance of small-scale famers and pastoralists as custodians of these resources is well recognized, but has never previously been disaggregated by gender. The differential roles of men and women have largely been neglected in studies of animal genetic resources management, but by piecing together several strands of argument and indirect evidence it can be concluded that women are the main guardians of livestock diversity. Global trends in the livestock sector – particularly the shift from subsistence-oriented to market-oriented production, the sedentarization and disintegration of pastoralism, and the emergence of demand for niche market products – are analysed from the perspective of their influence on gender roles in livestock keeping and animal genetic resources management. Likewise, women's role in the reproductive economy is analysed from the perspective of how this influences the type of livestock they keep. Case studies from many regions of the world illustrate that while to a degree women acquire their role as guardians of diversity by default because of global trends, many also make an active and conscious contribution to the management of animal genetic resources.

Animal Genetic Resources, 2012, 51, 153. © Food and Agriculture Organization of the United Nations, 2012
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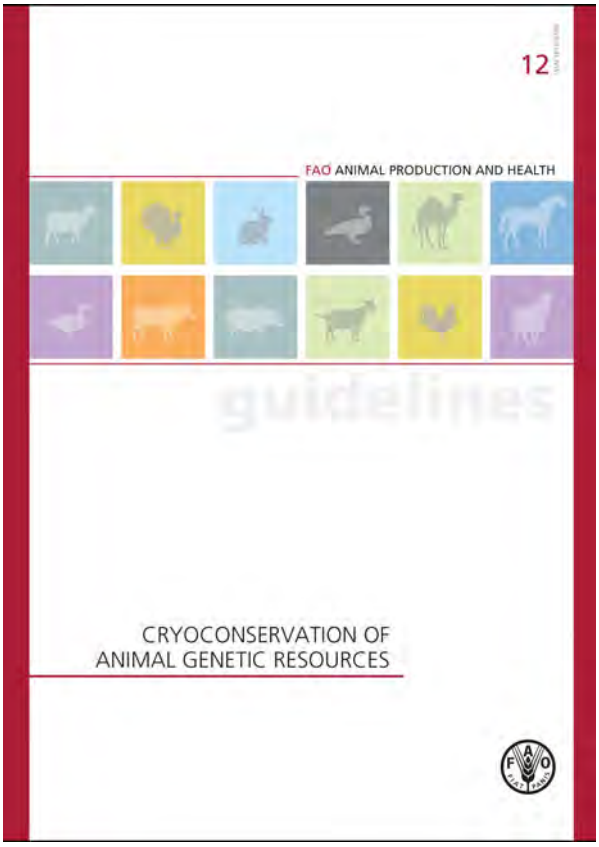
Recent Publication

Cryoconservation of animal genetic resources
Animal Production and Health Guidelines No. 12.
FAO
Published in 2012, pp. 199
ISBN 978-92-5-107306-3
Available at http://www.fao.org/docrep/016/i3017e/i3017e00.htm

doi:10.1017/S2078633612000628



This publication addresses Strategic Priority Area 3 (Conservation) of the *Global Plan of Action* for Animal Genetic Resources. It has been endorsed by the Commission on Genetic Resources for Food and Agriculture. Complementary guidelines on *in vivo* conservation are being prepared for publication in the same series. The guidelines describe, in logical chronological order, the process of establishing a programme for cryoconservation of animal genetic resources, starting with the initial step of confirming the decision to implement a cryoconservation programme. The task of organizing the institutions needed to meet the chosen conservation objectives is then described. This is followed by an overview of the types of germplasm that can be cryoconserved, and technical details regarding the physical plant required to set up a gene bank and the quantities of germplasm required to ensure the capture of sufficient genetic variability. Principles of cryopreservation are then explained from a biological point of view and cryopreservation procedures discussed for different species and tissue types. The main body of the guidelines concludes with sections on sanitary measures, data management, legal issues and capacity building. Appendices provide detailed protocols and lists of equipment and reagents for collection and cryopreservation of various tissues for a range of common livestock species.

Animal Genetic Resources, 2012, 51, 154. © Food and Agriculture Organization of the United Nations, 2012
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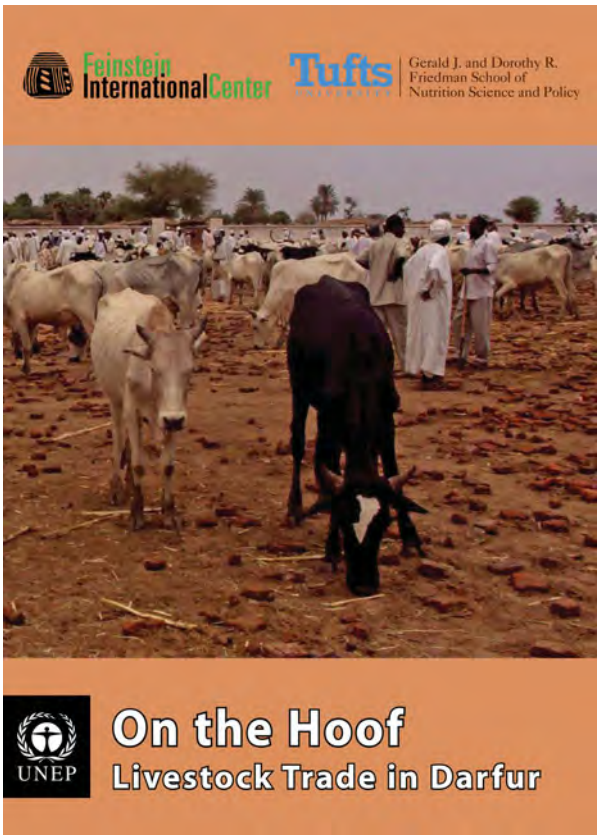
Recent Publication

On the hoof: livestock trade in Darfur

M. Buchanan-Smith, Abdul Jabbar Abdulla Fadul, Abdul Rahman Tahir and Yacob Aklilu
United Nations Environment Programme
Published in 2012, pp. 68
Available at http://sites.tufts.edu/feinstein/files/2012/09/On-the-Hoof-Final.pdf

doi:10.1017/S207863361200063X



This report explores what has happened to the livestock trade in the greater Darfur region during the nine years of conflict since 2003. Livestock is one of Darfur's main economic assets and makes a major contribution to Sudan's national livestock and meat exports. The report documents how Darfur's livestock trade has been negatively affected by the conflict, contracting in volume and losing competitiveness as trading costs have soared and as the quality of animals brought to the market has deteriorated. Physical market infrastructure has also deteriorated and the region has only one, poorly functioning slaughterhouse, although such facilities could play a critical role in stimulating Darfur's livestock trade and in efficiency gains if livestock no longer had to be trekked on the hoof to Omdurman, especially during the dry season. A positive development, however, has been the flourishing trade in hides and skins in Darfur during the conflict years. The report makes a number of recommendations, first, for immediate action to support the livestock trade in the current environment in Darfur, and second, at a policy and strategic level to support the eventual recovery of Darfur's economy and to contribute to the national economy. This report is based on fieldwork carried out across the Darfur region during 2011.

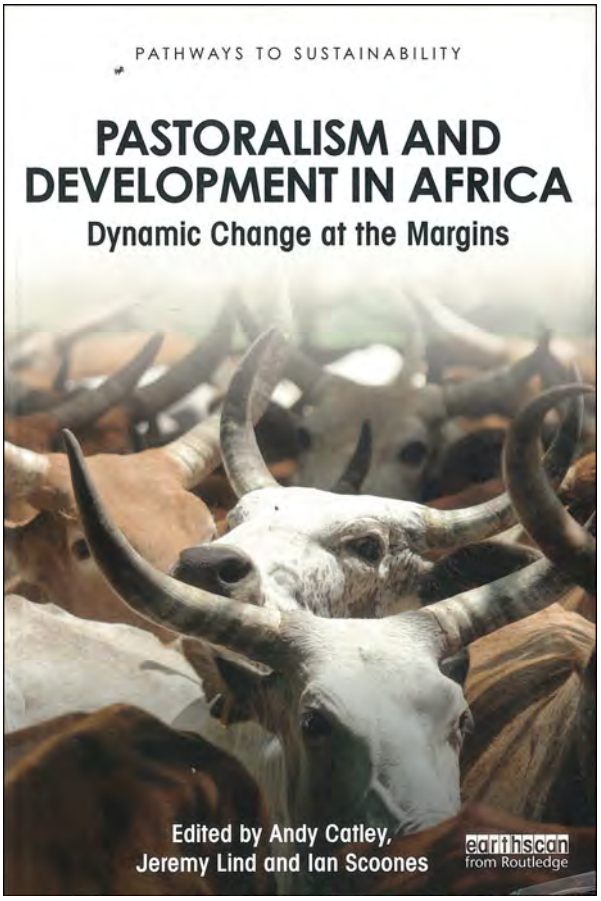
Animal Genetic Resources, 2012, 51, 155. © Food and Agriculture Organization of the United Nations, 2012
doi:10.1017/S2078633612000641

Recent Publication

Pastoralism and development in Africa: dynamic change at the margins

Edited by A. Catley, J. Lind and I. Scoones
Earthscan
Published in 2012, pp. 295
ISBN 978-0-415-54072-8

doi:10.1017/S2078633612000641



This book, which focuses on the Greater Horn of Africa region, seeks to address some of the recurrent misunderstandings about pastoral livelihoods. It presents examples of innovation and entrepreneurship, networking and cooperation "at the margins", rather than focusing merely on conflict, violence, drought and famine. Thematic chapters are grouped into three sections: resources and production (including discussion of rangeland enclosures, irrigation in pastoral areas and the effects of climate change); commercialization and markets (including dissections of the relationships between commercialization and destitution in pastoral areas, opportunities associated with camel export markets and the marketing of camel milk to small towns, and the role played by "responsible" companies – i.e. purveyors of Corporate Social Responsibility – in pastoral development); land and conflict (land grabbing, land deals, changing resource tenure, the need to strengthen land laws and pastoral rights); and alternative livelihoods (including discussion of distance learning programmes, social protection for pastoralists, and women and economic diversification). The book's last chapter summarizes six prominent inter-related themes important for the future of pastoral development and reflects on the future potential for a viable pastoralism. The author concludes that mobile pastoralism will continue in the low-rainfall rangelands of the Horn as no viable alternative use has been found for these areas. An "optimistic scenario" for pastoralism in the region in 2030 is contrasted with the current picture of poverty, food insecurity and land grabs.

Animal Genetic Resources, 2012, 51, 156. © Food and Agriculture Organization of the United Nations, 2012
doi:10.1017/S2078633612000653

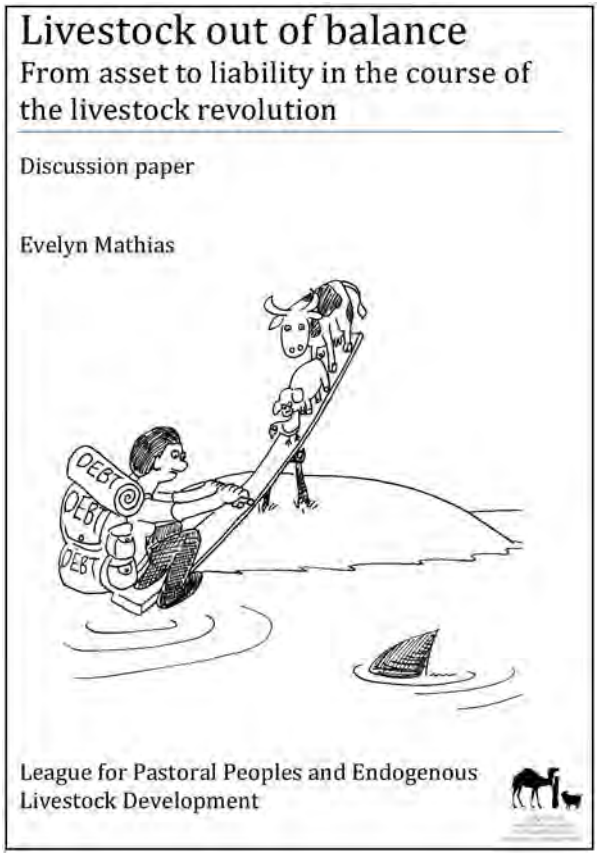
Recent Publication

Sustainable food planning

Edited by A. Villon and J.S.C. Wiskerte
Wageningen Academic Publishers
Published in 2012, pp. 598
ISBN 978-90-8686-187-3

doi:10.1017/S2078633612000653

Half of the world's population are now urban dwellers and are becoming increasingly isolated from the countryside. The authors of this large book provide perspectives from architecture, city planning, policy-making, design, sociology, transport, health, environmental pollution, water supply, waste disposal, fuel supply and city governance – all of which they argue are major issues in ensuring food for the residents of modern cities. The book describes an almost total absence of food planning on the part of the professionals in these areas of urban development. The authors argue that this must change and provide much information and many examples on how a better way forward can be achieved. The book focuses upon cities in the Western world, while the megacities of developing countries are exploding in size and are in desperate need of planning. From this well-written book, urban planners in the developing world can learn how to avoid mistakes and to make food supply a major component of sustainable urban planning, thus greatly improving the quality of life for people isolated from the countryside.



Animal Genetic Resources, 2012, 51, 157. © Food and Agriculture Organization of the United Nations, 2012
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Recent Publication

Livestock sector development for poverty reduction: an economic and policy perspective – Livestock's many virtues

J. Otte, A. Costales, J. Dijkman, U. Pica-Ciamarra, T. Robinson, V. Ahuja, C. Ly and D. Roland-Holst
FAO
Published in 2102 , pp. 161
ISBN 978-92-5-107242-4
Available at http://www.fao.org/docrep/015/i2744e/i2744e00.pdf

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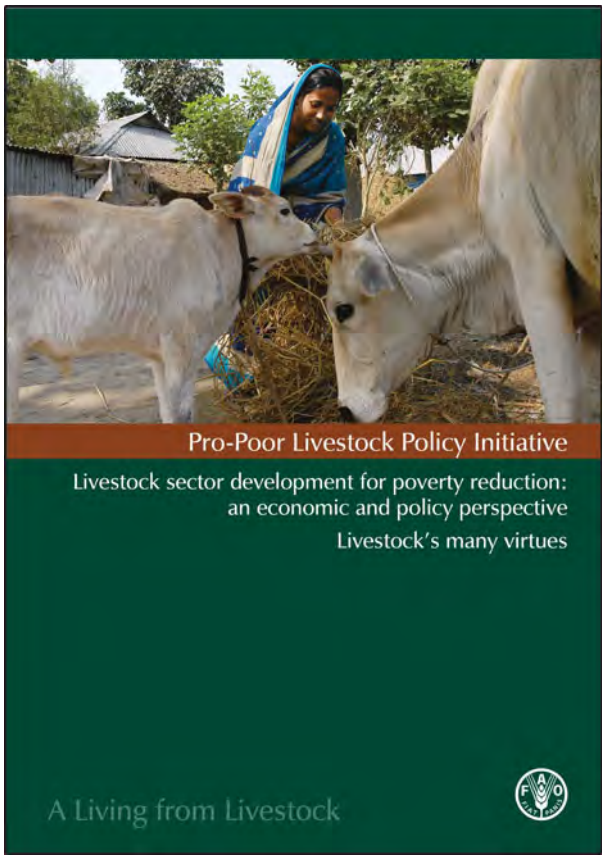

This book aims to identify the conditions under which livestock can be an effective tool for poverty reduction. It begins by presenting a global overview of poverty, food security and livestock keeping – *inter alia* collating data on the numbers and distribution of poor livestock keepers and on trends in demand for livestock products, and reviewing the roles of livestock in nutrition, food security and poverty reduction. The following, more detailed, chapters discuss the various livelihood contributions of livestock; the connections between livestock-sector development, economic growth and poverty reduction; markets and the link between households and the wider economy; and livestock-sector policies and institutions. Finally, conclusions on how to achieve pro-poor livestock development are presented. The authors caution against one-size-fits-all development solutions at both country and household levels. The strengths of locally adapted livestock breeds as providers of resilience to shocks, and in risk management and savings are recognized.

Animal Genetic Resources, 2012, 51, 158 © Food and Agriculture Organization of the United Nations, 2012
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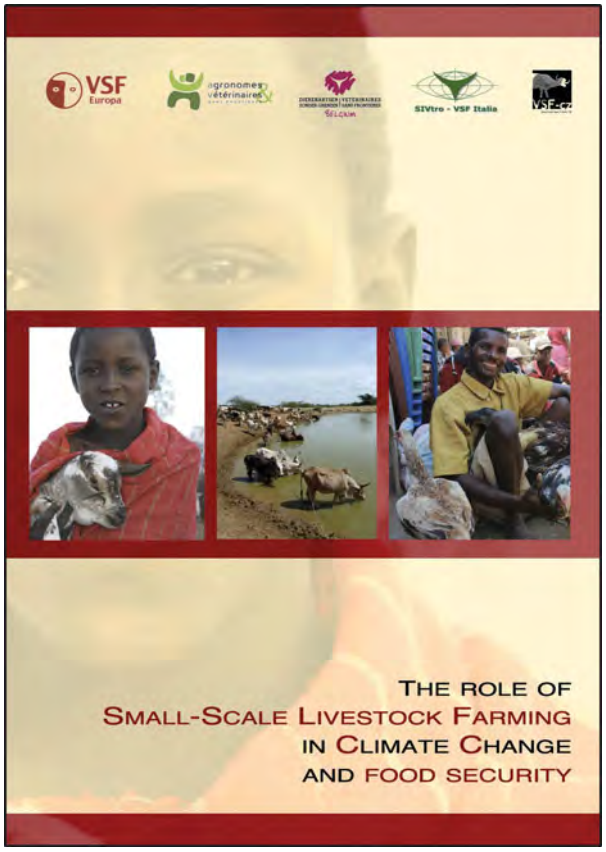
Recent Publication

The role of small-scale livestock farming in climate change and food security

M.G. Rivera-Ferre and F. López-i-Gelats
Center for Agro-food Economy and Development-CREDA-UPC-IRTA
Published in 2012, pp. 146.

doi:10.1017/S2078633612000677



The objectives of this report are to put the debates about small-scale livestock farming and climate change into context and highlight the potential contributions of small-scale livestock farming to food security. It attempts to address the following questions: How sustainable are small-scale livestock farming systems and can they contribute to climate change mitigation? How efficient are small-scale livestock farming practices in producing animal source foods needed by growing population and in responding to future food security challenges? How successfully have small-scale livestock farming communities traditionally adjusted to climate variability and how their strategies can help better respond to climate change? An introductory section provides an overview of the contribution of the food system to climate change, the potential contributions of small-scale livestock farming systems to food security and the characteristics of various different livestock production systems. Potential climate change mitigation strategies – involving market mechanisms, technological and managerial measures, and behavioural modification – are introduced and discussed in relation to small-scale livestock farming systems. This is followed by discussions of the roles of small-scale livestock farming systems in climate change adaptation and of socio-economic drivers that intensify the impacts of climate change on small-scale livestock farming systems. These scene-setting chapters are followed by case studies from Kenya, Madagascar, the Islamic Republic of Iran and Peru.

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Recent Publication

Sustainable livestock management for poverty alleviation and food security

K. van't Hooft, T.S. Wollen and D.P. Bhandari
CABI
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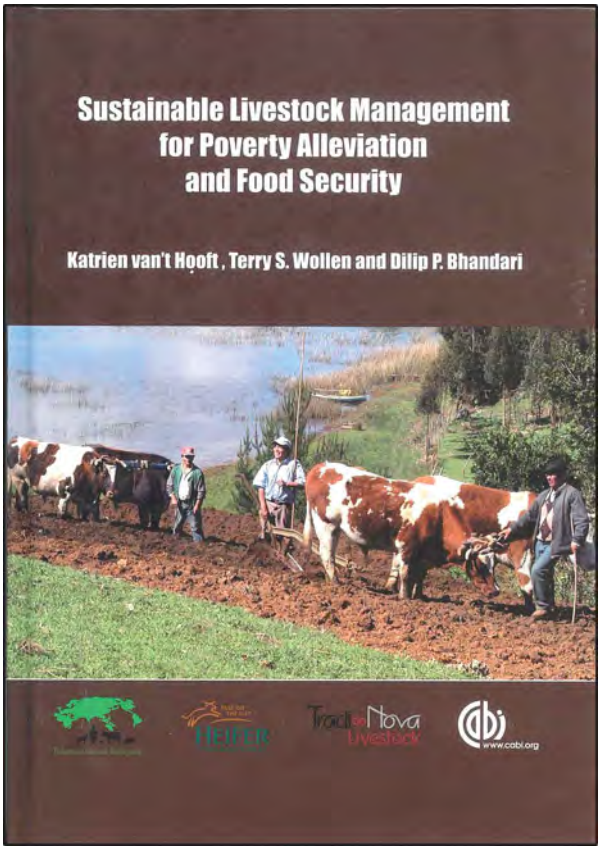

This publication is intended as a practical learning guide providing advice on how to understand and improve smallholder animal husbandry under a range of agricultural and ecological conditions. The focus is on Endogenous Livestock Development, an approach that seeks to enhance livestock keepers' own development efforts. The main target audience is livestock development practitioners working with resource-poor livestock keepers. The first part of the book provides an overview of livestock development and smallholder livestock production, including trends in the livestock sector, approaches to livestock development (including common causes of failure), classification of livestock production systems and key elements of smallholder production. The Endogenous Livestock Development approach is introduced, highlighting the methodologies involved and the networks and organizations that follow this approach. Two main livestock-keeping strategies are identified: low input and diversified livestock keeping on the one hand and more specialized livestock keeping on the other hand. The introductory chapters are followed by more detailed discussion on these two types of smallholder production, including a description of the characteristics of each, a discussion of transition from diversified to specialized livestock keeping and a discussion of steps that can be taken to optimize each type. A further chapter focuses on "finding pathways to markets". A number of case studies illustrating challenges and best practices in livestock development are then presented.

Animal Genetic Resources, 2012, 51, 160–161. © Food and Agriculture Organization of the United Nations, 2012
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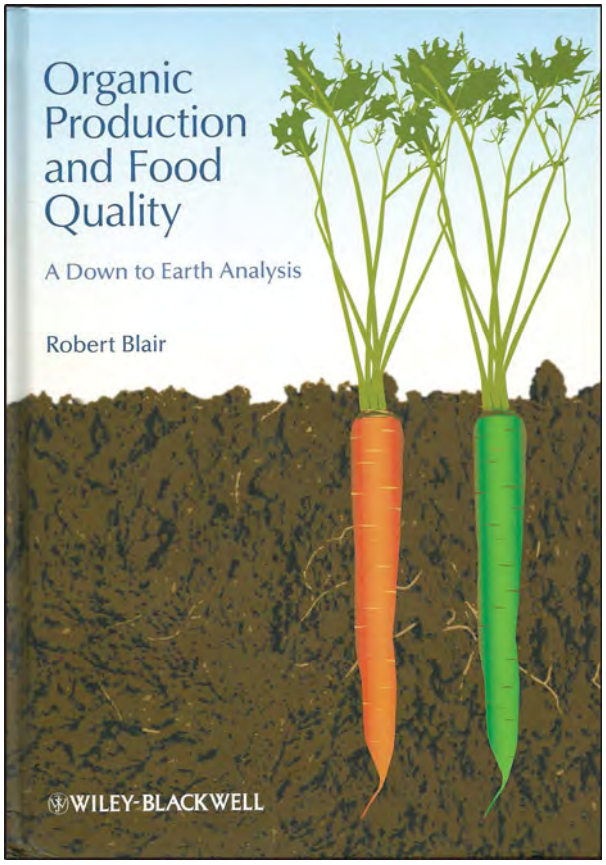
Recent Publication

Organic production and food quality: a down to earth analysis

R. Blair
Wiley-Blackwell, USA & UK
Published in 2012, pp. 296.
ISBN-13: 978-0-8138-1217-5

doi:10.1017/S2078633612000690



Organic food is a confused battleground. To appreciate this book, one needs to understand the background to this conflict. To date anyone seeking an independent assessment of the advantages and disadvantages of organic food is faced by a barrage of assertions and a lack of organized data. It is difficult to form a satisfactory position. On one side, economic interests dominate the agenda and are often supported by scientists whose worldview have been nurtured, even dazzled, by the spectacular increases in food production arising from conventional, intensive large-scale farming which has an impressive track record. Their argument is simple. We have a proven system – let us keep using it even though it involves massive inputs of chemicals and fossil energy. On the other hand are those who question the perfection of science in food production, suspect that chemical farming has negative long-term side effects for human nutrition and health, for the soil, plants and animals used in farming, for the environment and for the overall quality of life. They feel their questions are not seriously addressed by the big, the powerful and the wealthy in the business and scientific communities; for many years, their views were perceived by some governments and scientists as marginal, unscientific, irrational, heretical and even prejudicial to feeding the world. Publicly funded scientific research into potentials, problems, benefits and methods of organic food was seriously neglected until recently. Consequently, for many years, data on organic food production were scanty, unreplicated and suspect thus fuelling derision. Partly due to consumer demand for organic foods, this situation has changed shown by the many authentic publications marshalled by the author that enable him in the final chapter to highlight areas of apparent similarity and difference between organic and conventional foods.

However, the aura of battle still lingers. At worst, it has resulted in emotional reactions and unsubstantiated assumptions about the other side. Those interested in organic production have been portrayed as ignorant and foolish while mainstream scientists and business interests have been characterized as driven only by profit and disinterested in the quality of life issues that surround agriculture and food. The polemics are sometimes vicious and uncompromising. How is this impasse to be broken? How can each hear the other? How can facts take centre stage over prejudice?

For those who want to listen, learn and understand, this book is an excellent introduction. The author has been careful to search for all the authentic published experience. Significantly, in this endeavour he has not been sponsored, paid or supported by any interests. His goal has been to find and document the published facts. It has not been an easy task and doubtless some may chide him for failing to take sides. He is wise in remaining an independent observer. The serious and thoughtful reader can find herein a comprehensive statement on the current knowledge on any of the major issues associated with organic food production, nutrition and food quality.

The book has major sections on the food types: vegetables, fruit, cereals, meat and fish, milk and milk products and eggs. In each section, evidence is presented on pesticide and chemical residues and contaminants, other toxic and anti-nutritional compounds, hormones, microbial contamination problems, mycotoxins and antibiotic use and residues. Other topics relevant to certain types of food are

covered including the processing of products, raw milk, gene modified crops, cloning, mad-cow disease, cholesterol and food poisoning. Each of these major food sections also presents the evidence on nutrient concentrations, organoleptic quality, preserves, appearance and consumer findings. Each of these major sections on food types concludes with a comprehensive list of the references.

An important feature of this book is the extent to which the author presents actual research results from published papers in tables and diagrams that facilitate comparisons between conventional and organic foods. The reader can thus compare, for example, nutrient contents, amounts of residues and toxins, numbers of samples exceeding statutory limits, bacterial and cell counts, polyunsaturated fatty acids and many other measures. Further, the origins and circumstances of the research figures are given – whether independent or government or business together with references and maximum or minimum levels stated by government regulations. The reader can thus judge the seriousness of differences between organic and conventional products.

In addition to food types, there are major sections on the thorny issues of "Is organic food safe?" and "Is organic food more nutritious and tasty?". Here the author does not offer opinions but documents the reliable published evidence on each class of food product for residues, frequency of food poisoning, health studies, nutritional analyses, consumer views, health of farmers and farm workers, etc. The book also examines relevant food regulations affecting production and marketing of organic products.

In the final chapter, the author states the current view of many scientists and government agencies worldwide that organic and conventional foods are fairly similar in nutritional quality and freedom from harmful chemical residues. He notes the inability to define "fairly similar" more precisely. By this point in his study, the author is well placed to summarize the main differences shown by the evidence examined in the book – differences that probably lead some consumers to prefer organic products despite the price often being higher. These include, for example, taste and longer storage life of some fruit and vegetables, leaner but less tender beef with less marbling, lower nitrate and higher antioxidants, higher contents of polyunsaturated fatty acids, pig and poultry meat slightly tougher with enhanced flavour and some slight differences in milk and eggs. He concludes that the main differences between organic and conventional foods appear to be in the area of taste, freshness and the issue of nitrates and phenolic contents. He urges more research in these areas and also, on the basis of limited evidence to date, on the production of meat, milk and eggs from animals and birds raised on organic feed or forage.

The author concludes by posing one serious unanswered question. Do people eating organic foods live longer? The author says there is no evidence yet available to support this hypothesis. But as he, and everyone knows, data to address that question are not likely to be available from planned experiments and it may also be difficult to answer using large-scale population data. The author asks speculatively whether the areas in which organic foods show differences that he has listed help to explain the higher life expectancy found in some Asiatic countries.

Everyone with a serious interest in the differences between organic and conventional food should have this book on their coffee table or bookshelf because it is the most comprehensive and objective library of present evidence. The rhetoric should be quieted by this book, but the meta-narrative is far from complete and more research is urgently required. A new edition of this book will undoubtedly be needed in a few years.

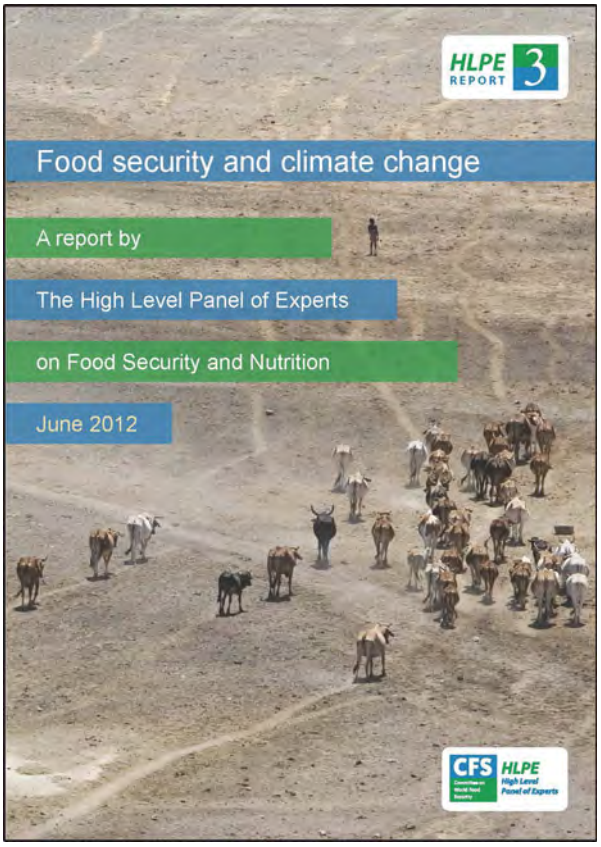
Animal Genetic Resources, 2012, 51, 162. © Food and Agriculture Organization of the United Nations, 2012
doi:10.1017/S2078633612000707

Recent Publication

Food security and climate change. A report by The High Level Panel of Experts on Food Security and Nutrition. HLPE Report No. 3

Published in 2012, pp. 98.
Available at http://www.fao.org/cfs/cfs-hlpe/report-3-food-security-and-climate-change/en/
Also available in Arabic, Chinese, French, Russian and Spanish.

doi:10.1017/S2078633612000707



The High Level Panel of Experts on Food Security and Nutrition (HLPE) was established in 2010 as part of the reform of the World Committee on Food Security. The HLPE's latest report focuses on food security and climate change. Specifically, the HLPE was asked to "review existing assessments and initiatives on the effects of climate change on food security and nutrition, with a focus on the most affected and vulnerable regions and populations and the interface between climate change and agricultural productivity, including the challenges and opportunities of adaptation and mitigation policies and actions for food security and nutrition." The report begins by reviewing the effects of climate change on food and nutrition security today: the nature and magnitude of climate change impacts on food insecurity and vulnerability; the impact of climate change on different food systems (e.g. small-scale farming); issues related to the role of women in agricultural production; the biological effects of climate change on crops, livestock and agricultural systems; evidence for climate change effects on agricultural production and in the chain from harvest to consumer; and the effects of climate change on livelihoods. This is followed by a review of plausible future climate change scenarios including social, economic and biophysical outcomes for vulnerable groups in regions and foods systems where climate change risks are high. Issues examined include increasing farm sizes, urbanization and the threat of conflict over resources. A section on adaptation to climate change (options for responding to food-security challenges) includes a discussion of what farmers (and livestock keepers) can do to adapt to climate change and how they can be supported. Improving access to and understanding of the characteristics of genetic resources is one of the measures highlighted. The potential role of currently neglected breeds of livestock and crop varieties is noted. Climate change mitigation options with food security synergies are then reviewed. Livestock-related options mentioned include improving grazing management and the management of manure. The final section discusses the importance of coordination and coherence among food security and climate change policies and actions. Each section concludes with a summary of policy recommendations.

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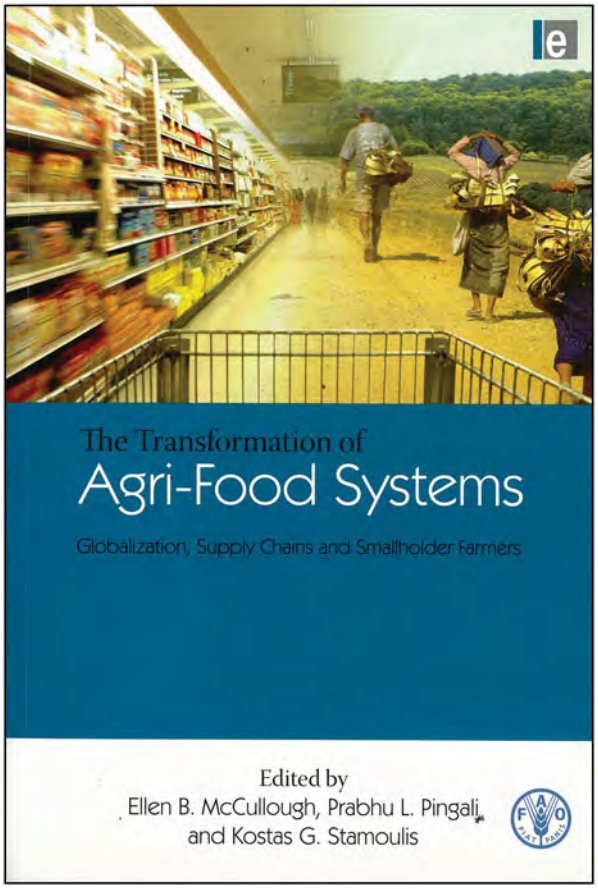
doi:10.1017/S2078633612000719

Recent Publication

The transformation of agri-food systems: globalization, supply chains and smallholder farmers

Edited by E.B. McCullough, P.L. Pingali and K.G. Stamoulis
Earthscan with FAO
Published in 2008, pp. 381.
ISBN 978-92-5-105962-3

doi:10.1017/S2078633612000719



The driving forces of income growth, demographic shifts, globalization and technical change have led to a reorganization of food systems from farm to plate. The characteristics of supply chains – particularly the role of supermarkets – linking farmers have changed, from consumption and retail to wholesale, processing, procurement and production. This has had a dramatic effect on smallholder farmers, particularly in developing countries. This book presents a comprehensive framework for assessing the impacts of changing agri-food systems on smallholder farmers, recognizing the importance of heterogeneity between developing countries as well as within them. The book includes a number of case studies from Asia, Africa, Latin America and Eastern Europe, which are used to illustrate differences in food systems' characteristics and trends. The country case studies explore impacts on the small farm sector across different countries, local contexts and farm types. Chapters with a particular focus on livestock include an analysis of the impact of globalization and vertical integration and agri-food processing on local suppliers in the Polish dairy sector.

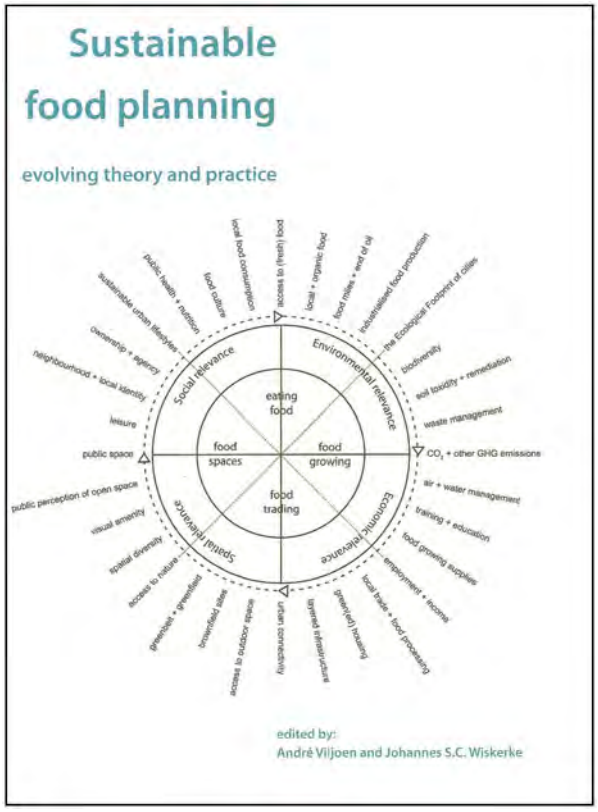
Animal Genetic Resources, 2012, 51, 164. © Food and Agriculture Organization of the United Nations, 2012
doi:10.1017/S2078633612000720

Recent Publication

Sustainable food planning

Edited by A. Villon and J.S.C. Wiskerte
Wageningen Academic
Publishers Published in 2012, pp. 98.
ISBN 978-90-8686-187-3

doi:10.1017/S2078633612000720



Half of the world's population are now urban dwellers and are becoming increasingly isolated from the countryside. The authors of this large book provide perspectives from architecture, city planning, policy-making, design, sociology, transport, health, environmental pollution, water supply, waste disposal, fuel supply and city governance – all of which they argue are major issues in ensuring food for the residents of modern cities. The book describes an almost total absence of food planning on the part of the professionals in these areas of urban development. The authors argue that this must change and provide much information and many examples on how a better way forward can be achieved. The book focuses upon cities in the Western world, while the megacities of developing countries are exploding in size and are in desperate need of planning. From this well-written book, urban planners in the developing world can learn how to avoid mistakes and to make food supply a major component of sustainable urban planning, thus greatly improving the quality of life for people isolated from the countryside.

Animal Genetic Resources, 2012, 51, 165–167. © Food and Agriculture Organization of the United Nations, 2012
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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.

Other published material – Readers are encouraged to send the following items by e-mail to AnGR-Journal@fao.org:

- 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.

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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.

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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.

Supplementary online material

The online platform gives authors the opportunity to include data that would be impossible or impractical to include in the printed version. Authors may include tables and figures as well as data such as videos, 3-D structures/images, extensive datasets and any other supplementary material not suitable for print duplication. All supplementary material must be submitted with the original manuscript. Supplementary data should be referred to in the text with the prefix "S" (e.g. Supplementary Table S1, Supplementary Figure S1). Supplementary files will not be copyedited but will be published as supplied. The electronic publication of this material needs to be approved by the editors. The manuscript must be able to stand alone without the supplementary material (for the benefit of readers with access to the hard copy only).

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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.

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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.

Révision par les pairs

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.

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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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