Puesta en valor de un sistema tradicional y de sus recursos genéticos mediante una Indicación Geográfica: El proceso de la Carne Caprina del Norte Neuquino en la Patagonia Argentina

M. Pérez Centeno[1], M.R. Lanari[2], P. Romero[1], L. Monacci[1], M. Zimerman[2], M. Barrionuevo[1], A. Vázquez[5], M. Champredonde[3], J. Rocca[1], F. López Raggi[4] & E. Domingo[2]

[1]*Instituto Nacional de Tecnología Agropecuaria,* ***AER Chos Malal****, Argentina[1],*
[2]*Genética en Rumiantes Menores, Area de Producción Animal, INTA EEA Bariloche,* ***San Carlos de Bariloche****,*
Paraje Valle Verde S/N CC 277 (8400), Río Negro, Patagonia, Argentina
[3]*INTA EEA. Bordenave CC Nro. 44 - 8187* ***Bordenave****, Buenos Aires, Argentina*
[4]*Fac. Economía UNCo, Argentina*
[5]*Dirección de Ganadería de la Prov. del Neuquen, Argentina*

Resumen

El sistema tradicional de producción caprina del norte de Neuquen (Patagonia, Argentina), desarrollado por "*crianceros*" trashumantes, es un sistema marginal de baja dotación de recursos económicos y alta fragilidad ambiental pero que dispone de un alto capital cultural, un recurso genético adaptado y un producto de calidad superior reconocida pero no diferenciado. A fin de superar esta situación se propone la aplicación de una Denominación de Origen (DO). La propuesta se basó en la organización de los integrantes de la cadena de valor de la carne caprina regional y la determinación de sus cualidades tecnológicas ligado a la raza Criolla Neuquina. Se construyó una visión común sobre el sistema y su identidad, expresada en el Protocolo de la Denominación de Origen del "Chivito Criollo del Norte Neuquino". Los estudios sobre la tipicidad y calidad han permitido establecer indicadores de la misma y la trazabilidad del producto. El fortalecimiento de las organizaciones campesinas y la conformación de un espacio de articulación ha permitido niveles de concertación inexistentes hasta el presente que potencian el desarrollo del territorio y lo capitalizan, dando proyección a la sostenibilidad del sistema y del recurso genético.

Summary

The traditional goat production system from North Neuquen (Patagonia, Argentina), developed by transhumant goat keepers is a marginal system with low economic input and fragile environment but with a high cultural capital, an adapted genetic resource and a product with high reputation but not differentiated. To overcome this situation the application of a Geographical Indication was proposed. This process was based on the organization of the local goat meat marketing chain and the description of technological properties of the product of the Neuquen Criollo breed. The chain actors have constructed a common vision about the system and its identity, which is reflected in the Protocol of the Designation of Origin of the "*Criollo Kid of North Neuquen*". The study on product's typicity and quality has contributed to define quality indicators and traceability of the product. As a result Goat Keepers organizations have been empowered, a common ground of communication has been established enhancing the understanding level among local actors, which was previously not existent. This has reinforced regional development and given projection to system and genetic resource sustainability.

Résumé

Le système traditionnel de production caprine dans le Nord du Neuquen (Patagonie, Argentine), développé par les "crianceros (éleveurs)" transhumants, est un système marginal à faible input en ressources économiques et grande fragilité environnementale, mais qui dispose d'un capital culturel élevé, une ressources génétique adaptée et un produit de qualité supérieure reconnu mais non différentié. Pour améliorer cette situation on propose la demande d'une Dénomination d'Origine (DO). La proposition se base sur l'organisation des différentes parties de la chaîne de valeur de la viande caprine dans la région et la définition de ses qualités technologiques liées à la race Criolla Neuquina. On a élaboré un plan commun sur le système et identité recueilli dans le Protocole de la Dénomination d'Origine du "Chivito Criollo del Norte Neuquino". Les études sur la typicité et la qualité ont permis d'établir des indicateurs de la race et la traceabilité du produit. Le renforcement des organisations d'éleveurs et la l'établissement d'un espace ont permis des niveaux d'accord inexistants auparavant qui permettent le développement du territoire et sa capitalisation, ce qui porte à une durabilité du système et de la ressources génétique.

Keywords*: Genetic resources, Traditional systems, Valuation of livestock keepers culture, Designation of Origin.*

Introducción

Existen dos planteos básicos sobre la estrategia de intervención para conservar y mantener los recursos genéticos en animales domésticos: el primero de ellos considera al animal *per se,* es decir la conservación de animales o grupos en estaciones experimentales, zoológicos o granjas educativas (Alderson, 1990), a la que en la actualidad se suma el concepto de conservación *in-vitro*, mediante conservación de semen u ovocitos congelados. Por el contrario otra corriente considera que la diversidad genética de las poblaciones de animales domésticos puede ser mantenida sólo en el contexto social y ambiental que les dio origen, fundamentándose en que la diversidad genética es principalmente el producto del proceso de selección dado por las condiciones ambientales locales combinadas con las estrategias de manejo y selección de las comunidades rurales que las crían (Köhler-Rollefson, 2000). Desde esta perspectiva la caracterización del recurso genético es el primer paso dentro de la estrategia de conservación (FAO, 1998). Los pasos posteriores deberían asegurar la sostenibilidad del recurso en el largo plazo.

En este sentido el trabajo realizado en relación con la Cabra Criolla Neuquina (CCN) adhiere al concepto de conservación enunciado por Köhler-Rollefson (2000), considerando la raza en el contexto del sistema rural tradicional del que es parte. A partir de 1997 el Instituto Nacional de Tecnología Agropecuaria (INTA) en cooperación con la Dirección de Agricultura y Ganadería (DAyG) de la provincia de Neuquén iniciaron una serie de trabajos de investigación tendentes a comprender el funcionamiento del sistema de producción y caracterizar la población caprina de la región ubicada en el norte de la provincia de Neuquén, Patagonia, Argentina en un área de unos 30 000 km^2 (Figura 1). La utilización de enfoques sistémicos orientados a los actores (Long, 1992) y metodologías de investigación-acción (Albadalejo y Casabianca, 1997) que involucró a los destinatarios en los estudios, buscaba comprender sus prácticas así como el modelo de gestión de los recursos existentes.

Los resultados de estos trabajos de caracterización fenotípica, genética y productiva han establecido sus particularidades que en síntesis la muestran como una entidad genética única y definida (Lanari, 2004; Lanari *et al*., 2006). La consideración de este enfoque sistémico, implicó involucrar los grupos sociales, en este caso de crianceros trashumantes, que son efectivamente quienes han modelado la población y viven de ella (Lanari *et al*., 2005). El ambiente físico, la historia económica y social de la región así como la importante intervención de las políticas de

Figura 1. Provincia de Neuquén (Patagonia, Argentina) y zona de intervención.

desarrollo emanadas desde el estado provincial han influido sobre el sistema tradicional (Pérez Centeno, 2001).

Los crianceros, constituyen un grupo social de más de 1 500 familias con fuerte arraigo a la tierra. Sus unidades de producción, asentadas generalmente sobre tierras públicas, son destinadas esencialmente al autoconsumo, con una inserción limitada al mercado. La historia y evolución de la población rural de la región muestran la capacidad de transformación y adaptación de estrategias para sobrevivir en un ambiente físico y social difícil (Pérez Centeno, 2007).

El sistema rural tradicional se caracteriza por ser extensivo y trashumante, de estacionalidad estricta (Lanari *et al.*, 2006). El reconocimiento de acuerdos sociales internos y de las prácticas culturales de raigambre indígena lo muestran como una respuesta socialmente construida frente a la realidad en la que se ha desarrollado (Pérez Centeno, 2001). El sistema presenta actualmente restricciones tales como reducción de áreas de pastoreo de invierno (*invernadas*) y particularmente de verano (*veranadas*) y las correspondientes rutas de arreo, el envejecimiento de los productores asentados efectivamente en el campo y la migración de los jóvenes entre otros problemas, que son comunes a otras comunidades pastorales (Blench, 2000; Leneman y Reid, 2001). Estas se suman a las condiciones estructurales del sistema que presenta una alta dispersión geográfica, gran distancia a los mercados, estacionalidad marcada en la producción y bajo nivel de organización de la oferta. Sin embargo el principal producto del sistema, el "*chivito del norte neuquino*", no solo es motivo de orgullo para los crianceros sino que detenta un alto reconocimiento en los mercados regionales. La utilización de su nombre como argumento de venta por parte de los comercializadores, es un claro indicador del prestigio que goza el producto en sus mercados tradicionales. En la actualidad, no es posible la diferenciación del "*chivito*" por parte de los consumidores respecto a las producciones provenientes de otras regiones, ya que no existe ningún mecanismo que garantice su procedencia. La falta de diferenciación del producto en el mercado podría promover, como señala Akerlof (1970) una selección adversa ante la imposibilidad de reconocimiento de la calidad que castiga su precio de venta.

En otras palabras, nos situamos frente a un sistema marginal de baja dotación de recursos económicos y alta fragilidad de los recursos naturales pero que dispone de un alto capital cultural, un recurso genético adaptado y un producto de calidad superior reconocida.

El trabajo interinstitucional contribuyó a la conformación de un espacio de diálogo entre crianceros, intermediarios, organizaciones profesionales, agentes de desarrollo e investigadores de diferentes disciplinas quienes construyeron una visión consensuada de la actividad, constituyéndose en una plataforma para el desarrollo territorial, basado en la valoración y la jerarquización de la producción caprina regional. El desafío que se planteó fue hacer sustentable al sistema, entendiendo que sólo de ese modo podrá dar lugar al desarrollo de esta comunidad rural y en consecuencia la preservación de su recurso genético.

El uso de signos de distinción de calidad como la Denominación de Origen (DO), surge como una herramienta que beneficia tanto al sector productivo como a los consumidores (Lacroix *et al.*, 2000) y de impacto social positivo (Jatib, 1995). Este signo no sólo distingue un producto sino que lo vincula con el saber hacer y la cultura existente detrás de la actividad productiva. Las experiencias existentes se localizan fundamentalmente en Europa mediterránea (Lambert-Derkimba, *et al.*, 2006), siendo los productos lácteos y los vinos los que más aprovechan estos mecanismos. En Argentina no se presentan ejemplos de DO en productos agroalimentarios a excepción de los vinos que son regulados según una legislación particular. En consecuencia la propuesta de valorizar un producto cárnico producido en un sistema tradicional en una región marginal de un país en desarrollo, supone atravesar nuevos caminos, crear condiciones y enfrentar un desafío.

En este trabajo se expone la experiencia realizada en el norte de la Patagonia Argentina, donde pequeños productores, intermediarios, comercializadores, e instituciones públicas se reunieron a fin de construir el marco tecnológico y organizativo de la Denominación de Origen (DO) para la carne caprina del norte neuquino. La hipótesis de nuestra experiencia sostiene que los mecanismos de diferenciación basados en el origen son una herramienta eficaz para la promoción del desarrollo territorial, la valoración de la cultura campesina y del recurso genético local.

Materiales y Métodos

Las actividades desarrolladas se enmarcaron en un proyecto de Investigación y Desarrollo financiado por la Agencia Nacional de Ciencia y Técnica, el

Municipio de la ciudad de Chos Malal, principal centro urbano de la región y el INTA. El proyecto se inició en el año 2005.

Los dos aspectos básicos del trabajo fueron: la organización de los integrantes de la cadena de valor de la carne caprina regional para la construcción de la DO y la determinación de cualidades tecnológicas y nutricionales de los productos a proteger. Asimismo se realizaron estudios sobre la actividad comercial y la conceptualización que tienen los diferentes actores sobre la calidad.

La organización de los integrantes de la cadena de valor se consideró a través de talleres en diferentes parajes de la región norte de Neuquén. En ellos se procuró identificar las motivaciones para el inicio de un proceso de diferenciación, así como los niveles de articulación entre los actores. Los talleres efectuados tuvieron dos objetivos diferentes:

1. Talleres informativos y de sensibilización.
2. Talleres de Construcción de la DO (Figura 2).

Talleres informativos y de sensibilización

Se efectuaron diez talleres en los cuales participaron más de trescientos productores, comercializadores e integrantes de quince instituciones de la región, a los que se informó sobre las diferentes alternativas para la diferenciación de productos agroalimentarios (Marcas comerciales, DO, IG, Producto Orgánico), las especificidades de los mismos y las exigencias para su obtención. Esta actividad de sensibilización fue acompañada por una campaña informativa a través de diferentes medios locales (radial, gráfico y televisivo) focalizada en los establecimientos educacionales con el fin de sensibilizar sobre el valor del recurso productivo y la necesidad de su protección en el mercado.

Talleres de Construcción de la DO

En una segunda etapa a lo largo de cuatro talleres, se indagó sobre la representación que la sociedad tiene del Norte Neuquino, sobre las especificidades de su identidad, los modos de producción local, así como los límites socialmente reconocidos de dicho territorio.

Los mencionados Talleres fueron la base de las actividades posteriores que incluyeron: Talleres de discusión sobre formas de asociación, constitución del consejo regulador de la DO, reglamentaciones y aspectos legales.

Los aspectos tecnológicos incluyeron la determinación de indicadores de calidad para las distintas fases de la elaboración del producto, es decir:

- La caracterización de las categorías a proteger, el grado de terminación in vivo.
- La calidad de la canal y la calidad sensorial.

Este trabajo se realizó en el Frigorífico de Chos Malal, cuyas instalaciones y procedimientos habilitan para la comercialización de los productos cárnicos a destinos diversos. Todos los muestreos realizados fueron realizados en época normal de comercialización, que corresponde a los meses de octubre a abril.

Por último se realizó un análisis de la demanda en el ámbito de operadores comerciales mediante encuestas a intermediarios, comercializadores y restaurantes, localizados en el área de producción así como en los centros naturales de consumo: la región de los Lagos cordilleranos, área de actividad turística, y en el Alto Valle de Río Negro y Neuquen, que con cerca de medio millón de habitantes es el

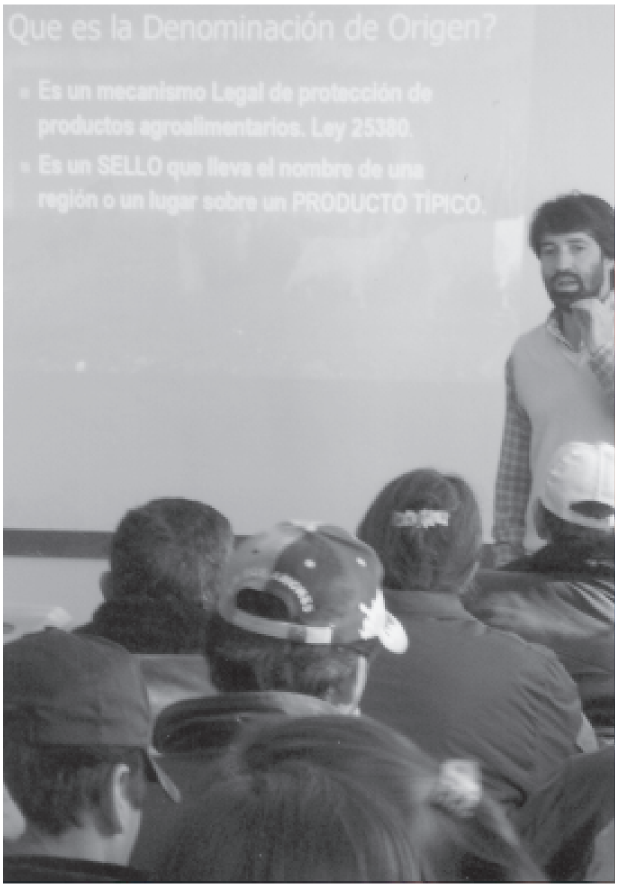

Figura 2. Foto tomada durante uno de los talleres informativos.

Figura 3. Foto del grupo delimitando la región.

mayor conglomerado urbano de la Patagonia. El objetivo particular de este análisis fue comprender los modos de compra y venta a lo largo de la cadena productivo-comercial, desde el criancero hasta el consumidor, así como la forma en que se construye la calidad del producto.

Resultados

La realización de los talleres informativos permitió consensuar el concepto de distinción de calidad como herramienta para poner en valor la producción caprina. Se observó un marcado orgullo por el ser "*criancero*" y por el producto "*chivito*", destacándose el valor que le asignan a la raza Criolla Neuquina. Esta autovaloración resulta fundamental al momento de construir la DO.

En los Talleres de construcción de la DO, la participación de más de cien productores, comercializadores e instituciones permitió explicitar la imagen común, que resume la especificidad regional. Los siguientes elementos surgieron como los de mayor importancia:

- La presencia de la Cabra Criolla Neuquina en cualquiera de sus dos biotipos.
- La realización de la trashumancia.
- La homogeneidad de los pastizales de los campos de veranada ubicados en la alta cuenca del río Neuquén y Barrancas.

Estos elementos delimitan territorios diferentes que se superponen en el área que define la Denominación de Origen (Figura 3). En ella se evidencia una identidad común construida en función del uso del espacio y los modos de circulación. El área de la DO está integrada por todas las unidades de producción que hacen trashumancia en los campos de veranada ubicados en los departamentos Minas, Chos Malal, Pehuenches o Ñorquin (Figura 4).

Los modos de producción que caracterizan a la región fueron descritos en dos talleres, en los cuales detallaron la gestión del rodeo, el manejo reproductivo, nutricional, sanitario, así como la rotación entre los diferentes campos y el arreo. El ciclo anual de producción fue definido como estrictamente estacional, con servicio de otoño y parición de primavera, gracias al trabajo del *castronero o chivatero*[1], en lugares alejados fuera de la época de servicio. Esta práctica fue desarrollada sin intervención externa surgida frente a la necesidad de regular la época de los nacimientos. La existencia de pautas no escritas, como los modos de retribución, los momentos de recepción y entrega de los reproductores y las formas de sancionar los descuidos en el manejo, permiten reconocerla como una práctica institucionalizada, que si bien se encuentra en sistemas productivos vecinos, no manifiesta igual intensidad.

La trashumancia entendida como "*... el hecho de trasladarse de un lugar a otro por arreo o excepcionalmente en camión. No importa el medio...el tema es estar un tiempo en una parte y otro tiempo en otra parte. Esto es lo que nos caracteriza a nosotros;… es un elemento estructurador de las relaciones sociales, ya que la participación de la familia permitió la formación de vínculos con pobladores distribuidos a lo largo de la ruta de arreo. Esto se constituyó en un elemento homogeneizador de las relaciones sociales y la información entre los productores. La alternancia entre los campos bajos y los campos altos fue señalada como un elemento esencial para la tipicidad del producto: El cambio de pastura es lo que da el sabor al chivo. Si no se cambia de pasto, no hay sabor del chivo…*".

Al definir qué tipo de animal y qué producto se debería proteger con la DO, se definió claramente por proteger la raza Criolla Neuquina y al chivito

[1]Castronero o chivatero: Productor especializado en el cuidado de machos normalmente durante el período noviembre a marzo.

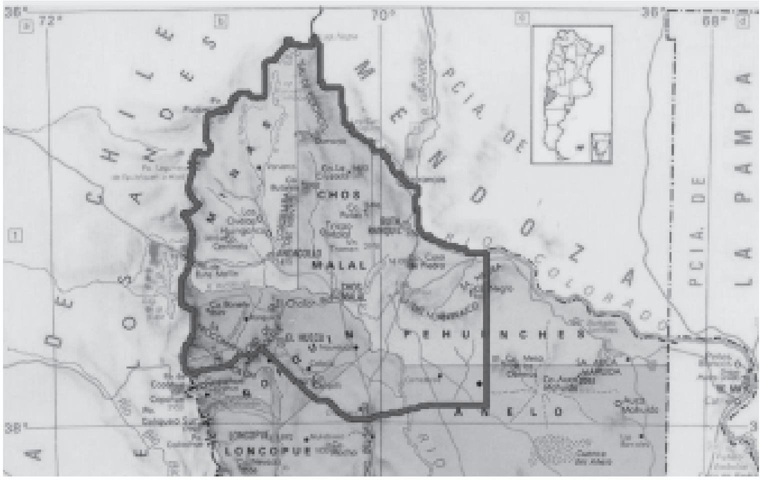

Figura 4. Mapa del área de la DO

con dos categorías posibles; el "chivito mamón", de hasta 90 días de edad, lactante y que no hubiese realizado arreos a las pasturas altas, y el "*chivito de veranada*", que realiza al menos un arreo y se ha alimentado de las pasturas de las veranadas, siendo su edad límite los 180 días. El nombre elegido por los propios participantes fue "*Chivito Criollo del Norte Neuquino*" (Figura 5)

El trabajo sobre los aspectos tecnológicos estuvo dirigido a establecer los parámetros y los indicadores de cada una de las categorías que los mismos crianceros buscan proteger en la DO. Los resultados de estos estudios fueron detallados por Domingo *et al*. (2005). En base a estos resultados se estableció una metodología para la clasificación de las canales y los umbrales de calidad pertinentes a la distinción con el sello de la DO, además del desarrollo de indicadores de calidad *in vivo*.

Como resultado del trabajo de talleres y sobre los aspectos que hacen a la calidad del producto, se redactó y acordó con los interesados el Protocolo de la DO. Este documento fue presentado ante las autoridades de la Secretaría de Agricultura, Ganadería, Pesca y Alimentación en diciembre de 2005 por el Consejo de Promoción de la Denominación. Dicha presentación fue la primera solicitud formal en Argentina en el marco de la ley Nº 25.380. Simultáneamente se constituyó el *Consejo Regulador* conformado por representantes de la cadena de valor (productores, comercializadores y transformadores) y el *Consejo Asesor* integrado por las instituciones tecnológicas, académicas y de desarrollo vinculadas al sector. Esta iniciativa permitió la organización del sector y la articulación entre los actores alrededor de un proyecto común.

Al mismo tiempo, se estudió el mercado local y regional (Alto Valle del Río Negro y Lagos cordilleranos) así como las articulaciones entre los diferentes actores de la cadena (productores, matarifes, restaurantes, supermercados y consumidores) con respecto a la calidad del producto. Simultáneamente, se evaluaron diferentes alternativas de presentación de productos (desarrollo de cortes comerciales, envasado al vacío, etc.), así como nuevas vías de comercialización para productos Premium.

Discusión

La presente experiencia nos ha permitido la implementación de nuevos enfoques aplicados a la investigación y el desarrollo dirigido a espacios multiactorales con énfasis en el sector campesino. Un enfoque orientado a los actores y su reconocimiento como sujetos "*capaces" y "competentes*" para delinear su propio desarrollo resulta esencial como punto de partida de la intervención pública.

Por otra parte este reconocimiento aplicado a la gestión de los recursos genéticos, conduce a reafirmar el derecho de los crianceros sobre el recurso. En este proceso iniciado en 1997 se ha demostrado no sólo que los crianceros han sido los formadores de la raza Criolla Neuquina (Lanari *et al*., 2005), que han construido y adaptado con sus propios conocimientos y sus propias estrategias de sobrevivencia en el marco de su sistema rural (Pérez Centeno, 2007), sino que también son activos en la

Figura 5. Logo de presentación del producto protegido por la Denominación de Origen.

formulación de propuestas superadoras. En este sentido este trabajo coincide con el concepto promovido por Lohkit Pashu-Palak Sansthan (2005) según el cual son los propios campesinos los que pueden y deben tomar sus propias decisiones con relación a sus recursos genéticos. Estos derechos los resguardan de perder la propiedad sobre los mismos, al tiempo que previene la introducción inadecuada de germoplasma exótico, frecuentemente promovida por intereses externos a las comunidades.

La valorización de los recursos genéticos y los saberes locales como capital permitió la construcción de un desarrollo alternativo que parte ya no de la asimilación de modelos exógenos basados en producciones estándares sino desde su identidad cultural.

La metodología de investigación-acción que ha promovido la concertación de los objetivos de investigación y la participación activa de los destinatarios durante la implementación de las mismas ha posibilitado la estructuración de un espacio de confianza fructífero que facilitó el intercambio de saberes, la comprensión de sus prácticas y la apropiación de las acciones públicas por parte de los beneficiarios.

La protección de un producto ligado a un recurso genético específico puede estar fundada en su tipicidad o simplemente estar relacionado al marketing (Lambert-Derkimba, *et al*., 2006). En nuestro caso, el recurso genético se halla ligado al sistema y su gente de modo estrecho y por lo tanto su vínculo es genuino.

Desde el punto de vista tecnológico esta experiencia ha sido innovadora en la puesta en valor de un producto local, al que se le aplican criterios de calidad y seguridad que protegen al consumidor y le dan garantías sanitarias y nutricionales. Por otra parte los aspectos productivos, se ponen del mismo modo en la perspectiva de la calidad y la sostenibilidad ambiental, orientando de este modo las decisiones productivas.

La articulación con otras actividades sociales y productivas movilizadas a partir de la valoración de la identidad local y la cultura, implícitas en la Denominación de Origen, genera una sinergia en las actividades desarrolladas en la región que refuerzan las interacciones entre los espacios rurales y los urbanos.

Por otra parte la DO ha favorecido el desarrollo de la institucionalidad, como es el Consejo de Regulador y las Asociaciones profesionales que refuerzan a través de dicho espacio su identidad. El fortalecimiento de las organizaciones campesinas y la conformación de un espacio multiactoral vinculado al sistema productivo permite niveles de concertación y articulación inexistentes hasta el presente que potencian el desarrollo del territorio y lo capitalizan. La DO abre las puertas a la revalorización territorial dando un nuevo horizonte a la sostenibilidad del sistema.

Referencias

Akerlof, A. 1970. The market for lemons: quality uncertainly and the market mechanism. Quaterly Journal of Economics, (84). 488-500.

Albadalejo, C. & F. Casabianca. 1997. Eléments pour un débat autour des pratiques de recherche-action. Etudes et Recherches sur les Systèmes Agraires et le Développement, INRA, pp. 127-149.

Alderson, L. 1990. The work of the rare Breeds Survival Trust. In: L. Alderson (Ed.) "Genetic Conservation of Domestic Livestock". CAB Internac. London. Cap. 3: 33-43.

Blench, R. 2000. Extensive Pastoral Production Systems: Issues and Options for the future. FAO, pp. 78.

Domingo, E. M. Zimerman, R. Raiman & M.R. Lanari. 2005. Caracterización de las canales de Chivitos Criollos Neuquinos. Revista Argentina de Producción Animal. 25:(Suplemento 1) pp. 370.

FAO. 1998. Primer documento de líneas directrices para la elaboración de planes nacionales de gestión de los recursos genéticos de animales de granja, pp. 146.

Jatib, M.I. 1995. Propuestas para la implementación del sistema de denominaciones de origen en argentina. In: Primer seminario internacional de denominaciones de origen. SAGPyA. Buenos Aires , 19-20 de abril, pp. 179-204.

Köhler-Rollefson, I. 2000. Management of animal genetic diversity at community level. I. Köhler-Rollefson (Ed.), GTZ, GMBH, pp. 24.

Lacroix,A., A. Mollard & B. Pecquer. 2000. Origine et produits de qualité territoriale: du signal á l´attribut? 01-21. (Abstract).

Lambert-Derkimba, A., F. Casablanca & E. Verrier. 2006. L'inscription du type génétique dans le reglements techniques des produits animaux sous AOC: consequences pour les races animales. INRA Prod. Anim. 19: 357-370.

Lanari, M.R. 2004. Variación y diferenciación genética y fenotípica de la Cabra Criolla Neuquina en relación con su sistema rural campesino. Fac. Biología. Centro Regional Universitario Bariloche. Univ. Nacional del Comahue, pp. 234.

Lanari, M.R., E. Domingo, M. Pérez Centeno & L. Gallo. 2005. Pastoral community selection and genetic structure of a local goat breed in Patagonia. FAO, AGRI 37: 31-42.

Lanari, M.R., M. Pérez Centeno, & E. Domingo. 2006. La Cabra Criolla Neuquina y su sistema de producción. En: FAO (2006) People and animals. Traditional Livestosck keepers: guardians of domestic animal diversity. A documentation of 13 case studies on how communities manage their local animal genetic resources. K. Tempelman and R.A. Cardellino (Eds). FAO Interdepartmental Working Group on Biol. Divers. For Food and Agric. Rome, Italy.

Leneman, M. & R. Reid. 2001. Pastoralism beyond the past. Development, Local/Global Encounters 44 (4): 85-89.

Lokhit Pashu-Palak Sansthan. 2005. Indigenous breeds. Local communities. Documenting Animal Breeds and Breeding from a Community Perspective. Ed. I. Köhler-Rollefson. Mudra, India, pp. 64.

Long, N. 1992. Battlefields of knowledge. The Interlocking of Theory and Practice in Social Research and Development. Routledge. London & New Cork, pp. 306.

Pérez Centeno, M. 2001. Etude des stratégies de la petite production familiale minifundiste et de son articulation avec les institutions du développement. Le cas des éleveurs transhumants du Nord de la Province de Neuquén (Patagonie Argentine). Université de Toulouse Le Mirail, pp.123.

Pérez Centeno, M. 2007. Transformations des stratégies social et productives des Crianceros transhumants de la province de Neuquén et leurs relations avec les interventions de développement. Thèse de doctorat (In Press).

Experience in establishing a herd book for the local Nguni breed in South Africa

M.M. Scholtz[1,2] & K.A. Ramsay[3]

[1]*Post Graduate School in Animal Breeding, University of the Free State, P.O. Box 339,* ***Bloemfontein*** *9301, South Africa*
[2]*(Corresponding address:ARC – Animal Production Institute, Private Bag X2,* ***Irene*** *0062, South Africa)*
[3]*Department of Agriculture, Private Bag X138,* ***Pretoria*** *0001, South Africa*

Summary

For many years the performance of the indigenous livestock of Africa was regarded as inferior. It was only when the results of research and performance recording were published that the value of a breed such as the Nguni was acknowledged. This resulted in an interest in the breed from commercial farmers, which lead to the establishment of a breeder's society in 1986, but with no official pedigrees it was a challenge to establish a herd book.

This article describes how the principles of upgrading were initially used to develop a herd book until the Nguni was recognized as an established breed in 1996. Subsequently a system of first registration was implemented. This system caters for emerging black farmers in South Africa who want to become seed stock breeders and allows for the good quality Nguni genetic material available to the communal black farmers to enter the seed stock industry.

Résumé

La performance des animaux indigènes Africains a été pendant longtemps considérée comme médiocre. C'est seulement après la publication des recherches et résultats de leurs performances que la valeur des races comme la Nguni a été reconnue; d'où l'intérêt soudain des fermiers pour cette race; intérêt qui résultera en la formation d'une Association d'éleveurs de la race Nguni en 1984; toutefois en l'absence des données fiables concernant leur pedigree, il était difficile d'établir le "*herd book*" de ces animaux.

Cet article décrit comment les méthodes d'amélioration génétiques avaient été entreprises pour l'établissement d'un "*herd book*" qui conduisit à la reconnaissance de la Nguni en tant que race en 1996; ce qui d'office résultat en la mise sur pieds d'un système d'inscription qui, d'une part pourvoit une place pour les fermiers noirs Sud-africains désireux de devenir éleveurs d'animaux de type pur sang Nguni; de l'autre ce système prévoit qu'une semence Nguni de bonne qualité soit disponible parmi les fermiers noirs; ce qui leur faciliterait l'accès au sein de l'Association d'éleveurs de la race Nguni.

Resumen

Durante mucho tiempo se ha considerado el rendimiento de las razas indígenas africanas como mediocre. A raíz de la publicación de una serie de resultados e investigaciones sobre sus rendimientos el valor de algunas razas como la Ngumi ha sido reconocido; de ahí el interés de algunos ganaderos por esta raza. Este interés llevo en 1984 a la creación de una asociación de ganaderos de la raza Nguni. Sin embargo, dada la escasez de datos fidedignos sobre el pedigrí era difícil establecer un libro genealógico de estos animales. Este artículo describe cómo se llevaron a cabo los métodos de mejora genética para establecer un libro genealógico que llevó al reconocimiento de la Nguni como raza en 1996. Esto fue posible gracias a la puesta en práctica de un sistema de inscripción que, por una parte, da espacio a los ganaderos negros sud-africanos que desean criar animales de tipo pura sangre Nguni, por otro lado, este sistema preve que el semen de buena calidad de Nguni sea disponible para los ganaderos negros, lo que le facilitará el acceso a la asociación de ganaderos de raza Nguni.

Keywords*: Sanga cattle, Commercial breeders, Upgrading program.*

Introduction

The Sanga cattle (*Bos Taurus africanis)* (Meyer, 1984) originally found along the east coast of Southern Africa are known as the Nguni. Due to a lack of performance recording during the period of colonization, these cattle and many other indigenous livestock of Africa were regarded as inferior. This perception was the result of African man living in a symbiotic relationship with his animals. His animals were invaluable as they provided for most of his needs (Matjuda, 2005). In addition, the status value of animals resulted in more animals being kept and overstocking became the order of the day (Scholtz, 1988). A second reason for the earlier ignorance surrounding the qualities of the Nguni stemmed from the variety of colours and colour patterns often encountered amongst animals of the breed. These wide ranges of colours and colour patterns are in sharp contrast to the general tendency in the stud breeding industry to emphasize uniformity. As a result of this, the stud breeding industry was unable to identify the much emphasized antiquated breed standards (Bonsma, 1980), and regarded these animals as an indiscriminate mixture of breeds (Scholtz, 1988).

In South Africa, this perception of inferiority led to the promulgation of an Act in 1934 in which indigenous breeds and types were regarded as 'scrub' (non descript). Inspectors were appointed to inspect the bulls in communal areas (those in possession of indigenous Africans) and to castrate them if regarded as inferior. Fortunately this Act was applied effectively for only a few years, since it was very unpopular (Hofmeyr, 1994). During the first part of the previous century little or no attention was paid to the improvement or study of the potential of indigenous cattle breeds in South Africa, except for the Afrikaner.

The potential of the Nguni was only demonstrated following the introduction of a beef cattle recording scheme in 1959 in South Africa and the publication of research results on the Nguni in the early 1980's. This resulted in a keen interest in the Nguni by the commercial farmers of South Africa, and the Nguni has now grown numerically to be the second largest stud beef breed in South Africa, according to the information obtained from South Africa's national database (Integrated Registration and Genetic Information System-INTERGIS) on 1 April 2007.

All the seed stock (stud) of Ngunis originates from the original custodians (communal farmers) that maintained the breed over many centuries. However, there was no benefit sharing by these original custodians and in many cases they were exploited by the commercial farmers in order to take possesion of their animals. Currently there is still very good quality Nguni genetic material available to South Africa's communal black farmers. Recognizing the value of such genetic material, the Nguni Cattle Breeder's Society in collaboration with the Agricultural Research Council (ARC) developed a process of first registration to cater for such animals. This system specifically caters for emerging black farmers that want to become Nguni stud breeders.

Methods

The interest in the Nguni from commercial breeders had already begun in the 1970's, when the only source of Ngunis was in remote tribal areas where the influence of imported exotic breeds was less prevalent (Hobbs, 2006). The initial attempts to collect animals from these areas were difficult. The commercial breeders were lucky to find animals that could be bought as "*nothing was for sale*" and such attempts would on many occasions result in the collection of only one heifer and an old cow or two with only one teat that had survived the onslaught of ticks.

In the 1980's the interest in the Nguni from the commercial sector accelerated and in August 1983 the breed was recognized as a developing breed under the Livestock Improvement Act (No. 25 of 1977) and a breeder's society was established in 1986. At that stage there were about 3 000 Nguni females in a few well managed herds (mostly government farms). However, the Nguni in the communal areas was under severe threat, mainly due to crossbreeding with the Brahman (Scholtz, 2005). During this period there were no effective mechanisms in place to control the acquisition of Ngunis, and the original custodians in many cases were exploited by commercial farmers in order to take possesion of their animals; *inter alia* two Brahman heifers would be swapped for one Nguni heifer.

With a breeder's society in place, but with no pedigree information, it was a challenge to establish a herd book. The usual techniques, namely top crossing or upgrading (Dalton, 1980) were not applicable to the Nguni. A top cross is when a breeder or breeders go back to the original source of the breed for some new genetic material. In the case of the Nguni this could not be done, since there was no herd book.

Upgrading is where one breed is changed (graded up) to another by continued crossing. It has been widely used throughout the world where stock was graded up by a number of crosses with registered Studbook Proper (SP) sires from a specific breed. It is commonly accepted that four generations of crossing with a registered sire (SP) will result in purebred status.

An upgrading program will work as follows:
Unspecified original Female x Registered Sire (SP)

↓

(50% pure) Female x Registered Sire (SP) (F_1)

↓

(75% pure) Female x Registered Sire (SP) (F_2)

↓

(87.5% pure) Female x Registered Sire (SP) (F_3)

↓

(93.75% pure) Female (SP) (F_4)

These principles of upgrading were adapted in the initial development of a herd book for the Nguni. In contrast to normal upgrading where the F_1 is 50% pure, in this case F_1 referred to animals that were phenotypically Nguni, but with no pedigree information. In cases where the farmers had pedigree information, their animals were accepted as F_2, irrespective of the number of pedigree generations.

The development process was thus as follows:

F_1 x F_1, F_2, F_3 or F_4 = F_2

F_2 x F_2, F_3 or F_4 = F_3

F_3 x F_3 or F_4 = F_4

F_4 x F_4 = F_4

F_1 referred to animals that were phenotypically Nguni, but with no pedigree information. In cases where the farmers had pedigree information, their animals were accepted as F_2, irrespective of the number of pedigree generations.

In 1996 the Nguni was recognized as an established (developed) breed, and the system changed from the F rating to an appendix and SP (Studbook Proper) system. All F_1 and F_2 animals that met the breed standards were classified as Appendix A, F_3 animals as Appendix B and F_4 animals as SP.

This system worked as follows:

Appendix A x A, B or SP = Appendix B
Appendix B x B or SP = Studbook Proper

Results and Discussion

The interest from the seed stock industry in the Nguni resulted in revived interest in the Nguni from the emerging/small scale sector. It is now generally accepted that the research and performance results that were published saved the Nguni from the possible threat of extinction. The Nguni has now grown numerically to the second largest stud beef breed in South Africa. The stud animals currently consist of over 30 000 females with an estimated 1.8 million Nguni type animals in South Africa. This clearly demonstrates the important role a breeder's society can play in *in-situ* conservation.

Currently there is still very high quality Nguni genetic material available amongst the cattle of South Africa's communal black farmers. However, up to now there has not been an easy way that this genetic material could enter the seed stock industry. Recognizing the value of such genetic material, the Nguni Cattle Breeder's Society in collaboration with the ARC developed a process of First Registration to cater for such animals. First Registration (FR) refers to phenotypically Nguni animals that enter the Nguni register from the first time, e.g. a farmer who has been farming commercially with Ngunis and now wants to become a Stud Breeder. This system also specifically caters for emerging black farmers who want to become Nguni Stud Breeders, and they are encouraged to enter the Seed Stock Industry.

This system works as follows :

First Registration (FR) x FR, A, B or SP=Appendix A (Phenotypic Nguni)

Appendix A x A, B or SP = Appendix B
Appendix B x B or SP = Studbook Proper

Restriction is placed on the sale of FR animals firstly to ensure that not only do they look like pure Ngunis, but also that they breed and perform like pure Ngunis and meet the minimum breed standards. Secondly the restriction ensures that the FR animals remain in the ownership of emerging farmers for a period of time, and are not exploited by established seed stock breeders who want to take possession of their good quality animals.

In the case of females a cow must have at least one calving interval and her average calving interval must not exceed 550 days. At least one of her calves must also have passed an inspection before she can be sold. Bulls must have at least 20 progeny submitted for inspection of which 50% have passed the inspection, before it can be sold.

The ARC launched an alien plant control programme in communal areas north of Pongola in KwaZulu-Natal. Following this project one of the communities demonstrated their intentions to commercialize their livestock enterprise. The Emoyeni community of 18 families secured the grazing rights to approximately 1 500 hectare of communal land. They have 85 sexual mature females most of which are Ngunis of high genetic quality that can enter the system of First Registration of the Nguni Cattle Breeders Society, and the ARC is busy assisting them with this process.

Conclusion

If the intervention in the Emoyeni community is successful it will be the first instance in South Africa and probably the world, where a communal community progressed to be stud farmers using their own original animals. For the first time it will be possible for communal farmers to benefit from the exceptionally high prices that are currently being paid for Stud Nguni cattle in South Africa.

A Breeder's Society can play a pivotal role in the sustainable use of local livestock genetic resources, since it can act as the modern custodians for the sustainable utilization of such breeds. However, they should move away from the antiquated overemphasis on uniformity and artificial breed standards, while ensuring that such breeds remain or become competitive. This will necessitate proper pedigree and performance recording in order to identify any undesirable genetic drift and to ensure competitiveness through proper breeding programs designed for local conditions.

List of References

Dalton, D.C. 1980. An introduction to practical animal breeding. Granada Publishing, Great Britain.

Bonsma, J.C. 1980. Livestock Production - A global approach. Tafelberg, Cape Town.

Hobbs, P. 2006. Musings of a (white) Nguni veteran. Nguni Journal, 3-9.

Hofmeyr, J.H. 1994. Findings of a committee re a gene bank for Livestock. Proc. Conf. Conservation Early Domesticated Animals of Southern Africa, Pretoria, 3-4 March 1994.

Matjuda, L.E. 2005. The role of the Angus breed in the emerging beef sector in South Africa. Proc. 9th World Angus Forum Technical Meeting. Cape Town, 19 March 2005, 61-65.

Meyer, E.H.H. 1984. Chromosomal and biochemical gentic markers of cattel breeds in southern Africa. Proceedings of th 2nd World Congress on Sheep and beef Cattle Breeding, 328-339.

Scholtz, M.M. 1988. Selection possibilities of hardy beef breeds in Africa:The Nguni example. Proc. 3rd World Congr. Sheep Beef Cattle Breed. Paris, 19–23 June 1988, 303–319.

Scholtz. M.M. 2005. History and background of the Nguni in South Africa. Nguni Journal, 7-9.

Development of international genetic evaluations of dairy cattle for sustainable breeding programs

W.F. Fikse & J. Philipsson

Interbull Centre, Dept. of Animal Breeding and Genetics, Swedish University of Agricultural Sciences (SLU), ***Uppsala****, Sweden*

Summary

A large proportion of dairy foods consumed by humans are produced using milk from commercial dairy breeds. The result of high selection intensities, narrow breeding objectives and ignoring inbreeding in past decades is that much attention now needs to be given to conserving these commercial breeds to maintain and increase food production and meet future demands. The characteristics of a sustainable breeding program are broad breeding objectives, measures to control inbreeding rates and continuous genetic improvement to keep populations competitive. It is necessary to include traits in the breeding objectives that reduce the cost price of products in addition to traits that increase the output of products. Breeding objectives differ between countries (production environments), and together with genotype-environment interaction for single traits (e.g. milk yield) the implication is that ranking of animals for local breeding goals differs between countries (production environments). Acknowledging this in selection programs leads to larger number of selected animals - at least on a global level, adding to the global diversity in commercial dairy cattle populations. Interbull provides international comparisons of bulls from six dairy breeds for most of the economically important traits, thereby enabling global selection for broad breeding objectives in many countries around the world.

Résumé

Une grande partie des produits laitiers pour la consommation humaine provient de lait de races commerciales. Le résultat d'une sélection intense, d'objectifs d'amélioration limités et ne pas tenir compte des problèmes de consanguinité dans le passé nous portent aujourd'hui à la nécessité d'une majeure attention à la conservation de ces races commerciales tout en conservant et augmentant la production alimentaire pour faire face à la demande dans le futur. Les caractéristiques d'un programme d'amélioration durable sont les objectifs plus larges, les mesures pour contrôler les niveaux de consanguinité et l'amélioration génétique continue pour obtenir que les populations soient compétitives. Il est nécessaire d'inclure certains traits dans les objectifs d'amélioration qui aident à réduire le coût des produits, ainsi que d'autres qui permettent d'augmenter la production de ces même produits. Les objectifs d'amélioration dépendent des pays (p.e. milieu de production) et de l'interaction génotype-milieu pour chacune de ces races (p.e. performances lait), ce qui entraîne que la marge du nombre d'animaux disponible pour les objectifs d'amélioration soit différente d'un pays à l'autre (milieu de production). Prenant en considération ce point nous pouvons augmenter le nombre d'animaux sélectionnés, au moins au niveau mondial, ainsi que la diversité mondiale dans les populations de bovin à lait. Interbull fournis des comparaisons au niveau internationale de taureaux appartenant à six races laitières parmi les plus rentables et importantes du point de vue commercial, ce qui permet une sélection mondiale pour des plus amples objectifs d'amélioration dans beaucoup de pays dans le monde.

Resumen

Una amplia parte de los productos lácteos para consumo humano provienen de leche de razas comerciales. El resultado de una selección intensificada, objetivos de mejora limitados y no tener en cuenta los problemas de consanguinidad en las pasadas décadas hacen que ahora sea necesaria una mayor atención para conservar estas razas comerciales al mismo tiempo que se mantiene e incrementa la producción alimentaria para hacer

frente a la demanda futura. Las características de un programa de mejora sostenible son los amplios objetivos de mejora, las medidas para controlar los niveles de consanguinidad y una mejora genética continua para conseguir que las poblaciones sean competitivas. Es necesario incluir algunos rasgos en los objetivos de mejora que reduzcan el costo de los productos , así como otros que incrementen la producción de los mismos. Los objetivos de mejora dependen de los países (p.e. ambiente de producción), y junto con la interacción genotipo-ambiente para cada una de las razas (p.e. rendimiento en leche), hacen que el margen de animales para los objetivos de mejora local difieren de un país a otro (ambientes de producción). El reconocer esto en un programa de selección permite ampliar el número de animales seleccionados, por lo menos a nivel mundial, ampliando la diversidad mundial en las poblaciones de vacuno de leche. Interbull proporciona comparaciones internacionales de toros pertenecientes a seis razas lecheras provenientes de entre las más económicamente importantes, lo que permite una selección mundial para mayores objetivos de mejora en muchos países del mundo.

Keywords: *Sustainability, Breeding objectives, Inbreeding, International genetic evaluations.*

Introduction

Globally, milk is one of the most important source of nutrients for human consumption. The so-called livestock revolution, envisaged by Delgado *et al.* (1999), predicts that the global demand for milk will increase considerably over a 20-year period. Developing countries will more than double their production (133%), whereas the developed world needs to increase production by just 7% to meet future demands. Most milk is produced by cattle, although buffalo, sheep and goats play very important roles for milk production in certain countries. Future demands for milk cannot be met by an increased number of animals but must result from increased productivity per animal and efficiency in the use of feed resources considering availing environments and production systems. The increased global demand for dairy products points to the importance of the commercial dairy breeds, and the need to ensure that breeding programs for these breeds are sustainable.

So far much of the national and international conservation efforts have been directed towards already endangered or nearly extinct breeds, whereas little emphasis has been put on the 'mainstream breeds' as their numbers are still quite high. In a developed country like Sweden, for example, only about 0.5% of the dairy herd population consists of endangered breeds and they produce about 0.3% of the milk.

If breeding programs for the major dairy breeds of the world fail to be sustainable the effects may be dramatic in several ways: demands for food will not be met, major losses in animal genetic diversity will occur and severe effects on land use and crop diversity may follow. Modern reproduction technologies, such as artificial insemination (AI) and embryo transfer (ET), have been proven to be very powerful tools in changing the genetics of cattle populations. The dynamics of these commercial populations effectively using AI and ET are therefore more important to monitor than just actual numbers of animals at a given time. The issue of genetic diversity is related to the number of breeds with distinctly different characteristics, the effective population size of each of these breeds, and effects of the within breed selection programs practiced.

The objectives of this paper are to illustrate the globalization of six major breeds or groups of breeds used for dairy production as a result of extensive use of AI and ET, some circumstances threatening the sustainability of the breeding programs practiced, and measures taken to improve the use of these genetic resources in such a way that demands for genetic diversity and sustainability can be met along with continuously improved production. Opportunities to monitor important genetic changes in the world's major dairy production breeds have been made possible since the establishment of Interbull, initially founded by European Association of Animal Production (EAAP), International Dairy Federation (IDF) and the International Committee of Animal Recording (ICAR). Nowadays regular exchange of data takes place between Interbull and nearly 30 countries in order to conduct international genetic evaluation of bulls. Nearly all continents are represented among these developed countries with two from North America, two from Oceania, one from Africa, one from Asia and the remainder from Europe.

Globalization of Breeds Included in Interbull Evaluations

An enormous increase in the semen trade followed the disclosure of results from the extensive FAO-experiment conducted in Poland, where 10 Friesian strains of dairy cattle were compared (Stolzmann *et al.*, 1981). The results showed an unexpectedly significant superiority of North-American Holstein-Friesians (HF) in production over their European ancestral populations. The New Zealand and Israeli populations also surprised many with their high productivity. A wave of importation of HF semen followed, and in a decade or two the black and white dairy cattle populations around the world had been 'Holsteinized' and the effective population size declined dramatically. Figure 1 shows that the Friesian cattle in northern Europe also went through a dramatic morphological change.

A parallel development also took place in other breeds. Braunvieh cattle had, similarly to Friesian cattle, been exported from western Europe to North America, where a new type of Brown Swiss was developed. Although this population was small it has provided the European ancestral populations with a lot of semen in the last 3-4 decades. The Red breed group, with Ayrshire ancestry, of Finland (Finnish Ayrshire), Norway (Norwegian Red) and Sweden (Swedish Red) started an early exchange of bull sire semen and became genetically closely linked. Ayrshire cattle, although only in small populations, were also part of the dairy populations in other regions of the world, e.g. North America, South Africa, Australia and in its area of origin in the UK. The Jersey breed had at an early stage become a globally utilised breed, well adapted to many different environmental conditions, including tropical areas. Genetically it differs markedly from most other commercial dairy breeds in live weight and milk composition. The Jersey breed has been very competitive in many countries, especially in Denmark, the USA and New Zealand, where the biggest populations are found. The other Channel Island breed, the Guernsey, has also been used a globally, but in a limited number of primarily Commonwealth countries. Major populations are found in the USA, the UK and Australia, but the number of cows has been rapidly decreasing in the last decades, despite its many interesting features. Another breed which has been spread to many countries is the Fleckvieh, primarily from central Europe, and internationally named as the Simmental. It is a dual purpose breed, but has been diverted into different lines for milk and beef vs. only for beef in some countries. The population used for dairy production is seen only in Europe and has largely been developed by use of Red Holstein semen imported from North America.

Need for comparable information

These breed and industry developments emphasized the need for methods to compare the genetic merit of bulls across countries in order to improve efficiency in the global selection of bulls. This challenge was taken up by both the IDF and EAAP, which in 1983 led to the formation of Interbull as an international committee for improved transparency of genetic evaluations of dairy cattle around the world. Following this development the Interbull Centre was established in 1991 aiming at conducting international genetic

a)

b)

Figure 1. European Friesian before (a)…… and after 'Holsteinization' (b).

evaluations of bulls including the breeds mentioned above (Philipsson, 1998).

Exchange of Genetic Material

The magnitude of exchange of genetic material can be illustrated in many ways. For example, the USA exported nine million semen doses (dairy bulls) in 2005, an increase of nearly 20% in 10 years. European AI organizations exported approximately five million semen doses in 2004. Through the Interbull system pedigree data on AI bulls is collected from 26 different countries on a routine basis, which makes it possible to monitor developments for the various breeds at the global level. The exchange of genetic material will be illustrated below based on information in the Interbull pedigree database.

Young bulls are typically tested in the country of birth and first registration (Table 1). The Guernseys and Holsteins showed the most exchange at the level of young bulls among the breed groups and countries considered in the Interbull evaluations; approximately 15% of the progeny tested bulls did not originate from the country in which they were tested. The trend for Guernsey, Holstein and Jersey is to import more young bulls from other countries, whereas the converse is true for the Brown Swiss and Red Dairy cattle breed groups.

The exchange of genetic material between countries is much more intense at the level of sires of sons. Between 13% and 67% of the progeny tested bulls had a foreign sire (Table 2). Selection of sires of sons is most global for the Brown Swiss and Holstein breed groups. The trend is generally increasing, particularly for the Guernsey and Jersey breed groups. Similar patterns were observed for the origin of maternal grand sires of progeny tested bulls.

By comparing table 1 and table 2 it becomes clear that, not surprisingly, the exchange of semen at the level of sires of sons is more frequent than the importation of calves to be put on progeny test. Fikse *et al.* (2006) reported that the proportion of foreign proven bulls used to breed cows for the commercial population ranged from 3% to 12%, with large variations between countries, and the impact of semen exchange at the level of proven bulls is less than that for sires of sons.

Table 1. Percentage of bulls progeny tested[1] in country of origin[2].

Breed group	Birth year of bull		
	1981-1985	1986-1990	1991-1995
Brown Swiss	93.2	94.7	94.6
Guernsey	96.1	88.5	84.9
Holstein		89.1	86.4
Jersey	98.1	95.6	94.5
Red Dairy Cattle	97.4	98.6	99.3
Simmental	97.9	98.4	97.3

[1]Country of test is defined as the country with most daughters.
[2]Origin is defined as country of first registration.

Table 2. Percentage of progeny tested bulls with foreign sire.

Breed group	Birth year of bull		
	1981-1985	1986-1990	1991-1995
Brown Swiss	67.3	57.4	64.9
Guernsey	14.6	13.0	32.7
Holstein		60.2	59.4
Jersey	14.9	26.1	35.0
Red Dairy Cattle	16.7	27.1	26.9
Simmental	23.6	26.0	28.6

Importance of Broad Breeding Objectives

There is accumulating evidence that single-trait selection for milk production has negative side-effects on the health and reproduction of dairy cows. These functional traits, i.e. characters of an animal that increase efficiency not by higher outputs of products but by reduced costs (Groen *et al.*, 1997), are unfavorably correlated with milk production, the magnitude of the genetic correlations being 0.2-0.5 (e.g. Roxström, 2001; Wall *et al.*, 2003). The complexity of functional traits, reflected in the categorical nature of data records and low heritabilities, is often given as a reason to ignore these traits in breeding objectives and breeding programs.

The considerable amount of genetic variation that exists for functional traits (Philipsson and Lindhé, 2003) justifies inclusion of these traits in breeding objectives. Aamand (2007) illustrated for example that the incidence of mastitis was about twice as high among daughters of sires with an index below 86 (2 SD below average) compared to sires with an index above 113 (2 SD above average). Zwald *et al.* (2004) also reported large differences in incidence (by a factor of between 1 and 5) of several diseases (ketosis, mastitis, lameness, cystic ovaries and metritis) depending on the genetic merit for disease susceptibility.

The merging of Nordic health and reproduction data with North American production and conformation data revealed an unfavorable relationship between health and dairy character (Rogers *et al.*, 1999). The emphasis on dairy character and the determination to breed for 'sharp' cows may indeed have contributed to the increase in health and reproductive problems in some breeds.

Given the existence of genetic variation and the negative relationship with production, ignoring functional traits will lead to deterioration of functional traits and ultimately an increase in costs of producing milk due to increased disease incidence, reproductive failures and involuntary culling of cows. On average, the length of productive life is 2-3 lactations. This measure must, however, be cautiously interpreted as it merely reflects the economics of markets and the production systems practiced rather than just the genetic stayability of the cows. The emphasis of dairy cattle breeding objectives has gradually shifted from production and conformation traits only to include more functional traits during the past couple of decades (Miglior *et al.*, 2005) and many countries now have genetic evaluations in place for important functional traits such as health, fertility, longevity and calving traits (Mark, 2004).

The inclusion of functional traits in selection indexes and breeding objectives not only increases genetic progress for total genetic merit in economic terms but has also positive implications for genetic diversity. Sorensen *et al.* (1999) observed with simulations that selection for milk yield was inferior to selection for total merit index in terms of genetic gain for total genetic merit and inbreeding rates.

Interbull International Genetic Evaluations

Traditionally, countries perform national genetic evaluations to assess the genetic merit of bulls, but the results of these evaluations are not directly comparable across countries. The main reasons (Philipsson, 1987) are

1. Differences in trait definitions and recording and evaluations practices.
2. Differences in genetic levels among countries.
3. Differences in animal performance under varying production systems (genotype-environment interaction).

It was nearly impossible for breeders to compare the genetic merit of domestic and foreign genetic material, complicating the process of identifying superior animals and realizing the potential benefits of exchange of genetic material between countries. The recognition of this problem formed the basis of developments and activities, initially by EAAP and IDF, that led to the establishment of Interbull and the launch of international genetic evaluations by Interbull.

MACE

The routine international genetic evaluations performed by Interbull combine the results of national genetic evaluations from various countries in a joint analysis often referred to as Multiple-trait Across Country Evaluation (MACE; Schaeffer, 1994). MACE is essentially a multiple-trait sire model where performance in each country is treated as a different trait. Important features of MACE are the ability to accommodate different parameters (heritability, genetic and residual variances) between countries and the possibility of considering relationships between bulls.

Genetic correlations between countries are accounted for in MACE to reflect the fact that performance in different environments can be viewed as different traits. Genetic correlations between countries less than unity indicate the presence of genotype-environment interaction, which means that ranking of animals (genotypes) differs between countries (environments). For example, if cows are fed on high quality feed then the cows' appetite and feed intake could be the factor that causes some cows to be superior in milk production over others, whereas if the cows are fed on poor feed it is likely that cows with the best feed utilization will be superior. Hence, a separate list of bulls with breeding values is computed for each participating country, expressed in their own units and relative to their own base group of animals (Figure 2).

Genetic correlations between countries

Genetic correlations between countries are on average highest for milk production and somatic cells and lowest for longevity and stillbirth (Table 3). These correlations reflect on one hand the harmonization in recording and evaluation of traits and on the other hand the degree of genotype-environment interaction between countries. Both milk yield and somatic cells are recorded and evaluated reasonably uniformly across countries, which is reflected in the high genetic correlations between countries. Longevity, on the other hand, is a more complex trait and genetic correlations between countries are relatively low and variable. Reasons for culling differ between countries due to economic conditions, climate and other production factors.

A closer look at the genetic correlations reveals that correlations are usually highest among countries in the same hemisphere and lowest among countries from different hemispheres (North vs. South). For example, the genetic correlations for milk production among countries from the same hemispheres range between 0.85 and 0.95, and are between 0.75 and 0.85 among countries from different hemispheres. Thus, milk production in the northern and southern hemispheres can be viewed as different traits, and different rankings of sires are to be expected in both hemispheres.

Global perspective on selection of dairy bulls

A consequence of genotype-environment interaction and genetic correlations among countries less than unity, is the re-ranking of animals across environments (illustrated in Figure 2). Table 4 is based on data available through Interbull and shows that bulls with high genetic merit for protein yield in Sweden, USA or the Netherlands do not always have high genetic merit for protein yield in

Table 3. Weighted[1] average and range in estimated genetic correlations (r_g) across different Holstein populations for selected traits (February 2007).

Trait	Populations	Mean r_g	SD of r_g	Range of r_g
Protein yield	24	0.84	0.05	0.18
Somatic cells	23	0.90	0.05	0.23
Clinical mastitis[2]	4	0.85	0.07	0.18
Longevity	19	0.71	0.14	0.61
Direct calving ease	12	0.78	0.11	0.51
Maternal calving ease	11	0.77	0.09	0.35
Direct stillbirth	5	0.69	0.11	0.29
Maternal stillbirth	5	0.80	0.07	0.21
Interval calving-first insemination	5	0.81	0.17	0.43
Non-return rate	5	0.74	0.09	0.32
Days open/calving interval	8	0.81	0.10	0.34
Body condition score[3]	2	0.92		

[1]Weighted by number of bulls with evaluations in both of the concerned countries.
[2]Taken from the Interbull March 2005 test evaluation.
[3]Estimated by Jorjani (2005).

Table 4. Number of bulls in common between the top 100 lists of Holstein bulls on four different country scales[1].

	Protein			Somatic cells			Longevity		
	NLD	USA	NZL	NLD	USA	NZL	NLD	USA	NZL
SWE	86	90	80	75	70	39	41	46	0
NLD		82	75		69	41		48	0
USA			75			34			3

[1] NLD = The Netherlands; SWE = Sweden; USA = United States of America; NZL = New Zealand

Table 5. Increase in total number of top 100 bulls when considering genotype-environment interaction by applying genetic correlations (r_g) less than unity (February 2007).

Breed group	Number of populations	Number of top bulls	
		$r_g = 1$	$r_g < 1$
Brown Swiss	9	100	179
Guernsey	6	100	140
Holstein	24	100	309
Jersey	10	100	282
Red Dairy Cattle	10	100	192
Simmental	10	100	179

New Zealand. The top 100 lists of the northern hemisphere countries had approximately 90 bulls in common, but only 75-80 with New Zealand. The situation is more extreme for somatic cells and especially longevity for which none of the top 100 bulls in Sweden and the Netherlands were among the top 100 in New Zealand (Table 4). It appears that due to the seasonal calving patterns and the grazing system, cows have to meet different requirements to survive in New Zealand compared with northern hemisphere countries.

Considering genotype-environment interaction in international comparisons leads to the selection of more bulls on a global level (Table 5). For example, treating protein yields as different traits in each of the 24 populations participating in the Interbull evaluation (Holstein), 309 different bulls were among the top 100 in any given country. Similarly, there were 611 different bulls among the top 100 lists for longevity in each of the 19 countries (Holstein). Different sires and dams are selected in different countries, which can increase the global effective population size (Goddard, 1992). Thus, taking genotype-environment interaction into account in international comparisons has a desirable effect on the utilization of animal genetic resources, in addition to accommodating differences in production environments around the world.

The number of potential selection candidates increases when selection is across-country rather than within-country. Consequently, higher selection intensities can be achieved which is especially beneficial for small and genetically inferior populations (Banos and Smith, 1991; Lohuis and Dekkers, 1998). Using the Interbull evaluation results it has been shown that the potential to increase selection differentials is up to 2.5 genetic standard deviation units for across-country selection compared to within-country selection (Fikse, 2004; Mark, 2005). Rather than exploiting the increased selection potential for increasing genetic progress, it can also be used to select less-related animals, thus reducing the inbreeding rate.

The combination of 1) genotype-environment interactions for individual traits and 2) differences in breeding objectives across countries (i.e. weights given to individual traits in an index for total genetic merit) results in relatively low genetic correlations between breeding objectives in different countries. Sonesson (2006) estimated the genetic correlation between the breeding objectives for the Nordic Red breeds to be around 0.8. Miglior *et al.* (2005) observed rather low numbers of bulls in common between the top 100 lists for total genetic merit in a range of countries, indicating considerable re-ranking of bulls across countries.

The presence of genotype-environment interaction for total genetic merit actualizes the question of whether separate breeding programs should be maintained for different environments and whether cooperation between breeding programs is beneficial. Sonesson (2006) investigated the difference between one breeding program for all countries and separate breeding programs in each country for the Nordic Red breeds and concluded there was little difference in overall genetic gain at constrained levels of inbreeding rate. A general rule-of-thumb is that multiple breeding programs are justifiable when the genetic correlation between breeding objectives is below 0.8 (e.g. Robertson, 1959), but this depends on the actual scenario (testing capacity, genetic parameters, selection intensity, etc.; Mulder and Bijma, 2006).

Interbull evaluations

Interbull started international genetic evaluations for production traits in 1994 and data from four countries and two breed groups were considered (Philipsson, 1998). Since then, Interbull services have expanded and they nowadays consider six breed groups and 26 countries (Table 6). Since February 2007, international evaluations for fertility have been computed, in addition to production, conformation, udder health, longevity and calving performance. Thus, international genetic evaluations are available for all economically important trait groups.

Routine evaluations are performed three times per year. For the Interbull evaluation of February 2007 the pedigree database included nearly 400 000 bulls (Table 7) and international evaluations were computed for 140 000 bulls. It should be noted that Interbull does not publish international breeding values; Interbull simply distributes them to participating countries. It is then the responsibility of these countries to rank the bulls within country according to their own breeding objectives, and publish these results.

The joint analysis of national genetic evaluations (MACE) depends on the results of national genetic evaluations systems (Figure 2). Therefore, international comparisons are only as good as the various national evaluation systems that provide the input. Procedures have been developed and are applied on a regular basis to check the quality of data used in Interbull evaluations (Klei *et al.*, 2002; Boichard *et al.*, 1995). In addition, Interbull organizes special workshops, conducted surveys and compiled guidelines for national genetic evaluation systems to monitor developments and promote standardization of national evaluation systems and their results.

Monitoring Global Trends in Dairy Cattle Breeding

Genetic progress

The genetic level for protein yield has increased noticeably during the past two decades for both the Holstein and Red Dairy cattle breed groups (Figure 3). The genetic trends were slightly negative (unfavorable) for clinical mastitis and direct longevity for the Holstein breed group. On the other hand, the genetic trend for clinical mastitis and direct longevity for the Red Dairy cattle breed group were slightly positive.

Philipsson and Lindhé (2003) illustrated the importance of having comparable information for all traits of economic importance for selection candidates by comparing the genetic trend in female fertility for the Swedish Holstein and the Swedish Red populations. The genetic trend for fertility in the Swedish Red population was slightly favorable, due to the availability of genetic evaluations for progeny tested bulls that were candidates for selection as sires of sons. The majority (~75%) of the bulls belonging to the Red Dairy cattle breed group are tested in Nordic countries where recording and evaluation of female fertility traits has been practiced for a long time. The situation for the Holstein breed group was much worse, because at the time of selection as sires of sons no female fertility information was available for the majority of bulls (> 90%). Selection emphasis was instead put on production and conformation, leading to an unfavorable correlated response for female fertility.

Inbreeding

The intensity of use of sires of sons has been highest for the Holstein breed group, as indicated by the number of sons per bull sire (Figure 4). For the other breed groups about ten sons per bull sire were tested on average. The oscillating pattern for the Holstein breed group is caused by a few very popular bull sires with hundreds or thousands of progeny tested sons. In 1983 and 1985, half of all progeny tested bulls were sired by one bull sire. Extreme use of Holstein bull sires has been tempered for bulls born after 1987 (Figure 5). For the Jersey breed group the intensity of use of bull sires has been tempered lately as well, whereas the trend is increasing for the Brown Swiss breed group. Due to the limited population size not more than five

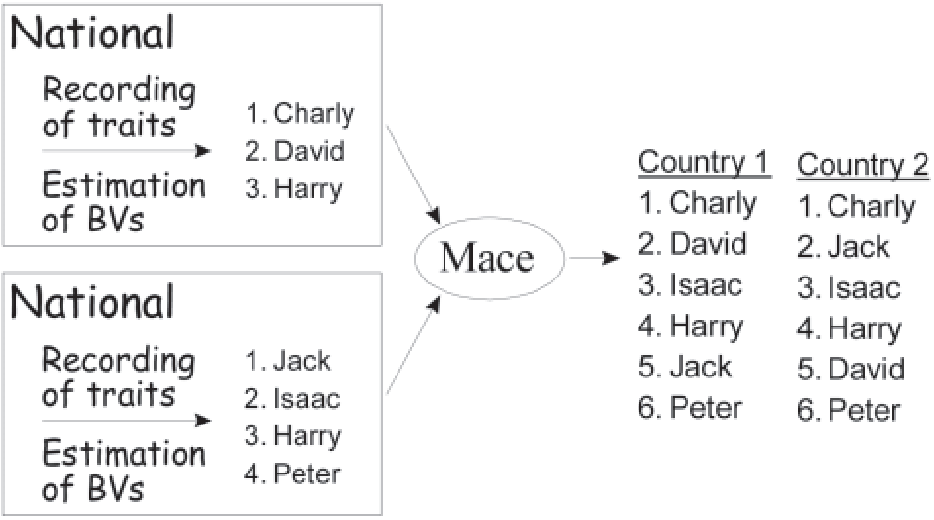

Figure 2. Schematic illustration of the international genetic evaluation model.

Table 6. Number of populations participating in the routine Interbull evaluation of February 2007.

Breed group	Production	Conformation	Udder health	Longevity	Calving	Female fertility
Brown Swiss	9	7	8	6	4	-
Guernsey	6	4	5	5	-	-
Holstein	24	20	23	19	12	11
Jersey	10	9	8	7	-	-
Red Dairy Cattle	10	8	10	9	5	-
Simmental	10	-	8	2	-	-
Total	69	48	62	48	21	11

Table 7. Number of bulls in pedigree database and bulls with publishable breeding values for production by breed group (February 2007).

	Pedigree database	Publishable breeding value for production
Brown Swiss	59 131	7 249
Guernsey	2 315	892
Holstein	226 357	95 629
Jersey	19 448	7562
Red Dairy Cattle	29 703	10 945
Simmental	33 816	19 980

Guernsey bull sires are selected annually, leading to the high number in figure 5.

In the last decade a multitude of studies have reported inbreeding trends and inbreeding depression in the major dairy breeds. Based on the inbreeding rate, Weigel (2001) estimated the effective population size at 161, 61, 65, 39, and 30 for the US Ayrshire, Brown Swiss, Guernsey, Holstein, and Jersey populations, respectively. Recent estimates based on Danish pedigree information were 49 and 53 for Holstein and Jersey, respectively, and a decrease was predicted for the immediate future (Sorensen *et al.*, 2005). Inbreeding is now at a level where the effects become

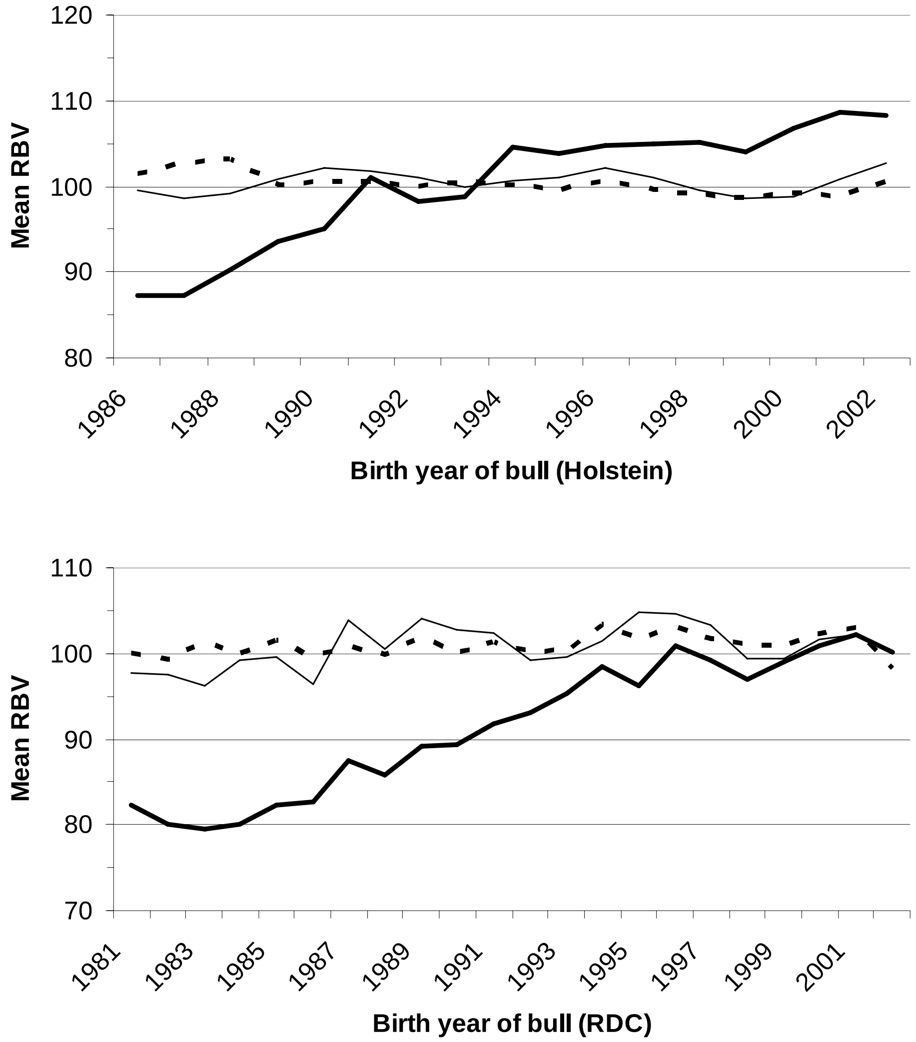

Figure 3. Estimated genetic trends in Holstein and Red Dairy cattle cow populations for protein yield (thick-solid line), clinical mastitis (dotted line) and direct longevity (thin-solid line) on Swedish scales (weighted average of international bull breeding values from February 2007 Interbull evaluations; weighted by total number of daughters across all countries; high breeding values are favorable; all breeding values are expressed with a standard deviation of 10).

noticeable, for example by the increased problems due to recessive genetic defects or inbreeding depression.

Dairy farmers in the US and other countries started to explore crossbreeding Holsteins with other breeds (Hansen, 2006) to circumvent problems due to increased inbreeding rates and deterioration of functional traits. The first experiences from these crossbreeding experiments are positive, resulting in F1 females with lower stillbirth rates, decreased calving difficulty, improved cow fertility, and enhanced survival with little, if any, loss of production (kg) of fat plus protein (Heins *et al.*, 2006a; 2006b; 2006c). The prospects of crossbreeding as a means to deal with problems in purebred populations depends on the implementation of crossbreeding programs on a herd basis that capture as much heterosis as possible, are easy to manage and result in as little variation among crossbred animals as possible. Most importantly, crossbreeding is only successful if continuous progress is made in the purebred populations.

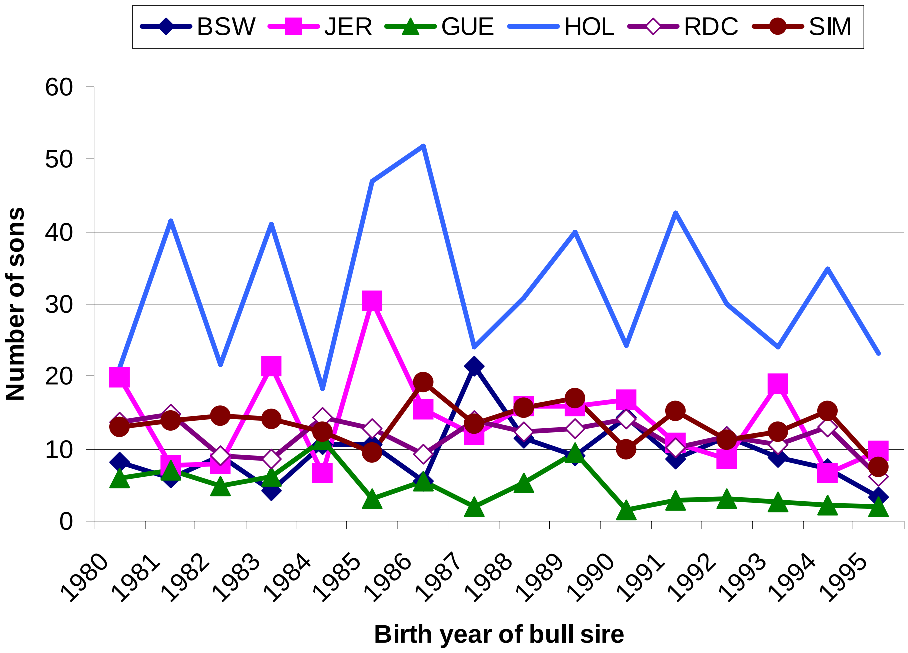

Figure 4. Average number of progeny tested sons per bull sire (February 2007).

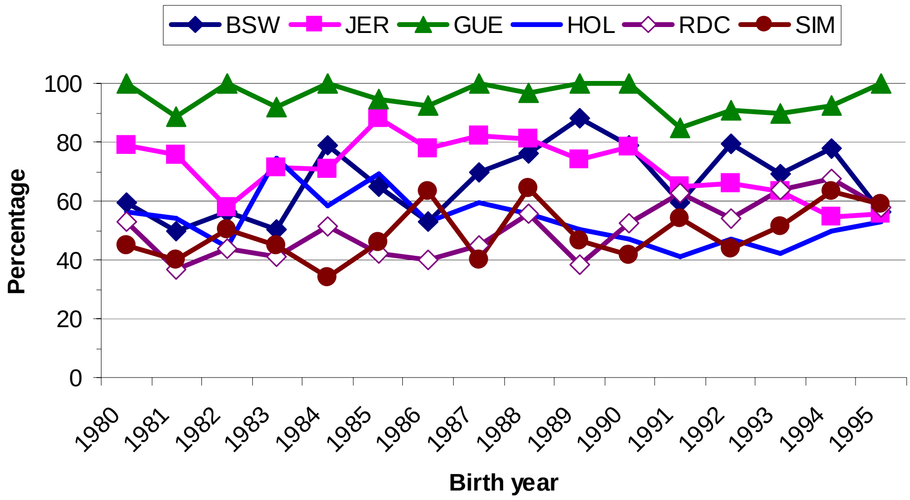

Figure 5. Percentage progeny tested bulls after the five most popular bull sires (February 2007).

Several tools to aid selection of parents have been developed that can maximize progress at restricted inbreeding rates (Meuwissen and Sonesson, 1998; Berg *et al*., 2006). While powerful, the success of these tools depends on the extent of their use. Important selection decisions in dairy cattle breeding (bull sire and bull dam selection) are taken by AI organizations that are in competition with each other. The challenge for these organizations is to balance the short-term interest in increasing genetic gain with the long-term need to avoid depletion of genetic resources. Initiatives like the European Forum of Farm Animal Breeders and the development of a Code of Good Practice for Farm Animal Breeding and Reproduction Organizations are steps in the right direction.

Measures to be taken for sustainability

A sustainable dairy cattle breeding program should be characterized by:

- A continuous genetic improvement of productivity to keep the population commercially competitive in relevant areas for production.
- The generation of products which have such value that they are marketable at a profitable farm-gate price.
- A broad definition of breeding objectives to take into account selection for all major economically important traits with a special restriction that fundamental characteristics of fertility, health and survival do not decline.
- Management of inbreeding at such a level that no depression of important traits resulting from increased inbreeding occurs. The effective population size should be monitored and selection practiced to keep it above levels at which the breed is considered to be at risk of endangerment.

In any dairy cattle population the most important assumption for a sustainable breeding program is that there is a comprehensive milk-recording scheme and links to other recordings of traits, e.g. health and fertility, to enable genetic evaluation of bulls for broad breeding objectives (Philipsson *et al.*, 2005).

As regards the design of breeding programs, the use of young bulls is essential in all systems. In large populations extensive use of young bulls enables progeny testing of many bulls, providing opportunities for strong selection of bulls to be used as sires of cows and sons. With large progeny groups, i.e. 100-150 daughters, reasonably accurate breeding values can also be obtained for most functional traits. In small populations progeny testing is of limited value for selection of bulls for wide-spread use, as such use is not possible from an inbreeding point of view. However, progeny information, as well as records of all relatives, can be used for evaluation and selection of parents of young bulls, each one of which should be limited in use.

The globalization of practically all breeds is a fact and the advantages of this should be captured while possible disadvantages must be avoided. To reach this goal it is important that all bulls in the countries in question are evaluated nationally (or regionally) for domestically defined broad breeding objectives and that these domestic breeding values become part of the international genetic evaluations that Interbull provides. In this way wise selection of bulls across countries is made possible for the broad breeding objectives set for each country (or region). This scenario is based on the assumption that the Interbull evaluations are published in each country in such a way that they are easily accessible by AI stud managers and progressive farmers.

Options for developing countries

Livestock recording schemes are well developed in most industrialized countries and may then provide the information necessary to conduct advanced genetic evaluations of cows and bulls. In most developing countries the situation is quite different. The most limiting factor for adoption of sustainable breeding programs is the lack of relevant recording schemes as a basis for both management and genetic evaluation purposes (Philipsson, 2000). For local breeds, variants of nucleus breeding schemes are plausible, but problems exist in selecting bulls of 'exotic' breeds, e.g. Holstein, Brown Swiss and Ayrshire. If no domestic evaluations exist in the developing countries, there are no opportunities to participate in international evaluations, and thus to select the best bulls for the country in question. The best advice so far is for each country to compare its environment and production system with those countries already participating in the Interbull evaluations and rely on the results of a country having the most similar environment. For instance, international breeding values published for New Zealand may indicate which bulls are best for other countries heavily relying on grazing systems, whereas Israeli results may be the best to use in other countries characterized by a hot climate and high intensity of grain feeding. In any case, breeding organizations in developing countries need to put more emphasis on defining their own breeding objectives and select for these according to the principle proposed above, rather than just using semen of any bulls advertised by foreign companies.

Do Commercial Breeds Need to Be Conserved?

In scrutinizing the criteria for sustainability of breeding programs for dairy cattle, and the review of what has happened in the most globally prominent breeds used for dairy production, it is obvious that certain facts indicate that some breeds, especially Holstein, are faced with severe problems that question the sustainability of the breed. The unfavorable correlations between e.g. production and fertility, or the rising stillbirth trend, have not been met globally by adequate means for genetic evaluation and selection until very recently. Still, for these breeds used globally there is no body that takes the overall responsibility for directing their development into more harmonized breeding programs in line with the criteria for sustainability rather than focusing on traditional breeding for conformation, and especially for such traits that are unfavorably correlated with fitness of the animals. However, there are notable exceptions. In Scandinavia, quite well harmonized breeding programs have long since been established for the Red Dairy breeds, considering broad breeding objectives. As a consequence semen of these breeds is now successfully used internationally in crossing Holsteins to capture not only effects of heterosis, but also to effectively incorporate genes for good fertility and health along with high production and to avoid further inbreeding (Hansen, 2006).

Another example and problem is demonstrated by the Guernsey breed, which has been declining in numbers for some time. In most countries the breeding program is characterized by traditional selection for just production and conformation, the latter leading to bigger and less fertile cows. However, the World Guernsey Cattle Federation has taken the initiative to launch a global breeding program based on sound scientific principles, whereby the genetic diversity is considered in combination with selection for a continuously broader breeding objective (Luff, 2006). It takes time, however, to harmonize ideas and breeding objectives and principles of selection across continents used with different breeding traditions, but such global efforts are very well worth supporting. This is also emphasized by the fact that the breed seems to offer certain characteristics in its milk that differ from other major breeds.

List of References

Aamand, G.P. 2007. Use of health data in genetic evaluation and breeding. Proceedings of the 35th Biennial session of ICAR. EAAP publication no. 121: 275-282.

Banos, G. & C. Smith. 1991. Selecting bulls across countries to maximize genetic improvement in dairy cattle. Journal of Animal Breeding and Genetics 108: 174-181.

Berg, P., J. Nielsen & M.K. Sorensen. 2006. EVA: realized and predicted optimal genetic contributions. Proceedings of the 8th World Congress on Genetics Applied to Livestock Production, communication no. 27-09.

Boichard, D., B. Bonaiti, A. Barbat & S. Mattalia. 1995. Three methods to validate the estimation of genetic trend for dairy cattle. Journal of Dairy Science 78: 431-437.

Delgado, C., M. Rosegrant, H. Steinfeld, S. Ehui & C. Courbois. 1999. Livestock to 2020-The next food revolution. Food, Agriculture, and the Environment Discussion Paper 28. IFPRI (International Food Policy Research Institute), Washington, DC, USA, pp. 72.

Fikse, W.F. 2004. Interbull guides through the labyrinth of national genetic evaluations. Proceeding of the 55th meeting of the EAAP. EAAP Book of Abstracts 10, 326.

Fikse, W.F., J.H. Jakobsen & C. Gustafsson. 2006. Selection of sires in different countries for global dairy breeds. Proceedings of the 8th World Congress on Genetics Applied to Livestock Production, communication no. 01-31.

Groen, A.F., T. Steine, J.J. Colleau, J. Pedersen, J. Pribyl & N. Reinsch. 1997. Economic values in dairy cattle breeding, with special reference to functional traits. Report of an EAAP-working group. Livestock Production Science 49:1-21.

Goddard, M.E. 1992. Optimal effective population size for the global population of black and white dairy cattle. Journal of Dairy Science 75: 2902-2911.

Hansen, L.B. 2006. Monitoring the worldwide genetic supply for cattle with emphasis on managing crossbreeding and inbreeding. Proceedings of the 8th World Congress on Genetics Applied to Livestock Production, communication no. 01-01.

Heins, B.J., L.B. Hansen & A.J. Seykora. 2006a. Production of pure Holsteins versus crossbreds of Holstein with Normande, Montbeliarde, and Scandinavian Red. Journal of Dairy Science 89: 2799-2804.

Heins, B.J., L.B. Hansen & A.J. Seykora. 2006b. Calving difficulty and stillbirths of pure Holsteins versus crossbreds of Holstein with Normande, Montbeliarde, and Scandinavian Red. Journal of Dairy Science 89: 2805-2810.

Heins, B.J., L.B. Hansen & A.J. Seykora. 2006c. Fertility and survival of pure Holsteins versus crossbreds of Holstein with Normande, Montbeliarde, and Scandinavian Red. Journal of Dairy Science 89: 4944-4951.

Klei, L., T. Mark, W.F. Fikse & T. Lawlor. 2002. A method for verifying genetic evaluation results. Interbull Bulletin 29: 178-182.

Lohuis, M.M. & J.C.M. Dekkers. 1998. Merits of borderless evaluations. Proceedings of the 6th World Congress on Genetics Applied to Livestock Production 26: 169-172.

Luff, B. 2006. Guernsey Global Breeding Programme. *http://www.worldguernseys.org/*.

Mark, T. 2004. Applied genetic evaluations for production and functional traits in dairy cattle. Journal of Dairy Science 87: 2641-2652.

Mark, T. 2005. International genetic evaluations for udder health traits in dairy cattle. PhD thesis. Acta Universitatis Agriculturae Sueciae, 2005: 93. Swedish University of Agricultural Sciences, Uppsala, Sweden.

Meuwissen, T.H.E. & A.K. Sonesson. 1998. Maximizing the response of selection with a predefined rate of inbreeding- overlapping generations. Journal of Animal Science 76: 2575-2583.

Miglior, F., B.L. Muir & B. J. Van Doormaal. 2005. Selection indices in Holstein cattle of various countries. Journal of Dairy Science 88: 1255-1263.

Mulder, H.A., R.F. Veerkamp, B.J. Ducro, J.A.M. van Arendonk & P. Bijma. 2006. Optimization of dairy cattle breeding programs for different environments with genotype by environment interaction. Journal of Dairy Science 89: 1740-1752.

Philipsson, J. 1987. Standards and procedures for international genetic evaluation of dairy cattle. Journal of Dairy Science 70: 418-424.

Philipsson, J. 1998. Global use of bulls and the "INTERBULL System". Agric. Scand., Sect.A, Animal Science 1998: Supplement 29: 98-107.

Philipsson, J. 2000. Sustainability of dairy cattle breeding systems utilising artificial insemination in less developed countries-examples of problems and prospects. ICAR Technical Series no. 3: 551-562.

Philipsson, J., J-Å. Eriksson & H. Stålhammar. 2005. Know-how transfer in animal breeding-the power of integrated cow data bases for farmer's selection of bulls to improve functional traits in dairy cows. In: Knowledge transfer in cattle husbandry. EAAP Publication no. 117: 85-95.

Philipsson, J. & B. Lindhé. 2003. Experiences of including reproduction and health traits in Scandinavian dairy cattle breeding programmes. Livestock Production Science 83: 99-112.

Robertson, A. 1959. The sampling variance of the genetic correlation coefficient. Biometrics 15: 469-485.

Rogers, G.W., G. Banos & U.S. Nielsen. 1999. Genetic correlations among protein yield, productive life, and type traits from the United States and diseases other than mastitis from Denmark and Sweden. Journal of Dairy Science 82: 1331-1338.

Roxström, A. 2001. Genetic aspects of fertility and longevity in dairy cattle. PhD thesis. Acta Universitatis Agriculturae Sueciae, Agraria 276. Swedish University of Agricultural Sciences, Uppsala, Sweden.

Schaeffer, L.R. 1994. Multiple-country comparisons of dairy sires. Journal of Dairy Science 77: 2671-2678.

Sonesson, A.K. 2006. Assessing total profit of alternative levels of co-operation between Nordic cattle populations. In: Project report: Sustainable Breeding in the Nordic Red Dairy Breeds.

Sorensen, M.K., P. Berg, J. Jensen & L.G. Christensen. 1999. Stochastic simulation of breeding schemes for total merit in dairy cattle. Interbull Bulletin 23: 183-192.

Sorensen, A.C., M.K. Sorensen & P. Berg. 2005. Inbreeding in Danish dairy cattle breeds. Journal of Dairy Science 88, 1865-1872.

Stolzmann, M., H. Jasiorowski, Z. Reklewski, A. Zarnecki & G. Kalinowska. 1981. Friesian cattle in Poland. Preliminary results of testing different strains. World Animal Review, 38: 9-15.

Wall, E., S. Brotherstone, J.A. Woolliam, G. Banos & M.P. Coffey. 2003. Genetic evaluation of fertility using direct and correlated traits. Journal of Dairy Science 86: 4093-5102.

Weigel, K.A. 2001. Controlling inbreeding in modern breeding programs. Journal of Dairy Science 84 (E. supplement): E177-E184.

Zwald, N.R., K.A. Weigel, Y.M. Chang, R.D. Welper & J.S. Clay. 2004. Genetic selection for health traits using producer-recorded data. I. Incidence rates, heritability estimates, and sire breeding values. Journal of Dairy Science 87: 4287-4294.